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X Window System

Version 11

Release 3

X Window System Protocol

Xlib - C Language X Interface

X Toolkit Intrinsics - C Language Interface

Bitmap Distribution Format 2.1

(Notice for Inside Front Cover)

This standard has been adopted for Federal Government use.

Details concerning its use within the Federal Government are contained in Federal Information Processing Standards Publication 158, The User Interface Component of the Applications Portability Profile. For a complete list of the publications available in the Federal Information Processing Standards Series, write to the Standards Processing Coordinator (ADP), National Institute of Standards and Technology, Gaithersburg, MD 20899.

X Window System Protocol

X Version 11, Release 3

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This document does not attempt to provide the rationale or pragmatics required to fully understand the protocol or to place it in perspective within a complete system.

The protocol contains many management mechanisms that are not intended for normal applications. Not all mechanisms are needed to build a particular user interface. It is important to keep in mind that the protocol is intended to provide mechanism, not policy.

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1. Terminology

Access control list

X maintains a list of hosts from which client programs can be run. By default, only programs on the local host and hosts specified in an initial list read by the server can use the display. Clients on the local host can change this access control list. Some server implementations can also implement other authorization mechanisms in addition to or in place of this mechanism. The action of this mechanism can be conditional based on the authorization protocol name and data received by the server at connection setup.

Active grab

A grab is active when the pointer or keyboard is actually owned by the single grabbing client.

Ancestors

If W is an inferior of A, then A is an ancestor of W.

Atom

An atom is a unique ID corresponding to a string name. Atoms are used to identify properties, types, and selections.

Background

An **InputOutput** window can have a background, which is defined as a pixmap. When regions of the window have their contents lost or invalidated, the server will automatically tile those regions with the background.

Backing store

When a server maintains the contents of a window, the pixels saved off screen are known as a backing store.

Bit gravity

When a window is resized, the contents of the window are not necessarily discarded. It is possible to request that the server relocate the previous contents to some region of the window (though no guarantees are made). This attraction of window contents for some location of a window is known as bit gravity.

Bit plane

When a pixmap or window is thought of as a stack of bitmaps, each bitmap is called a bit plane or plane.

Bitmap

A bitmap is a pixmap of depth one.

Border

An **InputOutput** window can have a border of equal thickness on all four sides of the window. A pixmap defines the contents of the border, and the server automatically maintains the contents of the border. Exposure events are never generated for border regions.

Button grabbing

Buttons on the pointer may be passively grabbed by a client. When the button is pressed, the pointer is then actively grabbed by the client.

Byte order

For image (pixmap/bitmap) data, the server defines the byte order, and clients with different native byte ordering must swap bytes as necessary. For all other parts of the protocol, the client defines the byte order, and the server swaps bytes as necessary.

Children

The children of a window are its first-level subwindows.

Client

An application program connects to the window system server by some interprocess communication (IPC) path, such as a TCP connection or a shared memory buffer. This program is referred to as a client of the window system server. More precisely, the client is the IPC path itself; a program with multiple paths open to the server is viewed as multiple clients by the protocol. Resource lifetimes are controlled by connection lifetimes, not by program lifetimes.

Clipping region

In a graphics context, a bitmap or list of rectangles can be specified to restrict output to a particular region of the window. The image defined by the bitmap or rectangles is called a clipping region.

Colormap

A colormap consists of a set of entries defining color values. The colormap associated with a window is used to display the contents of the window; each pixel value indexes the colormap to produce RGB values that drive the guns of a monitor. Depending on hardware limitations, one or more colormaps may be installed at one time, so that windows associated with those maps display with correct colors.

Connection

The IPC path between the server and client program is known as a connection. A client program typically (but not necessarily) has one connection to the server over which requests and events are sent.

Containment

A window "contains" the pointer if the window is viewable and the hotspot of the cursor is within a visible region of the window or a visible region of one of its inferiors. The border of the window is included as part of the window for containment. The pointer is "in" a window if the window contains the pointer but no inferior contains the pointer.

Coordinate system

The coordinate system has X horizontal and Y vertical, with the origin [0, 0] at the upper left. Coordinates are discrete and are in terms of pixels. Each window and pixmap has its own coordinate system. For a window, the origin is inside the border at the inside upper left.

Cursor

A cursor is the visible shape of the pointer on a screen. It consists of a hot spot, a source bitmap, a shape bitmap, and a pair of colors. The cursor defined for a window controls the visible appearance when the pointer is in that window.

Depth

The depth of a window or pixmap is the number of bits per pixel that it has. The depth of a graphics context is the depth of the drawables it can be used in conjunction with for graphics output.

Device

Keyboards, mice, tablets, track-balls, button boxes, and so on are all collectively known as input devices. The core protocol only deals with two devices, "the keyboard" and "the pointer."

DirectColor

DirectColor is a class of colormap in which a pixel value is decomposed into three separate subfields for indexing. The first subfield indexes an array to produce red intensity values. The second subfield indexes a second array to produce blue intensity values. The third subfield indexes a third array to produce green intensity values. The RGB values can be changed dynamically.

Display

A server, together with its screens and input devices, is called a display.

Drawable

Both windows and pixmaps can be used as sources and destinations in graphics operations. These windows and pixmaps are collectively known as drawables. However, an **InputOnly** window cannot be used as a source or destination in a graphics operation.

Event

Clients are informed of information asynchronously by means of events. These events can be generated either asynchronously from devices or as side effects of client requests. Events are grouped into types. The server never sends events to a client unless the client has specificially asked to be informed of that type of event. However, other clients can force events to be sent to other clients. Events are typically reported relative to a window.

Event mask

Events are requested relative to a window. The set of event types that a client requests relative to a window is described by using an event mask.

Event synchronization

There are certain race conditions possible when demultiplexing device events to clients (in particular deciding where pointer and keyboard events should be sent when in the middle of window management operations). The event synchronization mechanism allows synchronous processing of device events.

Event propagation

Device-related events propagate from the source window to ancestor windows until some client has expressed interest in handling that type of event or until the event is discarded explicitly.

Event source

The window the pointer is in is the source of a device-related event.

Exposure event

Servers do not guarantee to preserve the contents of windows when windows are obscured or reconfigured. Exposure events are sent to clients to inform them when contents of regions of windows have been lost.

Extension

Named extensions to the core protocol can be defined to extend the system. Extension to output requests, resources, and event types are all possible and are expected.

Focus window

The focus window is another term for the input focus.

Font

A font is a matrix of glyphs (typically characters). The protocol does no translation or interpretation of character sets. The client simply indicates values used to index the glyph array. A font contains additional metric information to determine interglyph and interline spacing.

GC, GContext

GC and gcontext are abbreviations for graphics context.

Glyph

A glyph is an image, typically of a character, in a font.

Grab

Keyboard keys, the keyboard, pointer buttons, the pointer, and the server can be grabbed for exclusive use by a client. In general, these facilities are not intended to be used by normal applications but are intended for various input and window managers to implement various styles of user interfaces.

Graphics context

Various information for graphics output is stored in a graphics context such as foreground pixel, background pixel, line width, clipping region, and so on. A graphics context can only be used with drawables that have the same root and the same depth as the graphics context.

Gravity

See **bit gravity** and **window gravity**.

GrayScale

GrayScale can be viewed as a degenerate case of **PseudoColor**, in which the red, green, and blue values in any given colormap entry are equal, thus producing shades of gray. The gray values can be changed dynamically.

Hotspot

A cursor has an associated hotspot that defines the point in the cursor corresponding to the coordinates reported for the pointer.

Identifier

An identifier is a unique value associated with a resource that clients use to name that resource. The identifier can be used over any connection.

Inferiors

The inferiors of a window are all of the subwindows nested below it: the children, the children's children, and so on.

Input focus

The input focus is normally a window defining the scope for processing of keyboard input. If a generated keyboard event would normally be reported to this window or one of its inferiors, the event is reported normally. Otherwise, the event is reported with respect to the focus window. The input focus also can be set such that all keyboard events are discarded and such that the focus window is dynamically taken to be the root window of whatever screen the pointer is on at each keyboard event.

Input manager

Control over keyboard input is typically provided by an input manager client.

InputOnly window

An **InputOnly** window is a window that cannot be used for graphics requests. **InputOnly** windows are invisible and can be used to control such things as cursors, input event generation, and grabbing. **InputOnly** windows cannot have **InputOutput** windows as inferiors.

InputOutput window

An **InputOutput** window is the normal kind of opaque window, used for both input and output. **InputOutput** windows can have both **InputOutput** and

InputOnly windows as inferiors.

Key grabbing

Keys on the keyboard can be passively grabbed by a client. When the key is pressed, the keyboard is then actively grabbed by the client.

Keyboard grabbing

A client can actively grab control of the keyboard, and key events will be sent to that client rather than the client the events would normally have been sent to.

Keysym

An encoding of a symbol on a keycap on a keyboard.

Mapped

A window is said to be mapped if a map call has been performed on it. Unmapped windows and their inferiors are never viewable or visible.

Modifier keys

Shift, Control, Meta, Super, Hyper, Alt, Compose, Apple, CapsLock, ShiftLock, and similar keys are called modifier keys.

Monochrome

Monochrome is a special case of **StaticGray** in which there are only two colormap entries.

Obscure

A window is obscured if some other window obscures it. Window A obscures window B if both are viewable **InputOutput** windows, A is higher in the global stacking order, and the rectangle defined by the outside edges of A intersects the rectangle defined by the outside edges of B. Note the distinction between obscure and occludes. Also note that window borders are included in the calculation and that a window can be obscured and yet still have visible regions.

Occlude

A window is occluded if some other window occludes it. Window A occludes window B if both are mapped, A is higher in the global stacking order, and the rectangle defined by the outside edges of A intersects the rectangle defined by the outside edges of B. Note the distinction between occludes and obscures. Also note that window borders are included in the calculation.

Padding

Some padding bytes are inserted in the data stream to maintain alignment of the protocol requests on natural boundaries. This increases ease of portability to some machine architectures.

Parent window

If C is a child of P, then P is the parent of C.

Passive grab

Grabbing a key or button is a passive grab. The grab activates when the key or button is actually pressed.

Pixel value

A pixel is an N-bit value, where N is the number of bit planes used in a particular window or pixmap (that is, N is the depth of the window or pixmap). For a window, a pixel value indexes a colormap to derive an actual color to be displayed.

Pixmap

A pixmap is a three-dimensional array of bits. A pixmap is normally thought of as a two-dimensional array of pixels, where each pixel can be a value from 0 to (2^N)-

1 and where N is the depth (z axis) of the pixmap. A pixmap can also be thought of as a stack of N bitmaps.

Plane

When a pixmap or window is thought of as a stack of bitmaps, each bitmap is called a plane or bit plane.

Plane mask

Graphics operations can be restricted to only affect a subset of bit planes of a destination. A plane mask is a bit mask describing which planes are to be modified. The plane mask is stored in a graphics context.

Pointer

The pointer is the pointing device attached to the cursor and tracked on the screens.

Pointer grabbing

A client can actively grab control of the pointer. Then button and motion events will be sent to that client rather than the client the events would normally have been sent to.

Pointing device

A pointing device is typically a mouse, tablet, or some other device with effective dimensional motion. There is only one visible cursor defined by the core protocol, and it tracks whatever pointing device is attached as the pointer.

Property

Windows may have associated properties, which consist of a name, a type, a data format, and some data. The protocol places no interpretation on properties. They are intended as a general-purpose naming mechanism for clients. For example, clients might use properties to share information such as resize hints, program names, and icon formats with a window manager.

Property list

The property list of a window is the list of properties that have been defined for the window.

PseudoColor

PseudoColor is a class of colormap in which a pixel value indexes the colormap to produce independent red, green, and blue values; that is, the colormap is viewed as an array of triples (RGB values). The RGB values can be changed dynamically.

Redirecting control

Window managers (or client programs) may want to enforce window layout policy in various ways. When a client attempts to change the size or position of a window, the operation may be redirected to a specified client rather than the operation actually being performed.

Reply

Information requested by a client program is sent back to the client with a reply. Both events and replies are multiplexed on the same connection. Most requests do not generate replies, although some requests generate multiple replies.

Request

A command to the server is called a request. It is a single block of data sent over a connection.

Resource

Windows, pixmaps, cursors, fonts, graphics contexts, and colormaps are known as resources. They all have unique identifiers associated with them for naming purposes. The lifetime of a resource usually is bounded by the lifetime of the connection over which the resource was created.

RGB values

Red, green, and blue (RGB) intensity values are used to define color. These values are always represented as 16-bit unsigned numbers, with 0 being the minimum intensity and 65535 being the maximum intensity. The server scales the values to match the display hardware.

Root

The root of a pixmap or graphics context is the same as the root of whatever drawable was used when the pixmap or graphics context was created. The root of a window is the root window under which the window was created.

Root window

Each screen has a root window covering it. It cannot be reconfigured or unmapped, but it otherwise acts as a full-fledged window. A root window has no parent.

Save set

The save set of a client is a list of other clients' windows that, if they are inferiors of one of the client's windows at connection close, should not be destroyed and that should be remapped if currently unmapped. Save sets are typically used by window managers to avoid lost windows if the manager terminates abnormally.

Scanline

A scanline is a list of pixel or bit values viewed as a horizontal row (all values having the same y coordinate) of an image, with the values ordered by increasing x coordinate.

Scanline order

An image represented in scanline order contains scanlines ordered by increasing y coordinate.

Screen

A server can provide several independent screens, which typically have physically independent monitors. This would be the expected configuration when there is only a single keyboard and pointer shared among the screens.

Selection

A selection can be thought of as an indirect property with dynamic type; that is, rather than having the property stored in the server, it is maintained by some client (the "owner"). A selection is global in nature and is thought of as belonging to the user (although maintained by clients), rather than as being private to a particular window subhierarchy or a particular set of clients. When a client asks for the contents of a selection, it specifies a selection "target type". This target type can be used to control the transmitted representation of the contents. For example, if the selection is "the last thing the user clicked on" and that is currently an image, then the target type might specify whether the contents of the image should be sent in XY format or Z format. The target type can also be used to control the class of contents transmitted; for example, asking for the "looks" (fonts, line spacing, indentation, and so on) of a paragraph selection rather than the text of the paragraph. The target type can also be used for other purposes. The protocol does not constrain the semantics.

Server

The server provides the basic windowing mechanism. It handles IPC connections from clients, demultiplexes graphics requests onto the screens, and multiplexes input back to the appropriate clients.

Server grabbing

The server can be grabbed by a single client for exclusive use. This prevents processing of any requests from other client connections until the grab is completed. This is typically only a transient state for such things as rubber-banding, pop-up menus, or to execute requests indivisibly.

Sibling

Children of the same parent window are known as sibling windows.

Stacking order

Sibling windows may stack on top of each other. Windows above other windows both obscure and occlude those lower windows. This is similar to paper on a desk. The relationship between sibling windows is known as the stacking order.

StaticColor

StaticColor can be viewed as a degenerate case of **PseudoColor** in which the RGB values are predefined and read-only.

StaticGray

StaticGray can be viewed as a degenerate case of **GrayScale** in which the gray values are predefined and read-only. The values are typically linear or near-linear increasing ramps.

Stipple

A stipple pattern is a bitmap that is used to tile a region that will serve as an additional clip mask for a fill operation with the foreground color.

Tile

A pixmap can be replicated in two dimensions to tile a region. The pixmap itself is also known as a tile.

Timestamp

A timestamp is a time value, expressed in milliseconds. It typically is the time since the last server reset. Timestamp values wrap around (after about 49.7 days). The server, given its current time is represented by timestamp T, always interprets timestamps from clients by treating half of the timestamp space as being earlier in time than T and half of the timestamp space as being later in time than T. One timestamp value (named **CurrentTime**) is never generated by the server. This value is reserved for use in requests to represent the current server time.

TrueColor

TrueColor can be viewed as a degenerate case of **DirectColor** in which the subfields in the pixel value directly encode the corresponding RGB values; that is, the colormap has predefined read-only RGB values. The values are typically linear or near-linear increasing ramps.

Type

A type is an arbitrary atom used to identify the interpretation of property data. Types are completely uninterpreted by the server and are solely for the benefit of clients.

Viewable

A window is viewable if it and all of its ancestors are mapped. This does not imply that any portion of the window is actually visible. Graphics requests can be performed on a window when it is not viewable, but output will not be retained unless the server is maintaining backing store.

Visible

A region of a window is visible if someone looking at the screen can actually see it; that is, the window is viewable and the region is not occluded by any other window.

Window gravity

When windows are resized, subwindows may be repositioned automatically relative to some position in the window. This attraction of a subwindow to some part of its parent is known as window gravity.

Window manager

Manipulation of windows on the screen and much of the user interface (policy) is typically provided by a window manager client.

XYFormat

The data for a pixmap is said to be in XY format if it is organized as a set of bitmaps representing individual bit planes, with the planes appearing from most-significant to least-significant in bit order.

ZFormat

The data for a pixmap is said to be in Z format if it is organized as a set of pixel values in scanline order.

2. Protocol Formats

Request Format

Every request contains an 8-bit major opcode and a 16-bit length field expressed in units of four bytes. Every request consists of four bytes of a header (containing the major opcode, the length field, and a data byte) followed by zero or more additional bytes of data. The length field defines the total length of the request, including the header. The length field in a request must equal the minimum length required to contain the request. If the specified length is smaller or larger than the required length, an error is generated. Unused bytes in a request are not required to be zero. Major opcodes 128 through 255 are reserved for extensions. Extensions are intended to contain multiple requests, so extension requests typically have an additional minor opcode encoded in the "spare" data byte in the request header. However, the placement and interpretation of this minor opcode and of all other fields in extension requests are not defined by the core protocol. Every request on a given connection is implicitly assigned a sequence number, starting with one, that is used in replies, errors, and events.

Reply Format

Every reply contains a 32-bit length field expressed in units of four bytes. Every reply consists of 32 bytes followed by zero or more additional bytes of data, as specified in the length field. Unused bytes within a reply are not guaranteed to be zero. Every reply also contains the least-significant 16 bits of the sequence number of the corresponding request.

Error Format

Error reports are 32 bytes long. Every error includes an 8-bit error code. Error codes 128 through 255 are reserved for extensions. Every error also includes the major and minor opcodes of the failed request and the least-significant 16 bits of the sequence number of the request. For the following errors (see section 5), the failing resource ID is also returned: **Colormap**, **Cursor**, **Drawable**, **Font**, **GContext**, **IDChoice**, **Pixmap**, and **Window**. For **Atom** errors, the failing atom is returned. For **Value** errors, the failing value is returned. Other core errors return no additional data. Unused bytes within an error are not guaranteed to be zero.

Event Format

Events are 32 bytes long. Unused bytes within an event are not guaranteed to be zero. Every event contains an 8-bit type code. The most-significant bit in this code is set if the event was generated from a **SendEvent** request. Event codes 64 through 127 are reserved for extensions, although the core protocol does not define a mechanism for selecting interest in such events. Every core event (with the exception of **KeymapNotify**) also contains the least-significant 16 bits of the sequence number of the last request issued by the client that was (or is currently being) processed by the server.

3. Syntactic Conventions

The rest of this document uses the following syntactic conventions.

- The syntax {...} encloses a set of alternatives.
- The syntax [...] encloses a set of structure components.
- In general, TYPEs are in uppercase and **AlternativeValues** are capitalized.
- Requests in section 10 are described in the following format:

RequestName

arg1: type1
...
argN: typeN

=>

result1: type1
...
resultM: typeM

Errors: kind1, ..., kindK

Description.

If no => is present in the description, then the request has no reply (it is asynchronous), although errors may still be reported. If =>+ is used, then one or more replies can be generated for a single request.

- Events in section 12 are described in the following format:

EventName

value1: type1
...
valueN: typeN

Description.

4. Common Types

LISTofFOO

A type name of the form LISTofFOO means a counted list of elements of type FOO. The size of the length field may vary (it is not necessarily the same size as a FOO), and in some cases, it may be implicit. It is fully specified in Appendix B. Except where explicitly noted, zero-length lists are legal.

BITMASK
LISTofVALUE

The types BITMASK and LISTofVALUE are somewhat special. Various requests contain arguments of the form:

value-mask: BITMASK
value-list: LISTofVALUE

These are used to allow the client to specify a subset of a heterogeneous collection of optional arguments. The value-mask specifies which arguments are to be provided; each such argument is assigned a unique bit position. The representation of the BITMASK will typically contain more bits than there are defined arguments. The unused bits in the value-mask must be zero (or the server generates a **Value** error). The value-list contains one value for each bit set to 1 in the mask, from least-significant to most-significant bit in the mask. Each value is represented with four bytes, but the actual value occupies only the least-significant bytes as required. The values of the unused bytes do not matter.

OR

A type of the form "T1 or ... or Tn" means the union of the indicated types. A single-element type is given as the element without enclosing braces.

WINDOW: 32-bit value (top three bits guaranteed to be zero)

PIXMAP: 32-bit value (top three bits guaranteed to be zero)

CURSOR: 32-bit value (top three bits guaranteed to be zero)

FONT: 32-bit value (top three bits guaranteed to be zero)

GCONTEXT: 32-bit value (top three bits guaranteed to be zero)

COLORMAP: 32-bit value (top three bits guaranteed to be zero)

DRAWABLE: WINDOW or PIXMAP

FONTABLE: FONT or GCONTEXT

ATOM: 32-bit value (top three bits guaranteed to be zero)

VISUALID: 32-bit value (top three bits guaranteed to be zero)

VALUE: 32-bit quantity (used only in LISTofVALUE)

BYTE: 8-bit value

INT8: 8-bit signed integer

INT16: 16-bit signed integer

INT32: 32-bit signed integer

CARD8: 8-bit unsigned integer

CARD16: 16-bit unsigned integer

CARD32: 32-bit unsigned integer

TIMESTAMP: CARD32

BITGRAVITY: {**Forget**, **Static**, **NorthWest**, **North**, **NorthEast**, **West**, **Center**, **East**,
SouthWest, **South**, **SouthEast**}

WINGRAVITY: {**Unmap**, **Static**, **NorthWest**, **North**, **NorthEast**, **West**, **Center**, **East**,
SouthWest, **South**, **SouthEast**}

BOOL: {**True**, **False**}

EVENT: {**KeyPress**, **KeyRelease**, **OwnerGrabButton**, **ButtonPress**, **ButtonRelease**, **EnterWindow**, **LeaveWindow**, **PointerMotion**, **PointerMotionHint**, **Button1Motion**, **Button2Motion**, **Button3Motion**, **Button4Motion**, **Button5Motion**, **ButtonMotion**, **Exposure**, **VisibilityChange**, **StructureNotify**, **ResizeRedirect**, **SubstructureNotify**, **SubstructureRedirect**, **FocusChange**, **PropertyChange**, **ColormapChange**, **KeymapState**}

POINTEREVENT: {**ButtonPress**, **ButtonRelease**, **EnterWindow**, **LeaveWindow**, **PointerMotion**, **PointerMotionHint**, **Button1Motion**, **Button2Motion**, **Button3Motion**, **Button4Motion**, **Button5Motion**, **ButtonMotion**, **KeymapState**}

DEVICEEVENT: {**KeyPress**, **KeyRelease**, **ButtonPress**, **ButtonRelease**, **PointerMotion**, **Button1Motion**, **Button2Motion**, **Button3Motion**, **Button4Motion**, **Button5Motion**, **ButtonMotion**}

KEYSYM: 32-bit value (top three bits guaranteed to be zero)

KEYCODE: CARD8

BUTTON: CARD8

KEYMASK: {**Shift**, **Lock**, **Control**, **Mod1**, **Mod2**, **Mod3**, **Mod4**, **Mod5**}

BUTMASK: {**Button1**, **Button2**, **Button3**, **Button4**, **Button5**}

KEYBUTMASK: KEYMASK or BUTMASK

STRING8: LISTofCARD8

STRING16: LISTofCHAR2B

CHAR2B: [byte1, byte2: CARD8]

POINT: [x, y: INT16]

RECTANGLE: [x, y: INT16,
width, height: CARD16]

ARC: [x, y: INT16,
width, height: CARD16,
angle1, angle2: INT16]

HOST: [family: {**Internet**, **DECnet**, **Chaos**}
address: LISTofBYTE]

The [x,y] coordinates of a RECTANGLE specify the upper-left corner.

The primary interpretation of large characters in a STRING16 is that they are composed of two bytes used to index a 2-D matrix; hence, the use of CHAR2B rather than CARD16. This corresponds to the JIS/ISO method of indexing 2-byte characters. It is expected that most large fonts will be defined with 2-byte matrix indexing. For large fonts constructed with linear indexing, a CHAR2B can be interpreted as a 16-bit number by treating byte1 as the most-significant byte. This means that clients should always transmit such 16-bit character values most-significant byte first, as the server will never byte-swap CHAR2B quantities.

The length, format, and interpretation of a HOST address are specific to the family (see **ChangeHosts** request).

5. Errors

In general, when a request terminates with an error, the request has no side effects (that is, there is no partial execution). The only requests for which this is not true are **ChangeWindowAttributes**, **ChangeGC**, **PolyText8**, **PolyText16**, **FreeColors**, **StoreColors**, and **ChangeKeyboardControl**.

The following error codes result from various requests as follows:

Error	Description
Access	An attempt is made to grab a key/button combination already grabbed by another client. An attempt is made to free a colormap entry not allocated by the client. An attempt is made to store into a read-only or an unallocated colormap entry. An attempt is made to modify the access control list from other than the local host (or otherwise authorized client). An attempt is made to select an event type that only one client can select at a time when another client has already selected it.
Alloc	The server failed to allocate the requested resource. Note that the explicit listing of **Alloc** errors in request only covers allocation errors at a very coarse level and is not intended to cover all cases of a server running out of allocation space in the middle of service. The semantics when a server runs out of allocation space are left unspecified, but a server may generate an **Alloc** error on any request for this reason, and clients should be prepared to receive such errors and handle or discard them.
Atom	A value for an ATOM argument does not name a defined ATOM.
Colormap	A value for a COLORMAP argument does not name a defined COLORMAP.
Cursor	A value for a CURSOR argument does not name a defined CURSOR.
Drawable	A value for a DRAWABLE argument does not name a defined WINDOW or PIXMAP.
Font	A value for a FONT argument does not name a defined FONT. A value for a FONTABLE argument does not name a defined FONT or a defined GCONTEXT.
GContext	A value for a GCONTEXT argument does not name a defined GCONTEXT.

Error	Description
IDChoice	The value chosen for a resource identifier either is not included in the range assigned to the client or is already in use.
Implementation	The server does not implement some aspect of the request. A server that generates this error for a core request is deficient. As such, this error is not listed for any of the requests, but clients should be prepared to receive such errors and handle or discard them.
Length	The length of a request is shorter or longer than that required to minimally contain the arguments. The length of a request exceeds the maximum length accepted by the server.
Match	An **InputOnly** window is used as a DRAWABLE. In a graphics request, the GCONTEXT argument does not have the same root and depth as the destination DRAWABLE argument. Some argument (or pair of arguments) has the correct type and range, but it fails to match in some other way required by the request.
Name	A font or color of the specified name does not exist.
Pixmap	A value for a PIXMAP argument does not name a defined PIXMAP.
Request	The major or minor opcode does not specify a valid request.
Value	Some numeric value falls outside the range of values accepted by the request. Unless a specific range is specified for an argument, the full range defined by the argument's type is accepted. Any argument defined as a set of alternatives typically can generate this error (due to the encoding).
Window	A value for a WINDOW argument does not name a defined WINDOW.

Note

The **Atom**, **Colormap**, **Cursor**, **Drawable**, **Font**, **GContext**, **Pixmap**, and **Window** errors are also used when the argument type is extended by union with a set of fixed alternatives, for example, <WINDOW or **PointerRoot** or **None**>.

6. Keyboards

A KEYCODE represents a physical (or logical) key. Keycodes lie in the inclusive range [8,255]. A keycode value carries no intrinsic information, although server implementors may attempt to encode geometry information (for example, matrix) to be interpreted in a server-dependent fashion. The mapping between keys and keycodes cannot be changed using the protocol.

A KEYSYM is an encoding of a symbol on the cap of a key. The set of defined KEYSYMs include the character sets Latin 1, Latin 2, Latin 3, Latin 4, Kana, Arabic, Cryllic, Greek, Tech, Special, Publish, APL, and Hebrew as well as a set of symbols common on keyboards (Return, Help, Tab, and so on). KEYSYMs with the most-significant bit (of the 29 bits) set are reserved as vendor-specific.

A list of KEYSYMs is associated with each KEYCODE, and the length of the list can vary with each KEYCODE. The list is intended to convey the set of symbols on the corresponding key. By convention, if the list contains a single KEYSYM and that KEYSYM is alphabetic and case distinction is relevant for it, then it should be treated as equivalent to a two-element list of the lowercase and uppercase KEYSYMs. For example, if the list contains the single KEYSYM for uppercase *A*, then the client should treat it as if it were instead a pair with lowercase *a* as the first KEYSYM and uppercase *A* as the second KEYSYM.

For any KEYCODE, the first KEYSYM in the list normally should be chosen as the interpretation of a **KeyPress** when no modifier keys are down. The second KEYSYM in the list normally should be chosen when the Shift modifier is on or when the Lock modifier is on and Lock is interpreted as ShiftLock. When the Lock modifier is on and is interpreted as CapsLock, it is suggested that the Shift modifier first be applied to choose a KEYSYM. However, if that KEYSYM is lowercase alphabetic, the corresponding uppercase KEYSYM should be used instead. Other interpretations of CapsLock are possible. For example, it may be viewed as equivalent to ShiftLock, applying only when the first KEYSYM is lowercase alphabetic and the second KEYSYM is the corresponding uppercase alphabetic. No interpretation of KEYSYMs beyond the first two in a list is suggested here. No spatial geometry of the symbols on the key is defined by their order in the KEYSYM list, although a geometry might be defined on a vendor-specific basis.

The mapping between KEYCODEs and KEYSYMs is not used directly by the server; it is merely stored for reading and writing by clients.

The KEYMASK modifier named Lock is intended to be mapped to either a CapsLock or a ShiftLock key, but which one is left as application-specific and/or user-specific. However, it is suggested that the determination be made according to the associated KEYSYM(s) of the corresponding KEYCODE.

7. Pointers

Buttons are always numbered starting with one.

8. Predefined Atoms

Predefined atoms are not strictly necessary and may not be useful in all environments, but they will eliminate many **InternAtom** requests in most applications. Note that they are predefined only in the sense of having numeric values, not in the sense of having required semantics. The core protocol imposes no semantics on these names, except as they are used in FONTPROP structures (see **QueryFont** request).

The following names have predefined atom values. Note that uppercase and lowercase matter.

ARC	ITALIC_ANGLE	STRING
ATOM	MAX_SPACE	SUBSCRIPT_X
BITMAP	MIN_SPACE	SUBSCRIPT_Y
CAP_HEIGHT	NORM_SPACE	SUPERSCRIPT_X
CARDINAL	NOTICE	SUPERSCRIPT_Y
COLORMAP	PIXMAP	UNDERLINE_POSITION
COPYRIGHT	POINT	UNDERLINE_THICKNESS
CURSOR	POINT_SIZE	VISUALID
CUT_BUFFER0	PRIMARY	WEIGHT
CUT_BUFFER1	QUAD_WIDTH	WINDOW
CUT_BUFFER2	RECTANGLE	WM_CLASS

CUT_BUFFER3	RESOLUTION	WM_CLIENT_MACHINE
CUT_BUFFER4	RESOURCE_MANAGER	WM_COMMAND
CUT_BUFFER5	RGB_BEST_MAP	WM_HINTS
CUT_BUFFER6	RGB_BLUE_MAP	WM_ICON_NAME
CUT_BUFFER7	RGB_COLOR_MAP	WM_ICON_SIZE
DRAWABLE	RGB_DEFAULT_MAP	WM_NAME
END_SPACE	RGB_GRAY_MAP	WM_NORMAL_HINTS
FAMILY_NAME	RGB_GREEN_MAP	WM_SIZE_HINTS
FONT	RGB_RED_MAP	WM_TRANSIENT_FOR
FONT_NAME	SECONDARY	WM_ZOOM_HINTS
FULL_NAME	STRIKEOUT_ASCENT	X_HEIGHT
INTEGER		STRIKEOUT_DESCENT

To avoid conflicts with possible future names for which semantics might be imposed (either at the protocol level or in terms of higher level user interface models), names beginning with an underscore should be used for atoms that are private to a particular vendor or organization. To guarantee no conflicts between vendors and organizations, additional prefixes need to be used. However, the protocol does not define the mechanism for choosing such prefixes. For names private to a single application or end user but stored in globally accessible locations, it is suggested that two leading underscores be used to avoid conflicts with other names.

9. Connection Setup

For remote clients, the X protocol can be built on top of any reliable byte stream.

The client must send an initial byte of data to identify the byte order to be employed. The value of the byte must be octal 102 or 154. The value 102 (ASCII uppercase B) means values are transmitted most-significant byte first, and value 154 (ASCII lowercase l) means values are transmitted least-significant byte first. Except where explicitly noted in the protocol, all 16-bit and 32-bit quantities sent by the client must be transmitted with this byte order, and all 16-bit and 32-bit quantities returned by the server will be transmitted with this byte order.

Following the byte-order byte, the client sends the following information at connection setup:

> protocol-major-version: CARD16
> protocol-minor-version: CARD16
> authorization-protocol-name: STRING8
> authorization-protocol-data: STRING8
>
> The version numbers indicate what version of the protocol the client expects the server to implement.
>
> The authorization name indicates what authorization protocol the client expects the server to use, and the data is specific to that protocol. Specification of valid authorization mechanisms is not part of the core X protocol. It is hoped that eventually one authorization protocol will be agreed upon. In the meantime, a server that implements a different protocol than the client expects or that only implements the host-based mechanism may simply ignore this information. If both name and data strings are empty, this is to be interpreted as "no explicit authorization."

The client receives the following information at connection setup:

> success: BOOL
> protocol-major-version: CARD16
> protocol-minor-version: CARD16
> length: CARD16

Length is the amount of additional data to follow, in units of four bytes. The version numbers are an escape hatch in case future revisions of the protocol are necessary. In general, the major version would increment for incompatible changes, and the minor version would increment for small upward compatible changes. Barring changes, the major version will be 11, and the minor version will be 0. The protocol version numbers returned indicate the protocol the server actually supports. This might not equal the version sent by the client. The server can (but need not) refuse connections from clients that offer a different version than the server supports. A server can (but need not) support more than one version simultaneously.

The client receives the following additional data if authorization fails:

reason: STRING8

The client receives the following additional data if authorization is accepted:

vendor: STRING8
release-number: CARD32
resource-id-base, resource-id-mask: CARD32
image-byte-order: {**LSBFirst**, **MSBFirst**}
bitmap-scanline-unit: {8, 16, 32}
bitmap-scanline-pad: {8, 16, 32}
bitmap-bit-order: {**LeastSignificant**, **MostSignificant**}
pixmap-formats: LISTofFORMAT
roots: LISTofSCREEN
motion-buffer-size: CARD32
maximum-request-length: CARD16
min-keycode, max-keycode: KEYCODE

where:

FORMAT:	[depth: CARD8, bits-per-pixel: {1, 4, 8, 16, 24, 32} scanline-pad: {8, 16, 32}]
SCREEN:	[root: WINDOW width-in-pixels, height-in-pixels: CARD16 width-in-millimeters, height-in-millimeters: CARD16 allowed-depths: LISTofDEPTH root-depth: CARD8 root-visual: VISUALID default-colormap: COLORMAP white-pixel, black-pixel: CARD32 min-installed-maps, max-installed-maps: CARD16 backing-stores: {**Never**, **WhenMapped**, **Always**} save-unders: BOOL current-input-masks: SETofEVENT]
DEPTH:	[depth: CARD8 visuals: LISTofVISUALTYPE]
VISUALTYPE:	[visual-id: VISUALID class: {**StaticGray**, **StaticColor**, **TrueColor**, **GrayScale**, **PseudoColor**, **DirectColor**} red-mask, green-mask, blue-mask: CARD32 bits-per-rgb-value: CARD8 colormap-entries: CARD16]

The information that is global to the server is:

The vendor string gives some identification of the owner of the server implementation. The vendor controls the semantics of the release number.

The resource-id-mask contains a single contiguous set of bits (at least 18). The client allocates resource IDs for types WINDOW, PIXMAP, CURSOR, FONT, GCONTEXT, and COLORMAP by choosing a value with only some subset of these bits set and ORing it with resource-id-base. Only values constructed in this way can be used to name newly created resources over this connection. Resource IDs never have the top three bits set. The client is not restricted to linear or contiguous allocation of resource IDs. Once an ID has been freed, it can be reused, but this should not be necessary. An ID must be unique with respect to the IDs of all other resources, not just other resources of the same type. However, note that the value spaces of resource identifiers, atoms, visualids, and keysyms are distinguished by context, and as such, are not required to be disjoint; for example, a given numeric value might be both a valid window ID, a valid atom, and a valid keysym.

Although the server is in general responsible for byte-swapping data to match the client, images are always transmitted and received in formats (including byte order) specified by the server. The byte order for images is given by image-byte-order and applies to each scanline unit in XY format (bitmap format) and to each pixel value in Z format.

A bitmap is represented in scanline order. Each scanline is padded to a multiple of bits as given by bitmap-scanline-pad. The pad bits are of arbitrary value. The scanline is quantized in multiples of bits as given by bitmap-scanline-unit. The bitmap-scanline-unit is always less than or equal to the bitmap-scanline-pad. Within each unit, the leftmost bit in the bitmap is either the least-significant or most-significant bit in the unit, as given by bitmap-bit-order. If a pixmap is represented in XY format, each plane is represented as a bitmap, and the planes appear from most-significant to least-significant in bit order with no padding between planes.

Pixmap-formats contains one entry for each depth value. The entry describes the Z format used to represent images of that depth. An entry for a depth is included if any screen supports that depth, and all screens supporting that depth must support only that Z format for that depth. In Z format, the pixels are in scanline order, left to right within a scanline. The number of bits used to hold each pixel is given by bits-per-pixel. Bits-per-pixel may be larger than strictly required by the depth, in which case the least-significant bits are used to hold the pixmap data, and the values of the unused high-order bits are undefined. When the bits-per-pixel is 4, the order of nibbles in the byte is the same as the image byte-order. When the bits-per-pixel is 1, the format is identical for bitmap format. Each scanline is padded to a multiple of bits as given by scanline-pad. When bits-per-pixel is 1, this will be identical to bitmap-scanline-pad.

How a pointing device roams the screens is up to the server implementation and is transparent to the protocol. No geometry is defined among screens.

The server may retain the recent history of pointer motion and do so to a finer granularity than is reported by **MotionNotify** events. The **GetMotionEvents** request makes such history available. The motion-buffer-size gives the approximate size of the history buffer.

Maximum-request-length specifies the maximum length of a request accepted by the server, in 4-byte units. That is, length is the maximum value that can appear in the length field of a request. Requests larger than this maximum generate a **Length** error, and the server will read and simply discard the entire request. Maximum-request-length will always be at least 4096 (that is, requests of length up to and including 16384 bytes will be accepted by all servers).

Min-keycode and max-keycode specify the smallest and largest keycode values transmitted by the server. Min-keycode is never less than 8, and max-keycode is never greater than 255. Not all keycodes in this range are required to have corresponding keys.

The information that applies per screen is:

The allowed-depths specifies what pixmap and window depths are supported. Pixmaps are supported for each depth listed, and windows of that depth are supported if at least one visual type is listed for the depth. A pixmap depth of one is always supported and listed, but windows of depth one might not be supported. A depth of zero is never listed, but zero-depth **InputOnly** windows are always supported.

Root-depth and root-visual specify the depth and visual type of the root window. Width-in-pixels and height-in-pixels specify the size of the root window (which cannot be changed). The class of the root window is always **InputOutput**. Width-in-millimeters and height-in-millimeters can be used to determine the physical size and the aspect ratio.

The default-colormap is the one initially associated with the root window. Clients with minimal color requirements creating windows of the same depth as the root may want to allocate from this map by default.

Black-pixel and white-pixel can be used in implementing a monochrome application. These pixel values are for permanently allocated entries in the default-colormap. The actual RGB values may be settable on some screens and, in any case, may not actually be black and white. The names are intended to convey the expected relative intensity of the colors.

The border of the root window is initially a pixmap filled with the black-pixel. The initial background of the root window is a pixmap filled with some unspecified two-color pattern using black-pixel and white-pixel.

Min-installed-maps specifies the number of maps that can be guaranteed to be installed simultaneously (with **InstallColormap**), regardless of the number of entries allocated in each map. Max-installed-maps specifies the maximum number of maps that might possibly be installed simultaneously, depending on their allocations. Multiple static-visual colormaps with identical contents but differing in resource ID should be considered as a single map for the purposes of this number. For the typical case of a single hardware colormap, both values will be 1.

Backing-stores indicates when the server supports backing stores for this screen, although it may be storage limited in the number of windows it can support at once. If save-unders is **True**, the server can support the save-under mode in **CreateWindow** and **ChangeWindowAttributes**, although again it may be storage limited.

The current-input-events is what **GetWindowAttributes** would return for the all-event-masks for the root window.

The information that applies per visual-type is:

A given visual type might be listed for more than one depth or for more than one screen.

For **PseudoColor**, a pixel value indexes a colormap to produce independent RGB values; the RGB values can be changed dynamically. **GrayScale** is treated in the same way as **PseudoColor** except which primary drives the screen is undefined; thus, the client should always store the same value for red, green, and blue in colormaps. For **DirectColor**, a pixel value is decomposed into separate RGB subfields, and each subfield separately indexes the colormap for the corresponding value. The RGB values can be changed dynamically. **TrueColor** is treated in the same way as **DirectColor** except the colormap has predefined read-only RGB values. These values are server-dependent but provide linear or near-linear increasing ramps in each primary. **StaticColor** is treated in the same way as **PseudoColor** except the colormap has predefined read-only RGB values, which are server-dependent. **StaticGray** is treated in the same way as **StaticColor** except the red, green, and blue values are equal for any single pixel value, resulting in shades of gray. **StaticGray** with a two-entry colormap can be thought of as monochrome.

The red-mask, green-mask, and blue-mask are only defined for **DirectColor** and **TrueColor**. Each has one contiguous set of bits set to 1 with no intersections. Usually each mask has the same number of bits set to 1.

The bits-per-rgb-value specifies the log base 2 of the number of distinct color intensity values (individually) of red, green, and blue. This number need not bear any relation to the number of colormap entries. Actual RGB values are always passed in the protocol within a 16-bit spectrum, with 0 being minimum intensity and 65535 being the maximum intensity. On hardware that provides a linear zero-based intensity ramp, the following relationship exists:

hw-intensity = protocol-intensity / (65536 / total-hw-intensities)

Colormap entries are indexed from 0. The colormap-entries defines the number of available colormap entries in a newly created colormap. For **DirectColor** and **TrueColor**, this will usually be 2 to the power of the maximum number of bits set to 1 in red-mask, green-mask, and blue-mask.

10. Requests

CreateWindow

wid, parent: WINDOW
class: {**InputOutput**, **InputOnly**, **CopyFromParent**}
depth: CARD8
visual: VISUALID or **CopyFromParent**
x, y: INT16
width, height, border-width: CARD16
value-mask: BITMASK
value-list: LISTofVALUE

Errors: **IDChoice**, **Window**, **Pixmap**, **Colormap**, **Cursor**, **Match**, **Value**, **Alloc**

This request creates an unmapped window and assigns the identifier wid to it.

A class of **CopyFromParent** means the class is taken from the parent. A depth of zero for class **InputOutput** or **CopyFromParent** means the depth is taken from the parent. A visual of **CopyFromParent** means the visual type is taken from the parent. For class **InputOutput**, the visual type and depth must be a combination supported for the screen (or a **Match** error results). The depth need not be the same as the parent, but the parent must not be of class **InputOnly** (or a **Match** error results). For class **InputOnly**, the depth must be zero (or a **Match** error results), and the visual must be one supported for the screen (or a **Match** error results). However, the parent can have any depth and class.

The server essentially acts as if **InputOnly** windows do not exist for the purposes of graphics requests, exposure processing, and **VisibilityNotify** events. An **InputOnly** window cannot be used as a drawable (as a source or destination for graphics requests). **InputOnly** and **InputOutput** windows act identically in other respects–properties, grabs, input control, and so on.

The window is placed on top in the stacking order with respect to siblings. The x and y coordinates are relative to the parent's origin and specify the position of the upper-left outer corner of the window (not the origin). The width and height specify the inside size (not including the border) and must be nonzero (or a **Value** error results). The border-width for an **InputOnly** window must be zero (or a **Match** error results).

The value-mask and value-list specify attributes of the window that are to be explicitly initialized. The possible values are:

Attribute	Type
background-pixmap	PIXMAP or **None** or **ParentRelative**
background-pixel	CARD32
border-pixmap	PIXMAP or **CopyFromParent**
border-pixel	CARD32
bit-gravity	BITGRAVITY
win-gravity	WINGRAVITY
backing-store	{**NotUseful**, **WhenMapped**, **Always**}
backing-planes	CARD32
backing-pixel	CARD32
save-under	BOOL
event-mask	SETofEVENT
do-not-propagate-mask	SETofDEVICEEVENT
override-redirect	BOOL
colormap	COLORMAP or **CopyFromParent**
cursor	CURSOR or **None**

The default values when attributes are not explicitly initialized are:

Attribute	Default
background-pixmap	**None**
border-pixmap	**CopyFromParent**
bit-gravity	**Forget**
win-gravity	**NorthWest**
backing-store	**NotUseful**
backing-planes	all ones
backing-pixel	zero
save-under	**False**
event-mask	{} (empty set)
do-not-propagate-mask	{} (empty set)
override-redirect	**False**
colormap	**CopyFromParent**
cursor	**None**

Only the following attributes are defined for **InputOnly** windows:

- win-gravity
- event-mask
- do-not-propagate-mask

- override-redirect
- cursor

It is a **Match** error to specify any other attributes for **InputOnly** windows.

If background-pixmap is given, it overrides the default background-pixmap. The background pixmap and the window must have the same root and the same depth (or a **Match** error results). Any size pixmap can be used, although some sizes may be faster than others. If background **None** is specified, the window has no defined background. If background **ParentRelative** is specified, the parent's background is used, but the window must have the same depth as the parent (or a **Match** error results). If the parent has background **None**, then the window will also have background **None**. A copy of the parent's background is not made. The parent's background is reexamined each time the window background is required. If background-pixel is given, it overrides the default background-pixmap and any background-pixmap given explicitly, and a pixmap of undefined size filled with background-pixel is used for the background. Range checking is not performed on the background-pixel value; it is simply truncated to the appropriate number of bits. For a **ParentRelative** background, the background tile origin always aligns with the parent's background tile origin. Otherwise, the background tile origin is always the window origin.

When no valid contents are available for regions of a window and the regions are either visible or the server is maintaining backing store, the server automatically tiles the regions with the window's background unless the window has a background of **None**. If the background is **None**, the previous screen contents from other windows of the same depth as the window are simply left in place if the contents come from the parent of the window or an inferior of the parent; otherwise, the initial contents of the exposed regions are undefined. Exposure events are then generated for the regions, even if the background is **None**.

The border tile origin is always the same as the background tile origin. If border-pixmap is given, it overrides the default border-pixmap. The border pixmap and the window must have the same root and the same depth (or a **Match** error results). Any size pixmap can be used, although some sizes may be faster than others. If **CopyFromParent** is given, the parent's border pixmap is copied (subsequent changes to the parent's border attribute do not affect the child), but the window must have the same depth as the parent (or a **Match** error results). The pixmap might be copied by sharing the same pixmap object between the child and parent or by making a complete copy of the pixmap contents. If border-pixel is given, it overrides the default border-pixmap and any border-pixmap given explicitly, and a pixmap of undefined size filled with border-pixel is used for the border. Range checking is not performed on the border-pixel value; it is simply truncated to the appropriate number of bits.

Output to a window is always clipped to the inside of the window, so that the border is never affected.

The bit-gravity defines which region of the window should be retained if the window is resized, and win-gravity defines how the window should be repositioned if the parent is resized (see **ConfigureWindow** request).

A backing-store of **WhenMapped** advises the server that maintaining contents of obscured regions when the window is mapped would be beneficial. A backing-store of **Always** advises the server that maintaining contents even when the window is unmapped would be beneficial. In this case, the server may generate an exposure event when the window is created. A value of **NotUseful** advises the server that maintaining contents is unnecessary, although a server may still choose to maintain contents while the window is mapped. Note that if the server maintains contents, then the server should maintain complete contents not just the region within the parent boundaries, even if the window is larger than its parent. While the server maintains contents, exposure events will not normally be generated, but the server may stop maintaining contents at any time.

If save-under is **True**, the server is advised that when this window is mapped, saving the contents of windows it obscures would be beneficial.

When the contents of obscured regions of a window are being maintained, regions obscured by noninferior windows are included in the destination (and source, when the window is the source) of graphics requests, but regions obscured by inferior windows are not included.

The backing-planes indicates (with bits set to 1) which bit planes of the window hold dynamic data that must be preserved in backing-stores and during save-unders. The backing-pixel specifies what value to use in planes not covered by backing-planes. The server is free to save only the specified bit planes in the backing-store or save-under and regenerate the remaining planes with the specified pixel value. Any bits beyond the specified depth of the window in these values are simply ignored.

The event-mask defines which events the client is interested in for this window (or for some event types, inferiors of the window). The do-not-propagate-mask defines which events should not be propagated to ancestor windows when no client has the event type selected in this window.

The override-redirect specifies whether map and configure requests on this window should override a **SubstructureRedirect** on the parent, typically to inform a window manager not to tamper with the window.

The colormap specifies the colormap that best reflects the true colors of the window. Servers capable of supporting multiple hardware colormaps may use this information, and window managers may use it for **InstallColormap** requests. The colormap must have the same visual type as the window (or a **Match** error results). If **CopyFromParent** is specified, the parent's colormap is copied (subsequent changes to the parent's colormap attribute do not affect the child). However, the window must have the same visual type as the parent (or a **Match** error results), and the parent must not have a colormap of **None** (or a **Match** error results). For an explanation of **None**, see **FreeColormap** request. The colormap is copied by sharing the colormap object between the child and the parent, not by making a complete copy of the colormap contents.

If a cursor is specified, it will be used whenever the pointer is in the window. If **None** is specified, the parent's cursor will be used when the pointer is in the window, and any change in the parent's cursor will cause an immediate change in the displayed cursor.

This request generates a **CreateNotify** event.

The background and border pixmaps and the cursor may be freed immediately if no further explicit references to them are to be made.

Subsequent drawing into the background or border pixmap has an undefined effect on the window state. The server might or might not make a copy of the pixmap.

ChangeWindowAttributes

window: WINDOW
value-mask: BITMASK
value-list: LISTofVALUE

Errors: **Window**, **Pixmap**, **Colormap**, **Cursor**, **Match**, **Value**, **Access**

The value-mask and value-list specify which attributes are to be changed. The values and restrictions are the same as for **CreateWindow**.

Setting a new background, whether by background-pixmap or background-pixel, overrides any previous background. Setting a new border, whether by border-pixel or border-pixmap, overrides any previous border.

Changing the background does not cause the window contents to be changed. Setting the border or changing the background such that the border tile origin changes causes the border to be repainted. Changing the background of a root window to **None** or **ParentRelative** restores the default background pixmap. Changing the border of a root window to **CopyFromParent** restores the default border pixmap.

Changing the win-gravity does not affect the current position of the window.

Changing the backing-store of an obscured window to **WhenMapped** or **Always** or changing the backing-planes, backing-pixel, or save-under of a mapped window may have no immediate effect.

Multiple clients can select input on the same window; their event-masks are disjoint. When an event is generated, it will be reported to all interested clients. However, only one client at a time can select for **SubstructureRedirect**, only one client at a time can select for **ResizeRedirect**, and only one client at a time can select for **ButtonPress**. An attempt to violate these restrictions results in an **Access** error.

There is only one do-not-propagate-mask for a window, not one per client.

Changing the colormap of a window (by defining a new map, not by changing the contents of the existing map) generates a **ColormapNotify** event. Changing the colormap of a visible window might have no immediate effect on the screen (see **InstallColormap** request).

Changing the cursor of a root window to **None** restores the default cursor.

The order in which attributes are verified and altered is server-dependent. If an error is generated, a subset of the attributes may have been altered.

GetWindowAttributes

window: WINDOW

=>

visual. VISUALID
class: {**InputOutput**, **InputOnly**}
bit-gravity: BITGRAVITY
win-gravity: WINGRAVITY
backing-store: {**NotUseful**, **WhenMapped**, **Always**}
backing-planes: CARD32
backing-pixel: CARD32
save-under: BOOL
colormap: COLORMAP or **None**
map-is-installed: BOOL
map-state: {**Unmapped**, **Unviewable**, **Viewable**}
all-event-masks, your-event-mask: SETofEVENT
do-not-propagate-mask: SETofDEVICEEVENT
override-redirect: BOOL

Errors: **Window**

This request returns the current attributes of the window. A window is **Unviewable** if it is mapped but some ancestor is unmapped. All-event-masks is the inclusive-OR of all event masks selected on the window by clients. Your-event-mask is the event mask selected by the querying client.

DestroyWindow

window: WINDOW

Errors: **Window**

If the argument window is mapped, an **UnmapWindow** request is performed automatically. The window and all inferiors are then destroyed, and a **DestroyNotify** event is generated for each window. The ordering of the **DestroyNotify** events is such that for any given window, **DestroyNotify** is generated on all inferiors of the window before being generated on the window itself. The ordering among siblings and across subhierarchies is not otherwise constrained.

Normal exposure processing on formerly obscured windows is performed.

If the window is a root window, this request has no effect.

DestroySubwindows

window: WINDOW

Errors: **Window**

This request performs a **DestroyWindow** request on all children of the window, in bottom-to-top stacking order.

ChangeSaveSet

window: WINDOW
mode: {**Insert**, **Delete**}

Errors: **Window**, **Match**, **Value**

This request adds or removes the specified window from the client's save-set. The window must have been created by some other client (or a **Match** error results). For further information about the use of the save-set, see section 11.

When windows are destroyed, the server automatically removes them from the save-set.

ReparentWindow

window, *parent*: WINDOW
x, *y*: INT16

Errors: **Window**, **Match**

If the window is mapped, an **UnmapWindow** request is performed automatically first. The window is then removed from its current position in the hierarchy and is inserted as a child of the specified parent. The x and y coordinates are relative to the parent's origin and specify the new position of the upper-left outer corner of the window. The window is placed on top in the stacking order with respect to siblings. A **ReparentNotify** event is then generated. The override-redirect attribute of the window is passed on in this event; a value of **True** indicates that a window manager should not tamper with this window. Finally, if the window was originally mapped, a **MapWindow** request is performed automatically.

Normal exposure processing on formerly obscured windows is performed. The server might not generate exposure events for regions from the initial unmap that are immediately obscured by the final map.

A **Match** error is generated if:

- The new parent is not on the same screen as the old parent.
- The new parent is the window itself or an inferior of the window.
- The window has a **ParentRelative** background, and the new parent is not the same depth as the window.

MapWindow

window: WINDOW

Errors: **Window**

If the window is already mapped, this request has no effect.

If the override-redirect attribute of the window is **False** and some other client has selected **SubstructureRedirect** on the parent, then a **MapRequest** event is generated, but the window remains unmapped. Otherwise, the window is mapped, and a **MapNotify** event is generated.

If the window is now viewable and its contents have been discarded, the window is tiled with its background (if no background is defined, the existing screen contents are not altered), and zero or more exposure events are generated. If a backing-store has been maintained while the window was unmapped, no exposure events are generated. If a backing-store will now be maintained, a full-window exposure is always generated. Otherwise, only visible regions may be reported. Similar tiling and exposure take place for any newly viewable inferiors.

MapSubwindows

window: WINDOW

Errors: **Window**

This request performs a **MapWindow** request on all unmapped children of the window, in top-to-bottom stacking order.

UnmapWindow

window: WINDOW

Errors: **Window**

If the window is already unmapped, this request has no effect. Otherwise, the window is unmapped, and an **UnmapNotify** event is generated. Normal exposure processing on formerly obscured windows is performed.

UnmapSubwindows

window: WINDOW

Errors: **Window**

This request performs an **UnmapWindow** request on all mapped children of the window, in bottom-to-top stacking order.

ConfigureWindow

window: WINDOW
value-mask: BITMASK
value-list: LISTofVALUE

Errors: **Window**, **Match**, **Value**

This request changes the configuration of the window. The value-mask and value-list specify which values are to be given. The possible values are:

Attribute	Type
x	INT16
y	INT16
width	CARD16
height	CARD16
border-width	CARD16
sibling	WINDOW

Attribute	Type
stack-mode	{**Above**, **Below**, **TopIf**, **BottomIf**, **Opposite**}

The x and y coordinates are relative to the parent's origin and specify the position of the upper-left outer corner of the window. The width and height specify the inside size, not including the border, and must be nonzero (or a **Value** error results). Those values not specified are taken from the existing geometry of the window. Note that changing just the border-width leaves the outer-left corner of the window in a fixed position but moves the absolute position of the window's origin. It is a **Match** error to attempt to make the border-width of an **InputOnly** window nonzero.

If the override-redirect attribute of the window is **False** and some other client has selected **SubstructureRedirect** on the parent, a **ConfigureRequest** event is generated, and no further processing is performed. Otherwise, the following is performed:

If some other client has selected **ResizeRedirect** on the window and the inside width or height of the window is being changed, a **ResizeRequest** event is generated, and the current inside width and height are used instead. Note that the override-redirect attribute of the window has no effect on **ResizeRedirect** and that **SubstructureRedirect** on the parent has precedence over **ResizeRedirect** on the window.

The geometry of the window is changed as specified, the window is restacked among siblings, and a **ConfigureNotify** event is generated if the state of the window actually changes. If the inside width or height of the window has actually changed, then children of the window are affected, according to their win-gravity. Exposure processing is performed on formerly obscured windows (including the window itself and its inferiors if regions of them were obscured but now are not). Exposure processing is also performed on any new regions of the window (as a result of increasing the width or height) and on any regions where window contents are lost.

If the inside width or height of a window is not changed but the window is moved or its border is changed, then the contents of the window are not lost but move with the window. Changing the inside width or height of the window causes its contents to be moved or lost, depending on the bit-gravity of the window. It also causes children to be reconfigured, depending on their win-gravity. For a change of width and height of W and H, we define the [x, y] pairs as:

Direction	Deltas
NorthWest	[0, 0]
North	[W/2, 0]
NorthEast	[W, 0]
West	[0, H/2]
Center	[W/2, H/2]
East	[W, H/2]
SouthWest	[0, H]
South	[W/2, H]
SouthEast	[W, H]

When a window with one of these bit-gravities is resized, the corresponding pair defines the change in position of each pixel in the window. When a window with one of these win-gravities has its parent window resized, the corresponding pair defines the change in position of the window within the parent. This repositioning generates a **GravityNotify** event. **GravityNotify** events are generated after the **ConfigureNotify** event is generated.

A gravity of **Static** indicates that the contents or origin should not move relative to the origin of the root window. If the change in size of the window is coupled with a change in position of [X, Y], then for bit-gravity the change in position of each pixel is [–X, –Y] and for win-gravity the change in position of a child when its parent is so resized is [–X, –Y]. Note that **Static** gravity still only takes effect when the width or height of the window is changed, not when the window is simply moved.

A bit-gravity of **Forget** indicates that the window contents are always discarded after a size change, even if backing-store or save-under has been requested. The window is tiled with its background (except, if no background is defined, the existing screen contents are not altered) and zero or more exposure events are generated. A server may also ignore the specified bit-gravity and use **Forget** instead.

A win-gravity of **Unmap** is like **NorthWest**, but the child is also unmapped when the parent is resized, and an **UnmapNotify** event is generated. **UnmapNotify** events are generated after the **ConfigureNotify** event is generated.

If a sibling and a stack-mode are specified, the window is restacked as follows:

Above	The window is placed just above the sibling.
Below	The window is placed just below the sibling.
TopIf	If the sibling occludes the window, then the window is placed at the top of the stack.
BottomIf	If the window occludes the sibling, then the window is placed at the bottom of the stack.
Opposite	If the sibling occludes the window, then the window is placed at the top of the stack. Otherwise, if the window occludes the sibling, then the window is placed at the bottom of the stack.

If a stack-mode is specified but no sibling is specified, the window is restacked as follows:

Above	The window is placed at the top of the stack.
Below	The window is placed at the bottom of the stack.
TopIf	If any sibling occludes the window, then the window is placed at the top of the stack.
BottomIf	If the window occludes any sibling, then the window is placed at the bottom of the stack.
Opposite	If any sibling occludes the window, then the window is placed at the top of the stack. Otherwise, if the window occludes any sibling, then the window is placed at the bottom of the stack.

It is a **Match** error if a sibling is specified without a stack-mode or if the window is not actually a sibling.

Note that the computations for **BottomIf**, **TopIf**, and **Opposite** are performed with respect to the window's final geometry (as controlled by the other arguments to the request), not to its initial geometry.

Attempts to configure a root window have no effect.

CirculateWindow

window: WINDOW
direction: {**RaiseLowest**, **LowerHighest**}

Errors: **Window**, **Value**

If some other client has selected **SubstructureRedirect** on the window, then a **CirculateRequest** event is generated, and no further processing is performed. Otherwise, the following is performed, and then a **CirculateNotify** event is generated if the window is actually restacked.

For **RaiseLowest**, **CirculateWindow** raises the lowest mapped child (if any) that is occluded by another child to the top of the stack. For **LowerHighest**, **CirculateWindow** lowers the highest mapped child (if any) that occludes another child to the bottom of the stack. Exposure processing is performed on formerly obscured windows.

GetGeometry

drawable: DRAWABLE

=>

root: WINDOW
depth: CARD8
x, y: INT16
width, height, border-width: CARD16

Errors: **Drawable**

This request returns the root and current geometry of the drawable. The depth is the number of bits per pixel for the object. The x, y, and border-width will always be zero for pixmaps. For a window, the x and y coordinates specify the upper-left outer corner of the window relative to its parent's origin, and the width and height specify the inside size, not including the border.

It is legal to pass an **InputOnly** window as a drawable to this request.

QueryTree

window: WINDOW

=>

root: WINDOW
parent: WINDOW or **None**
children: LISTofWINDOW

Errors: **Window**

This request returns the root, the parent, and the children of the window. The children are listed in bottom-to-top stacking order.

InternAtom

name: STRING8
only-if-exists: BOOL

=>

atom: ATOM or **None**

Errors: **Value**, **Alloc**

This request returns the atom for the given name. If only-if-exists is **False**, then the atom is created if it does not exist. The string should use the ISO Latin-1 encoding. Uppercase and lowercase matter.

The lifetime of an atom is not tied to the interning client. Atoms remained defined until server reset (see section 11).

GetAtomName

atom: ATOM

=>

name: STRING8

Errors: **Atom**

This request returns the name for the given atom.

ChangeProperty

window: WINDOW
property, type: ATOM
format: {8, 16, 32}
mode: {**Replace**, **Prepend**, **Append**}
data: LISTofINT8 or LISTofINT16 or LISTofINT32

Errors: **Window**, **Atom**, **Value**, **Match**, **Alloc**

This request alters the property for the specified window. The type is uninterpreted by the server. The format specifies whether the data should be viewed as a list of 8-bit, 16-bit, or 32-bit quantities so that the server can correctly byte-swap as necessary.

If the mode is **Replace**, the previous property value is discarded. If the mode is **Prepend** or **Append**, then the type and format must match the existing property value (or a **Match** error results). If the property is undefined, it is treated as defined with the correct type and format with zero-length data. For **Prepend**, the data is tacked on to the beginning of the existing data, and for **Append**, it is tacked on to the end of the existing data.

This request generates a **PropertyNotify** event on the window.

The lifetime of a property is not tied to the storing client. Properties remain until explicitly deleted, until the window is destroyed, or until server reset (see section 11).

The maximum size of a property is server-dependent and may vary dynamically.

DeleteProperty

window: WINDOW
property: ATOM

Errors: **Window**, **Atom**

This request deletes the property from the specified window if the property exists and generates a **PropertyNotify** event on the window unless the property does not exist.

GetProperty

window: WINDOW
property: ATOM
type: ATOM or **AnyPropertyType**
long-offset, long-length: CARD32
delete: BOOL

=>

type: ATOM or **None**
format: {0, 8, 16, 32}
bytes-after: CARD32
value: LISTofINT8 or LISTofINT16 or LISTofINT32

Errors: **Window**, **Atom**, **Value**

If the specified property does not exist for the specified window, then the return type is **None**, the format and bytes-after are zero, and the value is empty. The delete argument is ignored in this case. If the specified property exists but its type does not match the specified type, then the return type is the actual type of the property, the format is the actual format of the property (never zero), the bytes-after is the length of the property in bytes (even if the format is 16 or 32), and the value is empty. The delete argument is ignored in this case. If the specified property exists and either **AnyPropertyType** is specified or the specified type matches the actual type of the property, then the return type is the actual type of the property, the format is the actual format of the property (never zero), and the bytes-after and value are as follows, given:

N = actual length of the stored property in bytes
(even if the format is 16 or 32)
I = 4 * long-offset
T = N – I
L = MINIMUM(T, 4 * long-length)
A = N – (I + L)

The returned value starts at byte index I in the property (indexing from 0), and its length in bytes is L. However, it is a **Value** error if long-offset is given such that L is negative. The value of bytes-after is A, giving the number of trailing unread bytes in the stored property. If delete is **True** and the bytes-after is zero, the property is also deleted from the window, and a **PropertyNotify** event is generated on the window.

RotateProperties

window: WINDOW
delta: INT16
properties: LISTofATOM

Errors: **Window**, **Atom**, **Match**

If the property names in the list are viewed as being numbered starting from zero, and there are N property names in the list, then the value associated with property name I becomes the value associated with property name (I + delta) mod N, for all I from zero to N – 1. The effect is to rotate the states by delta places around the virtual ring of property names (right for positive delta, left for negative delta).

If delta mod N is nonzero, a **PropertyNotify** event is generated for each property in the order listed.

If an atom occurs more than once in the list or no property with that name is defined for the window, a **Match** error is generated. If an **Atom** or **Match** error is generated, no properties are changed.

ListProperties

window: WINDOW

=>

atoms: LISTofATOM

Errors: **Window**

This request returns the atoms of properties currently defined on the window.

SetSelectionOwner

selection: ATOM
owner: WINDOW or **None**
time: TIMESTAMP or **CurrentTime**

Errors: **Atom**, **Window**

This request changes the owner, owner window, and last-change time of the specified selection. This request has no effect if the specified time is earlier than the current last-change time of the specified selection or is later than the current server time. Otherwise, the last-change time is set to the specified time with **CurrentTime** replaced by the current server time. If the owner window is specified as **None**, then the owner of the selection becomes **None** (that is, no owner). Otherwise, the owner of the selection becomes the client executing the request. If the new owner (whether a client or **None**) is not the same as the current owner and the current owner is not **None**, then the current owner is sent a **SelectionClear** event.

If the client that is the owner of a selection is later terminated (that is, its connection is closed) or if the owner window it has specified in the request is later destroyed, then the owner of the selection automatically reverts to **None**, but the last-change time is not affected.

The selection atom is uninterpreted by the server. The owner window is returned by the **GetSelectionOwner** request and is reported in **SelectionRequest** and **SelectionClear** events.

Selections are global to the server.

GetSelectionOwner

selection: ATOM

=>

owner: WINDOW or **None**

Errors: **Atom**

This request returns the current owner window of the specified selection, if any. If **None** is returned, then there is no owner for the selection.

ConvertSelection

selection, *target*: ATOM
property: ATOM or **None**
requestor: WINDOW
time: TIMESTAMP or **CurrentTime**

Errors: **Atom**, **Window**

If the specified selection has an owner, the server sends a **SelectionRequest** event to that owner. If no owner for the specified selection exists, the server generates a **SelectionNotify** event to the requestor with property **None**. The arguments are passed on unchanged in either event.

SendEvent

destination: WINDOW or **PointerWindow** or **InputFocus**
propagate: BOOL
event-mask: SETofEVENT
event: <normal-event-format>

Errors: **Window**, **Value**

If **PointerWindow** is specified, destination is replaced with the window that the pointer is in. If **InputFocus** is specified and the focus window contains the pointer, destination is replaced with the window that the pointer is in. Otherwise, destination is replaced with the focus window.

If the event-mask is the empty set, then the event is sent to the client that created the destination window. If that client no longer exists, no event is sent.

If propagate is **False**, then the event is sent to every client selecting on destination any of the event types in event-mask.

If propagate is **True** and no clients have selected on destination any of the event types in event-mask, then destination is replaced with the closest ancestor of destination for which some client has selected a type in event-mask and no intervening window has that type in its do-not-propagate-mask. If no such window exists or if the window is an ancestor of the focus window and **InputFocus** was originally specified as the destination, then the event is not sent to any clients. Otherwise, the event is reported to every client selecting on the final destination any of the types specified in event-mask.

The event code must be one of the core events or one of the events defined by an extension (or a **Value** error results) so that the server can correctly byte-swap the contents as necessary. The contents of the event are otherwise unaltered and unchecked by the server except to force on the most-significant bit of the event code and to set the sequence number in the event correctly.

Active grabs are ignored for this request.

GrabPointer

grab-window: WINDOW
owner-events: BOOL
event-mask: SETofPOINTEREVENT
pointer-mode, keyboard-mode: {**Synchronous**, **Asynchronous**}
confine-to: WINDOW or **None**
cursor: CURSOR or **None**
time: TIMESTAMP or **CurrentTime**

=>

status: {**Success**, **AlreadyGrabbed**, **Frozen**, **InvalidTime**, **NotViewable**}

Errors: **Cursor**, **Window**, **Value**

This request actively grabs control of the pointer. Further pointer events are only reported to the grabbing client. The request overrides any active pointer grab by this client.

If owner-events is **False**, all generated pointer events are reported with respect to grab-window and are only reported if selected by event-mask. If owner-events is **True** and a generated pointer event would normally be reported to this client, it is reported normally. Otherwise, the event is reported with respect to the grab-window and is only reported if selected by event-mask. For either value of owner-events, unreported events are simply discarded.

If pointer-mode is **Asynchronous**, pointer event processing continues normally. If the pointer is currently frozen by this client, then processing of pointer events is resumed. If pointer-mode is **Synchronous**, the state of the pointer (as seen by means of the protocol) appears to freeze, and no further pointer events are generated by the server until the grabbing client issues a releasing **AllowEvents** request or until the pointer grab is released. Actual pointer changes are not lost while the pointer is frozen. They are simply queued for later processing.

If keyboard-mode is **Asynchronous**, keyboard event processing is unaffected by activation of the grab. If keyboard-mode is **Synchronous**, the state of the keyboard (as seen by means of the protocol) appears to freeze, and no further keyboard events are generated by the server until the grabbing client issues a releasing **AllowEvents** request or until the pointer grab is released. Actual keyboard changes are not lost while the keyboard is frozen. They are simply queued for later processing.

If a cursor is specified, then it is displayed regardless of what window the pointer is in. If no cursor is specified, then when the pointer is in grab-window or one of its subwindows, the normal cursor for that window is displayed. Otherwise, the cursor for grab-window is displayed.

If a confine-to window is specified, then the pointer will be restricted to stay contained in that window. The confine-to window need have no relationship to the grab-window. If the pointer is not initially in the confine-to window, then it is warped automatically to the closest edge (and enter/leave events are generated normally) just before the grab activates. If the confine-to window is subsequently reconfigured, the pointer will be warped automatically as necessary to keep it contained in the window.

This request generates **EnterNotify** and **LeaveNotify** events.

The request fails with status **AlreadyGrabbed** if the pointer is actively grabbed by some other client. The request fails with status **Frozen** if the pointer is frozen by an active grab of another client. The request fails with status **NotViewable** if grab-window or confine-to window is not viewable or if the confine-to window lies completely outside the boundaries of the root window. The request fails with status **InvalidTime** if the specified time is earlier than the last-pointer-grab time or later than the current server time. Otherwise, the last-pointer-grab time is set to the specified time, with **CurrentTime** replaced by the current server time.

UngrabPointer

time: TIMESTAMP or **CurrentTime**

This request releases the pointer if this client has it actively grabbed (from either **GrabPointer** or **GrabButton** or from a normal button press) and releases any queued events. The request has no effect if the specified time is earlier than the last-pointer-grab time or is later than the current server time.

This request generates **EnterNotify** and **LeaveNotify** events.

An **UngrabPointer** request is performed automatically if the event window or confine-to window for an active pointer grab becomes not viewable or if window reconfiguration causes the confine-to window to lie completely outside the boundaries of the root window.

GrabButton

modifiers: SETofKEYMASK or **AnyModifier**
button: BUTTON or **AnyButton**
grab-window: WINDOW
owner-events: BOOL
event-mask: SETofPOINTEREVENT
pointer-mode, keyboard-mode: {**Synchronous**, **Asynchronous**}
confine-to: WINDOW or **None**
cursor: CURSOR or **None**

Errors: **Cursor**, **Window**, **Value**, **Access**

This request establishes a passive grab. In the future, the pointer is actively grabbed as described in **GrabPointer**, the last-pointer-grab time is set to the time at which the button was pressed (as transmitted in the **ButtonPress** event), and the **ButtonPress** event is reported if all of the following conditions are true:

- The pointer is not grabbed and the specified button is logically pressed when the specified modifier keys are logically down, and no other buttons or modifier keys are logically down.
- The grab-window contains the pointer.
- The confine-to window (if any) is viewable.
- A passive grab on the same button/key combination does not exist on any ancestor of grab-window.

The interpretation of the remaining arguments is the same as for **GrabPointer**. The active grab is terminated automatically when the logical state of the pointer has all buttons released, independent of the logical state of modifier keys. Note that the logical state of a device (as seen by means of the protocol) may lag the physical state if device event processing is frozen.

This request overrides all previous passive grabs by the same client on the same button/key combinations on the same window. A modifier of **AnyModifier** is equivalent to issuing the request for all possible modifier combinations (including the combination of no modifiers). It is not required that all specified modifiers have currently assigned keycodes. A button of **AnyButton** is equivalent to issuing the request for all possible buttons. Otherwise, it is not required that the button specified currently be assigned to a physical button.

An **Access** error is generated if some other client has already issued a **GrabButton** request with the same button/key combination on the same window. When using **AnyModifier** or **AnyButton**, the request fails completely (no grabs are established), and an **Access** error is generated if there is a conflicting grab for any combination. The request has no effect on an active grab.

UngrabButton

modifiers: SETofKEYMASK or **AnyModifier**
button: BUTTON or **AnyButton**
grab-window: WINDOW

Errors: **Window**, **Value**

This request releases the passive button/key combination on the specified window if it was grabbed by this client. A modifiers argument of **AnyModifier** is equivalent to issuing the request for all possible modifier combinations (including the combination of no modifiers). A button of **AnyButton** is equivalent to issuing the request for all possible buttons. The request has no effect on an active grab.

ChangeActivePointerGrab

event-mask: SETofPOINTEREVENT
cursor: CURSOR or **None**
time: TIMESTAMP or **CurrentTime**

Errors: **Cursor**, **Value**

This request changes the specified dynamic parameters if the pointer is actively grabbed by the client and the specified time is no earlier than the last-pointer-grab time and no later than the current server time. The interpretation of event-mask and cursor are the same as in **GrabPointer**. This request has no effect on the parameters of any passive grabs established with **GrabButton**.

GrabKeyboard

grab-window: WINDOW
owner-events: BOOL
pointer-mode, keyboard-mode: {**Synchronous**, **Asynchronous**}
time: TIMESTAMP or **CurrentTime**

=>

status: {**Success**, **AlreadyGrabbed**, **Frozen**, **InvalidTime**, **NotViewable**}

Errors: **Window**, **Value**

This request actively grabs control of the keyboard. Further key events are reported only to the grabbing client. This request overrides any active keyboard grab by this client.

If owner-events is **False**, all generated key events are reported with respect to grab-window. If owner-events is **True** and if a generated key event would normally be reported to this client, it is reported normally. Otherwise, the event is reported with respect to the grab-window. Both **KeyPress** and **KeyRelease** events are always reported, independent of any event selection made by the client.

If keyboard-mode is **Asynchronous**, keyboard event processing continues normally. If the keyboard is currently frozen by this client, then processing of keyboard events is resumed. If keyboard-mode is **Synchronous**, the state of the keyboard (as seen by means of the protocol) appears to freeze. No further keyboard events are generated by the server until the grabbing client issues a releasing **AllowEvents** request or until the keyboard grab is released. Actual keyboard changes are not lost while the keyboard is frozen. They are simply queued for later processing.

If pointer-mode is **Asynchronous**, pointer event processing is unaffected by activation of the grab. If pointer-mode is **Synchronous**, the state of the pointer (as seen by means of the protocol) appears to freeze. No further pointer events are generated by the server until the grabbing client issues a releasing **AllowEvents** request or until the keyboard grab is released. Actual pointer changes are not lost while the pointer is frozen. They are simply queued for later processing.

This request generates **FocusIn** and **FocusOut** events.

The request fails with status **AlreadyGrabbed** if the keyboard is actively grabbed by some other client. The request fails with status **Frozen** if the keyboard is frozen by an active grab of another client. The request fails with status **NotViewable** if grab-window is not viewable. The request fails with status **InvalidTime** if the specified time is earlier than the last-keyboard-grab time or later than the current server time. Otherwise, the last-keyboard-grab time is set to the specified time with **CurrentTime** replaced by the current server time.

UngrabKeyboard

time: TIMESTAMP or **CurrentTime**

This request releases the keyboard if this client has it actively grabbed (as a result of either **GrabKeyboard** or **GrabKey**) and releases any queued events. The request has no effect if the specified time is earlier than the last-keyboard-grab time or is later than the current server time.

This request generates **FocusIn** and **FocusOut** events.

An **UngrabKeyboard** is performed automatically if the event window for an active keyboard grab becomes not viewable.

GrabKey

key: KEYCODE or **AnyKey**
modifiers: SETofKEYMASK or **AnyModifier**
grab-window: WINDOW
owner-events: BOOL
pointer-mode, keyboard-mode: {**Synchronous**, **Asynchronous**}

Errors: **Window**, **Value**, **Access**

This request establishes a passive grab on the keyboard. In the future, the keyboard is actively grabbed as described in **GrabKeyboard**, the last-keyboard-grab time is set to the time at which the key was pressed (as transmitted in the **KeyPress** event), and the **KeyPress** event is reported if all of the following conditions are true:

- The keyboard is not grabbed and the specified key (which can itself be a modifier key) is logically pressed when the specified modifier keys are logically down, and no other modifier keys are logically down.
- Either the grab-window is an ancestor of (or is) the focus window, or the grab-window is a descendent of the focus window and contains the pointer.
- A passive grab on the same key combination does not exist on any ancestor of grab-window.

The interpretation of the remaining arguments is the same as for **GrabKeyboard**. The active grab is terminated automatically when the logical state of the keyboard has the specified key released, independent of the logical state of modifier keys. Note that the logical state of a device (as seen by means of the protocol) may lag the physical state if device event processing is frozen.

This request overrides all previous passive grabs by the same client on the same key combinations on the same window. A modifier of **AnyModifier** is equivalent to issuing the request for all possible modifier combinations (including the combination of no modifiers). It is not required that all modifiers specified have currently assigned keycodes. A key of **AnyKey** is equivalent to issuing the request for all possible keycodes. Otherwise, the key must be in the range specified by min-keycode and max-keycode in the connection setup (or a **Value** error results).

An **Access** error is generated if some other client has issued a **GrabKey** with the same key combination on the same window. When using **AnyModifier** or **AnyKey**, the request fails completely (no grabs are established), and an **Access** error is generated if there is a conflicting grab for any combination.

UngrabKey

key: KEYCODE or **AnyKey**
modifiers: SETofKEYMASK or **AnyModifier**
grab-window: WINDOW

Errors: **Window**, **Value**

This request releases the key combination on the specified window if it was grabbed by this client. A modifiers argument of **AnyModifier** is equivalent to issuing the request for all possible modifier combinations (including the combination of no modifiers). A key of **AnyKey** is equivalent to issuing the request for all possible keycodes. This request has no effect on an active grab.

AllowEvents

mode: {**AsyncPointer**, **SyncPointer**, **ReplayPointer**, **AsyncKeyboard**, **SyncKeyboard**,
ReplayKeyboard, **AsyncBoth**, **SyncBoth**}
time: TIMESTAMP or **CurrentTime**

Errors: **Value**

This request releases some queued events if the client has caused a device to freeze. The request has no effect if the specified time is earlier than the last-grab time of the most recent active grab for the client or if the specified time is later than the current server time.

For **AsyncPointer**, if the pointer is frozen by the client, pointer event processing continues normally. If the pointer is frozen twice by the client on behalf of two separate grabs, **AsyncPointer** thaws for both. **AsyncPointer** has no effect if the pointer is not frozen by the client, but the pointer need not be grabbed by the client.

For **SyncPointer**, if the pointer is frozen and actively grabbed by the client, pointer event processing continues normally until the next **ButtonPress** or **ButtonRelease** event is reported to the client, at which time the pointer again appears to freeze. However, if the reported event causes the pointer grab to be released, then the pointer does not freeze. **SyncPointer** has no effect if the pointer is not frozen by the client or if the pointer is not grabbed by the client.

For **ReplayPointer**, if the pointer is actively grabbed by the client and is frozen as the result of an event having been sent to the client (either from the activation of a **GrabButton** or from a previous **AllowEvents** with mode **SyncPointer** but not from a **GrabPointer**), then the pointer grab is released and that event is completely reprocessed, this time ignoring any passive grabs at or above (towards the root) the grab-window of the grab just released. The request has no effect if the pointer is not grabbed by the client or if the pointer is not frozen as the result of an event.

For **AsyncKeyboard**, if the keyboard is frozen by the client, keyboard event processing continues normally. If the keyboard is frozen twice by the client on behalf of two separate grabs, **AsyncKeyboard** thaws for both. **AsyncKeyboard** has no effect if the keyboard is not frozen by the client, but the keyboard need not be grabbed by the client.

For **SyncKeyboard**, if the keyboard is frozen and actively grabbed by the client, keyboard event processing continues normally until the next **KeyPress** or **KeyRelease** event is reported to the client, at which time the keyboard again appears to freeze. However, if the reported event causes the keyboard grab to be released, then the keyboard does not freeze. **SyncKeyboard** has no effect if the keyboard is not frozen by the client or if the keyboard is not grabbed by the client.

For **ReplayKeyboard**, if the keyboard is actively grabbed by the client and is frozen as the result of an event having been sent to the client (either from the activation of a **GrabKey** or from a previous **AllowEvents** with mode **SyncKeyboard** but not from a **GrabKeyboard**), then the keyboard grab is released and that event is completely reprocessed, this time ignoring any passive grabs at or above (towards the root) the grab-window of the grab just released. The request has no effect if the keyboard is not grabbed by the client or if the keyboard is not frozen as the result of an event.

For **SyncBoth**, if both pointer and keyboard are frozen by the client, event processing (for both devices) continues normally until the next **ButtonPress**, **ButtonRelease**, **KeyPress**, or **KeyRelease** event is reported to the client for a grabbed device (button event for the pointer, key event for the keyboard), at which time the devices again appear to freeze. However, if the reported event causes the grab to be released, then the devices do not freeze (but if the other device is still grabbed, then a subsequent event for it will still cause both devices to freeze). **SyncBoth** has no effect unless both pointer and keyboard are frozen by the client. If the pointer or keyboard is frozen twice by the client on behalf of two separate grabs, **SyncBoth** thaws for both (but a subsequent freeze for **SyncBoth** will only freeze each device once).

For **AsyncBoth**, if the pointer and the keyboard are frozen by the client, event processing for both devices continues normally. If a device is frozen twice by the client on behalf of two separate grabs, **AsyncBoth** thaws for both. **AsyncBoth** has no effect unless both pointer and keyboard are frozen by the client.

AsyncPointer, **SyncPointer**, and **ReplayPointer** have no effect on processing of keyboard events. **AsyncKeyboard**, **SyncKeyboard**, and **ReplayKeyboard** have no effect on processing of pointer events.

It is possible for both a pointer grab and a keyboard grab to be active simultaneously (by the same or different clients). When a device is frozen on behalf of either grab, no event processing is performed for the device. It is possible for a single device to be frozen because of both grabs. In this case, the freeze must be released on behalf of both grabs before events can again be processed.

GrabServer

This request disables processing of requests and close-downs on all connections other than the one this request arrived on.

UngrabServer

This request restarts processing of requests and close-downs on other connections.

QueryPointer

window: WINDOW

=>

root: WINDOW
child: WINDOW or **None**
same-screen: BOOL
root-x, root-y, win-x, win-y: INT16
mask: SETofKEYBUTMASK

Errors: **Window**

The root window the pointer is logically on and the pointer coordinates relative to the root's origin are returned. If same-screen is **False**, then the pointer is not on the same screen as the argument window, child is **None**, and win-x and win-y are zero. If same-screen is **True**, then win-x and win-y are the pointer coordinates relative to the argument window's origin, and child is the child containing the pointer, if any. The current logical state of the modifier keys and the buttons are also returned. Note that the logical state of a device (as seen by means of the protocol) may lag the physical state if device event processing is frozen.

GetMotionEvents

start, stop: TIMESTAMP or **CurrentTime**
window: WINDOW

=>

events: LISTofTIMECOORD

where:

TIMECOORD: [x, y: INT16
time: TIMESTAMP]

Errors: **Window**

This request returns all events in the motion history buffer that fall between the specified start and stop times (inclusive) and that have coordinates that lie within (including borders) the specified window at its present placement. The x and y coordinates are reported relative to the origin of the window.

If the start time is later than the stop time or if the start time is in the future, no events are returned. If the stop time is in the future, it is equivalent to specifying **CurrentTime**.

TranslateCoordinates

src-window, *dst-window*: WINDOW
src-x, *src-y*: INT16

=>

same-screen: BOOL
child: WINDOW or **None**
dst-x, dst-y: INT16

Errors: **Window**

The src-x and src-y coordinates are taken relative to src-window's origin and are returned as dst-x and dst-y coordinates relative to dst-window's origin. If same-screen is **False**, then src-window and dst-window are on different screens, and dst-x and dst-y are zero. If the coordinates are contained in a mapped child of dst-window, then that child is returned.

WarpPointer

src-window: WINDOW or **None**
dst-window: WINDOW or **None**
src-x, *src-y*: INT16
src-width, *src-height*: CARD16
dst-x, *dst-y*: INT16

Errors: **Window**

If dst-window is **None**, this request moves the pointer by offsets [dst-x, dst-y] relative to the current position of the pointer. If dst-window is a window, this request moves the pointer to [dst-x, dst-y] relative to dst-window's origin. However, if src-window is not **None**, the move only takes place if src-window contains the pointer and the pointer is contained in the specified rectangle of src-window.

The src-x and src-y coordinates are relative to src-window's origin. If src-height is zero, it is replaced with the current height of src-window minus src-y. If src-width is zero, it is replaced with the current width of src-window minus src-x.

This request cannot be used to move the pointer outside the confine-to window of an active pointer grab. An attempt will only move the pointer as far as the closest edge of the confine-to window.

This request will generate events just as if the user had instantaneously moved the pointer.

SetInputFocus

focus: WINDOW or **PointerRoot** or **None**
revert-to: {**Parent**, **PointerRoot**, **None**}
time: TIMESTAMP or **CurrentTime**

Errors: **Window**, **Value**, **Match**

This request changes the input focus and the last-focus-change time. The request has no effect if the specified time is earlier than the current last-focus-change time or is later than the current server time. Otherwise, the last-focus-change time is set to the specified time with **CurrentTime** replaced by the current server time.

If **None** is specified as the focus, all keyboard events are discarded until a new focus window is set. In this case, the revert-to argument is ignored.

If a window is specified as the focus, it becomes the keyboard's focus window. If a generated keyboard event would normally be reported to this window or one of its inferiors, the event is reported normally. Otherwise, the event is reported with respect to the focus window.

If **PointerRoot** is specified as the focus, the focus window is dynamically taken to be the root window of whatever screen the pointer is on at each keyboard event. In this case, the revert-to argument is ignored.

This request generates **FocusIn** and **FocusOut** events.

The specified focus window must be viewable at the time of the request (or a **Match** error results). If the focus window later becomes not viewable, the new focus window depends on the revert-to argument. If revert-to is **Parent**, the focus reverts to the parent (or the closest viewable ancestor) and the new revert-to value is taken to be **None**. If revert-to is **PointerRoot** or **None**, the focus reverts to that value. When the focus reverts, **FocusIn** and **FocusOut** events are generated, but the last-focus-change time is not affected.

GetInputFocus

=>

focus: WINDOW or **PointerRoot** or **None**
revert-to: {**Parent**, **PointerRoot**, **None**}

This request returns the current focus state.

QueryKeymap

=>

keys: LISTofCARD8

This request returns a bit vector for the logical state of the keyboard. Each bit set to 1 indicates that the corresponding key is currently pressed. The vector is represented as 32 bytes. Byte N (from 0) contains the bits for keys 8N to 8N + 7 with the least-significant bit in the byte representing key 8N. Note that the logical state of a device (as seen by means of the protocol) may lag the physical state if device event processing is frozen.

OpenFont

fid: FONT
name: STRING8

Errors: **IDChoice**, **Name**, **Alloc**

This request loads the specified font, if necessary, and associates identifier fid with it. The font name should use the ISO Latin-1 encoding, and uppercase and lowercase do not matter.

Fonts are not associated with a particular screen and can be stored as a component of any graphics context.

CloseFont

font: FONT

Errors: **Font**

This request deletes the association between the resource ID and the font. The font itself will be freed when no other resource references it.

QueryFont

font: FONTABLE

=>

font-info: FONTINFO
char-infos: LISTofCHARINFO

where:

FONTINFO: [draw-direction: {**LeftToRight**, **RightToLeft**}
min-char-or-byte2, max-char-or-byte2: CARD16
min-byte1, max-byte1: CARD8

all-chars-exist: BOOL
default-char: CARD16
min-bounds: CHARINFO
max-bounds: CHARINFO
font-ascent: INT16
font-descent: INT16
properties: LISTofFONTPROP]

FONTPROP: [name: ATOM
value: <32-bit-value>]

CHARINFO: [left-side-bearing: INT16
right-side-bearing: INT16
character-width: INT16
ascent: INT16
descent: INT16
attributes: CARD16]

Errors: **Font**

This request returns logical information about a font. If a gcontext is given for font, the currently contained font is used.

The draw-direction is just a hint and indicates whether most char-infos have a positive, **LeftToRight**, or a negative, **RightToLeft**, character-width metric. The core protocol defines no support for vertical text.

If min-byte1 and max-byte1 are both zero, then min-char-or-byte2 specifies the linear character index corresponding to the first element of char-infos, and max-char-or-byte2 specifies the linear character index of the last element. If either min-byte1 or max-byte1 are nonzero, then both min-char-or-byte2 and max-char-or-byte2 will be less than 256, and the 2-byte character index values corresponding to char-infos element N (counting from 0) are:

byte1 = N/D + min-byte1
byte2 = N\D + min-char-or-byte2

where:

D = max-char-or-byte2 – min-char-or-byte2 + 1
/ = integer division
\ = integer modulus

If char-infos has length zero, then min-bounds and max-bounds will be identical, and the effective char-infos is one filled with this char-info, of length:

L = D * (max-byte1 – min-byte1 + 1)

That is, all glyphs in the specified linear or matrix range have the same information, as given by min-bounds (and max-bounds). If all-chars-exist is **True**, then all characters in char-infos have nonzero bounding boxes.

The default-char specifies the character that will be used when an undefined or nonexistent character is used. Note that default-char is a CARD16, not CHAR2B. For a font using 2-byte matrix format, the default-char has byte1 in the most-significant byte and byte2 in the least-significant byte. If the default-char itself specifies an undefined or nonexistent character, then no printing is performed for an undefined or nonexistent character.

The min-bounds and max-bounds contain the minimum and maximum values of each individual CHARINFO component over all char-infos (ignoring nonexistent characters). The bounding box of the font (that is, the smallest rectangle enclosing the shape obtained by superimposing all characters at the same origin [x,y]) has its upper-left coordinate at:

$$[x + \text{min-bounds.left-side-bearing},\ y - \text{max-bounds.ascent}]$$

with a width of:

$$\text{max-bounds.right-side-bearing} - \text{min-bounds.left-side-bearing}$$

and a height of:

$$\text{max-bounds.ascent} + \text{max-bounds.descent}$$

The font-ascent is the logical extent of the font above the baseline and is used for determining line spacing. Specific characters may extend beyond this. The font-descent is the logical extent of the font at or below the baseline and is used for determining line spacing. Specific characters may extend beyond this. If the baseline is at Y-coordinate y, then the logical extent of the font is inclusive between the Y-coordinate values (y – font-ascent) and (y + font-descent – 1).

A font is not guaranteed to have any properties. The interpretation of the property value (for example, INT32, CARD32) must be derived from a priori knowledge of the property. When possible, fonts should have at least the following properties (note that uppercase and lowercase matter).

Property	Type	Description
MIN_SPACE	CARD32	The minimum interword spacing, in pixels.
NORM_SPACE	CARD32	The normal interword spacing, in pixels.
MAX_SPACE	CARD32	The maximum interword spacing, in pixels.
END_SPACE	CARD32	The additional spacing at the end of sentences, in pixels.
SUPERSCRIPT_X SUPERSCRIPT_Y	INT32	Offsets from the character origin where superscripts should begin, in pixels. If the origin is at [x,y], then superscripts should begin at [x + SUPERSCRIPT_X, y – SUPERSCRIPT_Y].
SUBSCRIPT_X SUBSCRIPT_Y	INT32	Offsets from the character origin where subscripts should begin, in pixels. If the origin is at [x,y], then subscripts should begin at [x + SUBSCRIPT_X, y + SUBSCRIPT_Y].
UNDERLINE_POSITION	INT32	Y offset from the baseline to the top of an underline, in pixels. If the baseline is Y-coordinate y, then the top of the underline is at (y + UNDERLINE_POSITION).
UNDERLINE_THICKNESS	CARD32	Thickness of the underline, in pixels.
STRIKEOUT_ASCENT STRIKEOUT_DESCENT	INT32	Vertical extents for boxing or voiding characters, in pixels. If the baseline is at Y-coordinate y, then the top of the strikeout box is at (y – STRIKEOUT_ASCENT) and the height of the box is (STRIKEOUT_ASCENT + STRIKEOUT_DESCENT).

Property	Type	Description
ITALIC_ANGLE	INT32	The angle of the dominant staffs of characters in the font, in degrees scaled by 64, relative to the three-o'clock position from the character origin, with positive indicating counterclockwise motion (as in Arc requests).
X_HEIGHT	INT32	1 ex as in TeX, but expressed in units of pixels. Often the height of lowercase x.
QUAD_WIDTH	INT32	1 em as in TeX, but expressed in units of pixels. Often the width of the digits 0-9.
CAP_HEIGHT	INT32	Y offset from the baseline to the top of the capital letters, ignoring accents, in pixels. If the baseline is at Y-coordinate y, then the top of the capitals is at (y – CAP_HEIGHT).
WEIGHT	CARD32	The weight or boldness of the font, expressed as a value between 0 and 1000.
POINT_SIZE	CARD32	The point size, expressed in 1/10, of this font at the ideal resolution.
RESOLUTION	CARD32	The number of pixels per point, expressed in 1/100, at which this font was created.

For a character origin at [x,y], the bounding box of a character (that is, the smallest rectangle enclosing the character's shape), described in terms of CHARINFO components, is a rectangle with its upper-left corner at:

[x + left-side-bearing, y – ascent]

with a width of:

right-side-bearing – left-side-bearing

and a height of:

ascent + descent

and the origin for the next character is defined to be:

[x + character-width, y]

Note that the baseline is logically viewed as being just below nondescending characters (when descent is zero, only pixels with Y-coordinates less than y are drawn) and that the origin is logically viewed as being coincident with the left edge of a nonkerned character (when left-side-bearing is zero, no pixels with X-coordinate less than x are drawn).

Note that CHARINFO metric values can be negative.

A nonexistent character is represented with all CHARINFO components zero.

The interpretation of the per-character attributes field is server-dependent.

QueryTextExtents

font: FONTABLE
string: STRING16

=>

draw-direction: {**LeftToRight**, **RightToLeft**}
font-ascent: INT16
font-descent: INT16
overall-ascent: INT16
overall-descent: INT16
overall-width: INT32
overall-left: INT32
overall-right: INT32

Errors: **Font**

This request returns the logical extents of the specified string of characters in the specified font. If a gcontext is given for font, the currently contained font is used. The draw-direction, font-ascent, and font-descent are the same as described in **QueryFont**. The overall-ascent is the maximum of the ascent metrics of all characters in the string, and the overall-descent is the maximum of the descent metrics. The overall-width is the sum of the character-width metrics of all characters in the string. For each character in the string, let W be the sum of the character-width metrics of all characters preceding it in the string, let L be the left-side-bearing metric of the character plus W, and let R be the right-side-bearing metric of the character plus W. The overall-left is the minimum L of all characters in the string, and the overall-right is the maximum R.

For fonts defined with linear indexing rather than 2-byte matrix indexing, the server will interpret each CHAR2B as a 16-bit number that has been transmitted most-significant byte first (that is, byte1 of the CHAR2B is taken as the most-significant byte).

If the font has no defined default-char, then undefined characters in the string are taken to have all zero metrics.

ListFonts

pattern: STRING8
max-names: CARD16

=>

names: LISTofSTRING8

This request returns a list of available font names (as controlled by the font search path; see **SetFontPath** request) that match the pattern. At most, max-names names will be returned. The pattern should use the ISO Latin-1 encoding, and uppercase and lowercase do not matter. In the pattern, the "?" character (octal value 77) will match any single character, and the "*" character (octal value 52) will match any number of characters. The returned names are in lowercase.

ListFontsWithInfo

pattern: STRING8
max-names: CARD16

=>+

name: STRING8
info: FONTINFO
replies-hint: CARD32

where:

FONTINFO: <same type definition as in **QueryFont**>

This request is similar to **ListFonts**, but it also returns information about each font. The information returned for each font is identical to what **QueryFont** would return except that the per-character metrics are not returned. Note that this request can generate multiple replies. With each reply, replies-hint may provide an indication of how many more fonts will be returned. This number is a hint only and may be larger or smaller than the number of fonts actually returned. A zero value does not guarantee that no more fonts will be returned. After the font replies, a reply with a zero-length name is sent to indicate the end of the reply sequence.

SetFontPath

path: LISTofSTRING8

Errors: **Value**

This request defines the search path for font lookup. There is only one search path per server, not one per client. The interpretation of the strings is operating-system-dependent, but the strings are intended to specify directories to be searched in the order listed.

Setting the path to the empty list restores the default path defined for the server.

As a side effect of executing this request, the server is guaranteed to flush all cached information about fonts for which there currently are no explicit resource IDs allocated.

The meaning of an error from this request is system specific.

GetFontPath

=>

path: LISTofSTRING8

This request returns the current search path for fonts.

CreatePixmap

pid: PIXMAP
drawable: DRAWABLE
depth: CARD8
width, height: CARD16

Errors: **IDChoice**, **Drawable**, **Value**, **Alloc**

This request creates a pixmap and assigns the identifier pid to it. The width and height must be nonzero (or a **Value** error results). The depth must be one of the depths supported by the root of the specified drawable (or a **Value** error results). The initial contents of the pixmap are undefined.

It is legal to pass an **InputOnly** window as a drawable to this request.

FreePixmap

pixmap: PIXMAP

Errors: **Pixmap**

This request deletes the association between the resource ID and the pixmap. The pixmap storage will be freed when no other resource references it.

CreateGC

cid: GCONTEXT
drawable: DRAWABLE
value-mask: BITMASK
value-list: LISTofVALUE

Errors: **IDChoice**, **Drawable**, **Pixmap**, **Font**, **Match**, **Value**, **Alloc**

This request creates a graphics context and assigns the identifier cid to it. The gcontext can be used with any destination drawable having the same root and depth as the specified drawable; use with other drawables results in a **Match** error.

The value-mask and value-list specify which components are to be explicitly initialized. The context components are:

Component	Type
function	{**Clear**, **And**, **AndReverse**, **Copy**, **AndInverted**, **NoOp**, **Xor**, **Or**, **Nor**, **Equiv**, **Invert**, **OrReverse**, **CopyInverted**, **OrInverted**, **Nand**, **Set**}
plane-mask	CARD32
foreground	CARD32
background	CARD32
line-width	CARD16
line-style	{**Solid**, **OnOffDash**, **DoubleDash**}
cap-style	{**NotLast**, **Butt**, **Round**, **Projecting**}
join-style	{**Miter**, **Round**, **Bevel**}
fill-style	{**Solid**, **Tiled**, **OpaqueStippled**, **Stippled**}
fill-rule	{**EvenOdd**, **Winding**}
arc-mode	{**Chord**, **PieSlice**}
tile	PIXMAP
stipple	PIXMAP
tile-stipple-x-origin	INT16
tile-stipple-y-origin	INT16
font	FONT
subwindow-mode	{**ClipByChildren**, **IncludeInferiors**}
graphics-exposures	BOOL
clip-x-origin	INT16
clip-y-origin	INT16
clip-mask	PIXMAP or **None**
dash-offset	CARD16
dashes	CARD8

In graphics operations, given a source and destination pixel, the result is computed bitwise on corresponding bits of the pixels; that is, a Boolean operation is performed in each bit plane. The plane-mask restricts the operation to a subset of planes, so the result is:

((src FUNC dst) AND plane-mask) OR (dst AND (NOT plane-mask))

Range checking is not performed on the values for foreground, background, or plane-mask. They are simply truncated to the appropriate number of bits.

The meanings of the functions are:

Function	Operation
Clear	0
And	src AND dst
AndReverse	src AND (NOT dst)
Copy	src
AndInverted	(NOT src) AND dst
NoOp	dst

Xor	src XOR dst
Or	src OR dst
Nor	(NOT src) AND (NOT dst)
Equiv	(NOT src) XOR dst
Invert	NOT dst
OrReverse	src OR (NOT dst)
CopyInverted	NOT src
OrInverted	(NOT src) OR dst
Nand	(NOT src) OR (NOT dst)
Set	1

The line-width is measured in pixels and can be greater than or equal to one, a wide line, or the special value zero, a thin line.

Wide lines are drawn centered on the path described by the graphics request. Unless otherwise specified by the join or cap style, the bounding box of a wide line with endpoints [x1, y1], [x2, y2] and width w is a rectangle with vertices at the following real coordinates:

[x1–(w*sn/2), y1+(w*cs/2)], [x1+(w*sn/2), y1–(w*cs/2)],
[x2–(w*sn/2), y2+(w*cs/2)], [x2+(w*sn/2), y2–(w*cs/2)]

The sn is the sine of the angle of the line and cs is the cosine of the angle of the line. A pixel is part of the line (and hence drawn) if the center of the pixel is fully inside the bounding box, which is viewed as having infinitely thin edges. If the center of the pixel is exactly on the bounding box, it is part of the line if and only if the interior is immediately to its right (x increasing direction). Pixels with centers on a horizontal edge are a special case and are part of the line if and only if the interior or the boundary is immediately below (y increasing direction) and if the interior or the boundary is immediately to the right (x increasing direction). Note that this description is a mathematical model describing the pixels that are drawn for a wide line and does not imply that trigonometry is required to implement such a model. Real or fixed point arithmetic is recommended for computing the corners of the line endpoints for lines greater than one pixel in width.

Thin lines (zero line-width) are "one pixel wide" lines drawn using an unspecified, device-dependent algorithm. There are only two constraints on this algorithm. First, if a line is drawn unclipped from [x1,y1] to [x2,y2] and another line is drawn unclipped from [x1+dx,y1+dy] to [x2+dx,y2+dy], then a point [x,y] is touched by drawing the first line if and only if the point [x+dx,y+dy] is touched by drawing the second line. Second, the effective set of points comprising a line cannot be affected by clipping. Thus, a point is touched in a clipped line if and only if the point lies inside the clipping region and the point would be touched by the line when drawn unclipped.

Note that a wide line drawn from [x1,y1] to [x2,y2] always draws the same pixels as a wide line drawn from [x2,y2] to [x1,y1], not counting cap-style and join-style. Implementors are encouraged to make this property true for thin lines, but it is not required. A line-width of zero may differ from a line-width of one in which pixels are drawn. In general, drawing a thin line will be faster than drawing a wide line of width one, but thin lines may not mix well aesthetically with wide lines because of the different drawing algorithms. If it is desirable to obtain precise and uniform results across all displays, a client should always use a line-width of one, rather than a line-width of zero.

The line-style defines which sections of a line are drawn:

Solid	The full path of the line is drawn.
DoubleDash	The full path of the line is drawn, but the even dashes are filled differently than the odd dashes (see fill-style), with Butt cap-style used where even and odd dashes meet.
OnOffDash	Only the even dashes are drawn, and cap-style applies to all internal ends of the individual dashes (except **NotLast** is treated as **Butt**).

The cap-style defines how the endpoints of a path are drawn:

NotLast	The result is equivalent to **Butt**, except that for a line-width of zero the final endpoint is not drawn.
Butt	The result is square at the endpoint (perpendicular to the slope of the line) with no projection beyond.
Round	The result is a circular arc with its diameter equal to the line-width, centered on the endpoint; it is equivalent to **Butt** for line-width zero.
Projecting	The result is square at the end, but the path continues beyond the endpoint for a distance equal to half the line-width; it is equivalent to **Butt** for line-width zero.

The join-style defines how corners are drawn for wide lines:

Miter	The outer edges of the two lines extend to meet at an angle. However, if the angle is less than 11 degrees, a **Bevel** join-style is used instead.
Round	The result is a circular arc with a diameter equal to the line-width, centered on the joinpoint.
Bevel	The result is **Butt** endpoint styles, and then the triangular "notch" is filled.

For a line with coincident endpoints (x1=x2, y1=y2), when the cap-style is applied to both endpoints, the semantics depends on the line-width and the cap-style:

NotLast	thin	This is device-dependent, but the desired effect is that nothing is drawn.
Butt	thin	This is device-dependent, but the desired effect is that a single pixel is drawn.
Round	thin	This is the same as **Butt**/thin.
Projecting	thin	This is the same as **Butt**/thin.
Butt	wide	Nothing is drawn.
Round	wide	The closed path is a circle, centered at the endpoint and with a diameter equal to the line-width.
Projecting	wide	The closed path is a square, aligned with the coordinate axes, centered at the endpoint and with sides equal to the line-width.

For a line with coincident endpoints (x1=x2, y1=y2), when the join-style is applied at one or both endpoints, the effect is as if the line was removed from the overall path. However, if the total path consists of (or is reduced to) a single point joined with itself, the effect is the same as when the cap-style is applied at both endpoints.

The tile/stipple and clip origins are interpreted relative to the origin of whatever destination drawable is specified in a graphics request.

The tile pixmap must have the same root and depth as the gcontext (or a **Match** error results). The stipple pixmap must have depth one and must have the same root as the gcontext (or a **Match** error results). For fill-style **Stippled** (but not fill-style **OpaqueStippled**), the stipple pattern is tiled in a single plane and acts as an additional clip mask to be ANDed with the clip-mask. Any size pixmap can be used for tiling or stippling, although some sizes may be faster to use than others.

The fill-style defines the contents of the source for line, text, and fill requests. For all text and fill requests (for example, **PolyText8**, **PolyText16**, **PolyFillRectangle**, **FillPoly**, and **PolyFillArc**) as well as for line requests with line-style **Solid**, (for example, **PolyLine**, **PolySegment**, **PolyRectangle**, **PolyArc**) and for the even dashes for line requests with line-style **OnOffDash** or **DoubleDash**:

Solid	Foreground
Tiled	Tile
OpaqueStippled	A tile with the same width and height as stipple but with background everywhere stipple has a zero and with foreground everywhere stipple has a one
Stippled	Foreground masked by stipple

For the odd dashes for line requests with line-style **DoubleDash**:

Solid	Background
Tiled	Same as for even dashes
OpaqueStippled	Same as for even dashes
Stippled	Background masked by stipple

The dashes value allowed here is actually a simplified form of the more general patterns that can be set with **SetDashes**. Specifying a value of N here is equivalent to specifying the two element list [N, N] in **SetDashes**. The value must be nonzero (or a **Value** error results). The meaning of dash-offset and dashes are explained in the **SetDashes** request.

The clip-mask restricts writes to the destination drawable. Only pixels where the clip-mask has bits set to 1 are drawn. Pixels are not drawn outside the area covered by the clip-mask or where the clip-mask has bits set to 0. The clip-mask affects all graphics requests, but it does not clip sources. The clip-mask origin is interpreted relative to the origin of whatever destination drawable is specified in a graphics request. If a pixmap is specified as the clip-mask, it must have depth 1 and have the same root as the gcontext (or a **Match** error results). If clip-mask is **None**, then pixels are always drawn, regardless of the clip origin. The clip-mask can also be set with the **SetClipRectangles** request.

For **ClipByChildren**, both source and destination windows are additionally clipped by all viewable **InputOutput** children. For **IncludeInferiors**, neither source nor destination window is clipped by inferiors. This will result in including subwindow contents in the source and drawing through subwindow boundaries of the destination. The use of **IncludeInferiors** with a source or destination window of one depth with mapped inferiors of differing depth is not illegal, but the semantics is undefined by the core protocol.

The fill-rule defines what pixels are inside (that is, are drawn) for paths given in **FillPoly** requests. **EvenOdd** means a point is inside if an infinite ray with the point as origin crosses the path an odd number of times. For **Winding**, a point is inside if an infinite ray with the point as origin crosses an unequal number of clockwise and counterclockwise directed path segments. A clockwise directed path segment is one that crosses the ray from left to right as observed from the point. A counter-clockwise segment is one that crosses the ray from right to left as observed from the point. The case where a directed line segment is coincident with the ray is uninteresting because one can simply choose a different ray that is not coincident with a segment.

For both fill rules, a point is infinitely small and the path is an infinitely thin line. A pixel is inside if the center point of the pixel is inside and the center point is not on the boundary. If the center point is on the boundary, the pixel is inside if and only if the polygon interior is immediately to its right (x increasing direction). Pixels with centers along a horizontal edge are a special case and are inside if and only if the polygon interior is immediately below (y increasing direction).

The arc-mode controls filling in the **PolyFillArc** request.

The graphics-exposures flag controls **GraphicsExposure** event generation for **CopyArea** and **CopyPlane** requests (and any similar requests defined by extensions).

The default component values are:

Component	Default
function	**Copy**
plane-mask	all ones
foreground	0
background	1
line-width	0
line-style	**Solid**
cap-style	**Butt**
join-style	**Miter**
fill-style	**Solid**
fill-rule	**EvenOdd**
arc-mode	**PieSlice**
tile	Pixmap of unspecified size filled with foreground pixel (that is, client specified pixel if any, else 0) (subsequent changes to foreground do not affect this pixmap)
stipple	Pixmap of unspecified size filled with ones
tile-stipple-x-origin	0
tile-stipple-y-origin	0
font	<server-dependent-font>
subwindow-mode	**ClipByChildren**
graphics-exposures	**True**
clip-x-origin	0
clip-y-origin	0

Component	Default
clip-mask	**None**
dash-offset	0
dashes	4 (that is, the list [4, 4])

Storing a pixmap in a gcontext might or might not result in a copy being made. If the pixmap is later used as the destination for a graphics request, the change might or might not be reflected in the gcontext. If the pixmap is used simultaneously in a graphics request as both a destination and as a tile or stipple, the results are not defined.

It is quite likely that some amount of gcontext information will be cached in display hardware and that such hardware can only cache a small number of gcontexts. Given the number and complexity of components, clients should view switching between gcontexts with nearly identical state as significantly more expensive than making minor changes to a single gcontext.

ChangeGC

gc: GCONTEXT
value-mask: BITMASK
value-list: LISTofVALUE

Errors: **GContext**, **Pixmap**, **Font**, **Match**, **Value**, **Alloc**

This request changes components in gc. The value-mask and value-list specify which components are to be changed. The values and restrictions are the same as for **CreateGC**.

Changing the clip-mask also overrides any previous **SetClipRectangles** request on the context. Changing dash-offset or dashes overrides any previous **SetDashes** request on the context.

The order in which components are verified and altered is server-dependent. If an error is generated, a subset of the components may have been altered.

CopyGC

src-gc, dst-gc: GCONTEXT
value-mask: BITMASK

Errors: **GContext**, **Value**, **Match**, **Alloc**

This request copies components from src-gc to dst-gc. The value-mask specifies which components to copy, as for **CreateGC**. The two gcontexts must have the same root and the same depth (or a **Match** error results).

SetDashes

gc: GCONTEXT
dash-offset: CARD16
dashes: LISTofCARD8

Errors: **GContext**, **Value**, **Alloc**

This request sets dash-offset and dashes in gc for dashed line styles. Dashes cannot be empty (or a **Value** error results). Specifying an odd-length list is equivalent to specifying the same list concatenated with itself to produce an even-length list. The initial and alternating elements of dashes are the even dashes; the others are the odd dashes. Each element specifies a dash length in pixels. All of the elements must be nonzero (or a **Value** error results). The dash-offset defines the phase of the pattern, specifying how many pixels into dashes the pattern should actually begin in any single graphics request. Dashing is continuous through path elements combined with a join-style, but it is reset to the dash-offset each time a cap-style is applied at a line endpoint.

The unit of measure for dashes is the same as in the ordinary coordinate system. Ideally, a dash length is measured along the slope of the line, but implementations are only required to match this ideal for horizontal and vertical lines. Failing the ideal semantics, it is suggested that the length be measured along the major axis of the line. The major axis is defined as the x axis for lines drawn at an angle of between –45 and +45 degrees or between 315 and 225 degrees from the x axis. For all other lines, the major axis is the y axis.

SetClipRectangles

gc: GCONTEXT
clip-x-origin, clip-y-origin: INT16
rectangles: LISTofRECTANGLE
ordering: {**UnSorted**, **YSorted**, **YXSorted**, **YXBanded**}

Errors: **GContext**, **Value**, **Alloc**, **Match**

This request changes clip-mask in gc to the specified list of rectangles and sets the clip origin. Output will be clipped to remain contained within the rectangles. The clip origin is interpreted relative to the origin of whatever destination drawable is specified in a graphics request. The rectangle coordinates are interpreted relative to the clip origin. The rectangles should be nonintersecting, or graphics results will be undefined. Note that the list of rectangles can be empty, which effectively disables output. This is the opposite of passing **None** as the clip-mask in **CreateGC** and **ChangeGC**.

If known by the client, ordering relations on the rectangles can be specified with the ordering argument. This may provide faster operation by the server. If an incorrect ordering is specified, the server may generate a **Match** error, but it is not required to do so. If no error is generated, the graphics results are undefined. **UnSorted** means that the rectangles are in arbitrary order. **YSorted** means that the rectangles are nondecreasing in their Y origin. **YXSorted** additionally constrains **YSorted** order in that all rectangles with an equal Y origin are nondecreasing in their X origin. **YXBanded** additionally constrains **YXSorted** by requiring that, for every possible Y scanline, all rectangles that include that scanline have identical Y origins and Y extents.

FreeGC

gc: GCONTEXT

Errors: **GContext**

This request deletes the association between the resource ID and the gcontext and destroys the gcontext.

ClearArea

window: WINDOW
x, y: INT16
width, height: CARD16
exposures: BOOL

Errors: **Window**, **Value**, **Match**

The x and y coordinates are relative to the window's origin and specify the upper-left corner of the rectangle. If width is zero, it is replaced with the current width of the window minus x. If height is zero, it is replaced with the current height of the window minus y. If the window has a defined background tile, the rectangle is tiled with a plane-mask of all ones and function of **Copy** and a subwindow-mode of **ClipByChildren**. If the window has background **None**, the contents of the window are not changed. In either case, if exposures is **True**, then one or more exposure events are generated for regions of the rectangle that are either visible or are being retained in a backing store.

It is a **Match** error to use an **InputOnly** window in this request.

CopyArea

src-drawable, dst-drawable: DRAWABLE
gc: GCONTEXT
src-x, src-y: INT16
width, height: CARD16
dst-x, dst-y: INT16

Errors: **Drawable**, **GContext**, **Match**

This request combines the specified rectangle of src-drawable with the specified rectangle of dst-drawable. The src-x and src-y coordinates are relative to src-drawable's origin. The dst-x and dst-y are relative to dst-drawable's origin, each pair specifying the upper-left corner of the rectangle. The src-drawable must have the same root and the same depth as dst-drawable (or a **Match** error results).

If regions of the source rectangle are obscured and have not been retained in backing store or if regions outside the boundaries of the source drawable are specified, then those regions are not copied, but the following occurs on all corresponding destination regions that are either visible or are retained in backing-store. If the dst-drawable is a window with a background other than **None**, these corresponding destination regions are tiled (with plane-mask of all ones and function **Copy**) with that background. Regardless of tiling and whether the destination is a window or a pixmap, if graphics-exposures in gc is **True**, then **GraphicsExposure** events for all corresponding destination regions are generated.

If graphics-exposures is **True** but no **GraphicsExposure** events are generated, then a **NoExposure** event is generated.

GC components: function, plane-mask, subwindow-mode, graphics-exposures, clip-x-origin, clip-y-origin, clip-mask

CopyPlane

src-drawable, dst-drawable: DRAWABLE
gc: GCONTEXT
src-x, src-y: INT16
width, height: CARD16
dst-x, dst-y: INT16
bit-plane: CARD32

Errors: **Drawable**, **GContext**, **Value**, **Match**

The src-drawable must have the same root as dst-drawable (or a **Match** error results), but it need not have the same depth. The bit-plane must have exactly one bit set to 1 and the value of bit-plane must be less than 2^n where n is the depth of src-drawable (or a **Value** error results). Effectively, a pixmap of the same depth as dst-drawable and with size specified by the source region is formed using the foreground/background pixels in gc (foreground everywhere the bit-plane in src-drawable contains a bit set to 1, background everywhere the bit-plane contains a bit set to 0), and the equivalent of a **CopyArea** is performed, with all the same exposure semantics. This can also be thought of as using the specified region of the source bit-plane as a stipple with a fill-style of **OpaqueStippled** for filling a rectangular area of the destination.

GC components: function, plane-mask, foreground, background, subwindow-mode, graphics-exposures, clip-x-origin, clip-y-origin, clip-mask

PolyPoint

drawable: DRAWABLE
gc: GCONTEXT
coordinate-mode: {**Origin**, **Previous**}
points: LISTofPOINT

Errors: **Drawable**, **GContext**, **Value**, **Match**

This request combines the foreground pixel in gc with the pixel at each point in the drawable. The points are drawn in the order listed.

The first point is always relative to the drawable's origin. The rest are relative either to that origin or the previous point, depending on the coordinate-mode.

GC components: function, plane-mask, foreground, subwindow-mode, clip-x-origin, clip-y-origin, clip-mask

PolyLine

drawable: DRAWABLE
gc: GCONTEXT
coordinate-mode: {**Origin**, **Previous**}
points: LISTofPOINT

Errors: **Drawable**, **GContext**, **Value**, **Match**

This request draws lines between each pair of points (point[i], point[i+1]). The lines are drawn in the order listed. The lines join correctly at all intermediate points, and if the first and last points coincide, the first and last lines also join correctly.

For any given line, no pixel is drawn more than once. If thin (zero line-width) lines intersect, the intersecting pixels are drawn multiple times. If wide lines intersect, the intersecting pixels are drawn only once, as though the entire **PolyLine** were a single filled shape.

The first point is always relative to the drawable's origin. The rest are relative either to that origin or the previous point, depending on the coordinate-mode.

GC components: function, plane-mask, line-width, line-style, cap-style, join-style, fill-style, subwindow-mode, clip-x-origin, clip-y-origin, clip-mask

GC mode-dependent components: foreground, background, tile, stipple, tile-stipple-x-origin, tile-stipple-y-origin, dash-offset, dashes

PolySegment

drawable: DRAWABLE
gc: GCONTEXT
segments: LISTofSEGMENT

where:

SEGMENT: [x1, y1, x2, y2: INT16]

Errors: **Drawable**, **GContext**, **Match**

For each segment, this request draws a line between [x1, y1] and [x2, y2]. The lines are drawn in the order listed. No joining is performed at coincident endpoints. For any given line, no pixel is drawn more than once. If lines intersect, the intersecting pixels are drawn multiple times.

GC components: function, plane-mask, line-width, line-style, cap-style, fill-style, subwindow-mode, clip-x-origin, clip-y-origin, clip-mask

GC mode-dependent components: foreground, background, tile, stipple, tile-stipple-x-origin, tile-stipple-y-origin, dash-offset, dashes

PolyRectangle

drawable: DRAWABLE
gc: GCONTEXT
rectangles: LISTofRECTANGLE

Errors: **Drawable**, **GContext**, **Match**

This request draws the outlines of the specified rectangles, as if a five-point **PolyLine** were specified for each rectangle:

[x,y] [x+width,y] [x+width,y+height] [x,y+height] [x,y]

The x and y coordinates of each rectangle are relative to the drawable's origin and define the upper-left corner of the rectangle.

The rectangles are drawn in the order listed. For any given rectangle, no pixel is drawn more than once. If rectangles intersect, the intersecting pixels are drawn multiple times.

GC components: function, plane-mask, line-width, line-style, join-style, fill-style, subwindow-mode, clip-x-origin, clip-y-origin, clip-mask

GC mode-dependent components: foreground, background, tile, stipple, tile-stipple-x-origin, tile-stipple-y-origin, dash-offset, dashes

PolyArc

drawable: DRAWABLE
gc: GCONTEXT
arcs: LISTofARC

Errors: **Drawable**, **GContext**, **Match**

This request draws circular or elliptical arcs. Each arc is specified by a rectangle and two angles. The angles are signed integers in degrees scaled by 64, with positive indicating counterclockwise motion and negative indicating clockwise motion. The start of the arc is specified by angle1 relative to the three-o'clock position from the center of the rectangle, and the path and extent of the arc is specified by angle2 relative to the start of the arc. If the magnitude of angle2 is greater than 360 degrees, it is truncated to 360 degrees. The x and y coordinates of the rectangle are relative to the origin of the drawable. For an arc specified as [x,y,w,h,a1,a2], the origin of the major and minor axes is at [x+(w/2),y+(h/2)], and the infinitely thin path describing the entire circle/ellipse intersects the horizontal axis at [x,y+(h/2)] and [x+w,y+(h/2)] and intersects the vertical axis at [x+(w/2),y] and [x+(w/2),y+h]. These coordinates can be fractional; that is, they are not truncated to discrete coordinates. The path should be defined by the ideal mathematical path. For a wide line with line-width lw, the bounding outlines for filling are given by the two infinitely thin paths consisting of all points whose perpendicular distance from the path of the circle/ellipse is equal to lw/2 (which may be a fractional value). The cap-style and join-style are applied the same as for a line corresponding to the tangent of the circle/ellipse at the endpoint.

For an arc specified as [x,y,w,h,a1,a2], the angles must be specified in the effectively skewed coordinate system of the ellipse (for a circle, the angles and coordinate systems are identical). The relationship between these angles and angles expressed in the normal coordinate system of the screen (as measured with a protractor) is as follows:

skewed-angle = atan(tan(normal-angle) * w/h) + adjust

The skewed-angle and normal-angle are expressed in radians (rather than in degrees scaled by 64) in the range [0,2*PI). The atan returns a value in the range [-PI/2,PI/2]. The adjust is:

0	for normal-angle in the range	[0,PI/2)
PI	for normal-angle in the range	[PI/2,(3*PI)/2)
2*PI	for normal-angle in the range	[(3*PI)/2,2*PI)

The arcs are drawn in the order listed. If the last point in one arc coincides with the first point in the following arc, the two arcs will join correctly. If the first point in the first arc coincides with the last point in the last arc, the two arcs will join correctly. For any given arc, no pixel is drawn more than once. If two arcs join correctly and the line-width is greater than zero and the arcs intersect, no pixel is drawn more than once. Otherwise, the intersecting pixels of intersecting arcs are drawn multiple times. Specifying an arc with one endpoint and a clockwise extent draws the same pixels as specifying the other endpoint and an equivalent counter-clockwise extent, except as it affects joins.

By specifying one axis to be zero, a horizontal or vertical line can be drawn.

Angles are computed based solely on the coordinate system, ignoring the aspect ratio.

GC components: function, plane-mask, line-width, line-style, cap-style, join-style, fill-style, subwindow-mode, clip-x-origin, clip-y-origin, clip-mask

GC mode-dependent components: foreground, background, tile, stipple, tile-stipple-x-origin, tile-stipple-y-origin, dash-offset, dashes

FillPoly

drawable: DRAWABLE
gc: GCONTEXT
shape: {**Complex**, **Nonconvex**, **Convex**}
coordinate-mode: {**Origin**, **Previous**}
points: LISTofPOINT

Errors: **Drawable**, **GContext**, **Match**, **Value**

This request fills the region closed by the specified path. The path is closed automatically if the last point in the list does not coincide with the first point. No pixel of the region is drawn more than once.

The first point is always relative to the drawable's origin. The rest are relative either to that origin or the previous point, depending on the coordinate-mode.

The shape parameter may be used by the server to improve performance. **Complex** means the path may self-intersect.

Nonconvex means the path does not self-intersect, but the shape is not wholly convex. If known by the client, specifying **Nonconvex** over **Complex** may improve performance. If **Nonconvex** is specified for a self-intersecting path, the graphics results are undefined.

Convex means the path is wholly convex. If known by the client, specifying **Convex** can improve performance. If **Convex** is specified for a path that is not convex, the graphics results are undefined.

GC components: function, plane-mask, fill-style, fill-rule, subwindow-mode, clip-x-origin, clip-y-origin, clip-mask

GC mode-dependent components: foreground, background, tile, stipple, tile-stipple-x-origin, tile-stipple-y-origin

PolyFillRectangle

drawable: DRAWABLE
gc: GCONTEXT
rectangles: LISTofRECTANGLE

Errors: **Drawable**, **GContext**, **Match**

This request fills the specified rectangles, as if a four-point **FillPoly** were specified for each rectangle:

[x,y] [x+width,y] [x+width,y+height] [x,y+height]

The x and y coordinates of each rectangle are relative to the drawable's origin and define the upper-left corner of the rectangle.

The rectangles are drawn in the order listed. For any given rectangle, no pixel is drawn more than once. If rectangles intersect, the intersecting pixels are drawn multiple times.

GC components: function, plane-mask, fill-style, subwindow-mode, clip-x-origin, clip-y-origin, clip-mask

GC mode-dependent components: foreground, background, tile, stipple, tile-stipple-x-origin, tile-stipple-y-origin

PolyFillArc

drawable: DRAWABLE
gc: GCONTEXT
arcs: LISTofARC

Errors: **Drawable**, **GContext**, **Match**

For each arc, this request fills the region closed by the infinitely thin path described by the specified arc and one or two line segments, depending on the arc-mode. For **Chord**, the single line segment joining the endpoints of the arc is used. For **PieSlice**, the two line segments joining the endpoints of the arc with the center point are used. The arcs are as specified in the **PolyArc** request.

The arcs are filled in the order listed. For any given arc, no pixel is drawn more than once. If regions intersect, the intersecting pixels are drawn multiple times.

GC components: function, plane-mask, fill-style, arc-mode, subwindow-mode, clip-x-origin, clip-y-origin, clip-mask

GC mode-dependent components: foreground, background, tile, stipple, tile-stipple-x-origin, tile-stipple-y-origin

PutImage

drawable: DRAWABLE
gc: GCONTEXT
depth: CARD8
width, height: CARD16
dst-x, dst-y: INT16
left-pad: CARD8
format: {**Bitmap**, **XYPixmap**, **ZPixmap**}
data: LISTofBYTE

Errors: **Drawable**, **GContext**, **Match**, **Value**

This request combines an image with a rectangle of the drawable. The dst-x and dst-y coordinates are relative to the drawable's origin.

If **Bitmap** format is used, then depth must be one (or a **Match** error results), and the image must be in XY format. The foreground pixel in gc defines the source for bits set to 1 in the image, and the background pixel defines the source for the bits set to 0.

For **XYPixmap** and **ZPixmap**, the depth must match the depth of the drawable (or a **Match** error results). For **XYPixmap**, the image must be sent in XY format. For **ZPixmap**, the image must be sent in the Z format defined for the given depth.

The left-pad must be zero for **ZPixmap** format (or a **Match** error results). For **Bitmap** and **XYPixmap** format, left-pad must be less than bitmap-scanline-pad as given in the server connection setup information (or a **Match** error results). The first left-pad bits in every scanline are to be ignored by the server. The actual image begins that many bits into the data. The width argument defines the width of the actual image and does not include left-pad.

GC components: function, plane-mask, subwindow-mode, clip-x-origin, clip-y-origin, clip-mask

GC mode-dependent components: foreground, background

GetImage

drawable: DRAWABLE
x, y: INT16
width, height: CARD16
plane-mask: CARD32
format: {**XYPixmap**, **ZPixmap**}

=>

depth: CARD8
visual: VISUALID or **None**
data: LISTofBYTE

Errors: **Drawable**, **Value**, **Match**

This request returns the contents of the given rectangle of the drawable in the given format. The x and y coordinates are relative to the drawable's origin and define the upper-left corner of the rectangle. If **XYPixmap** is specified, only the bit planes specified in plane-mask are transmitted, with the planes appearing from most-significant to least-significant in bit order. If **ZPixmap** is specified, then bits in all planes not specified in plane-mask are transmitted as zero. Range checking is not performed on plane-mask; extraneous bits are simply ignored. The returned depth is as specified when the drawable was created and is the same as a depth component in a FORMAT structure (in the connection setup), not a bits-per-pixel component. If the drawable is a window, its visual type is returned. If the drawable is a pixmap, the visual is **None**.

If the drawable is a pixmap, then the given rectangle must be wholly contained within the pixmap (or a **Match** error results). If the drawable is a window, the window must be viewable, and it must be the case that, if there were no inferiors or overlapping windows, the specified rectangle of the window would be fully visible on the screen and wholly contained within the outside edges of the window (or a **Match** error results). Note that the borders of the window can be included and read with this request. If the window has a backing store, then the backing-store contents are returned for regions of the window that are obscured by noninferior windows; otherwise, the returned contents of such obscured regions are undefined. Also undefined are the returned contents of visible regions of inferiors of different depth than the specified window. The pointer cursor image is not included in the contents returned.

This request is not general-purpose in the same sense as other graphics-related requests. It is intended specifically for rudimentary hardcopy support.

PolyText8

drawable: DRAWABLE
gc: GCONTEXT
x, y: INT16
items: LISTofTEXTITEM8

where:

TEXTITEM8:	TEXTELT8 or FONT
TEXTELT8:	[delta: INT8 string: STRING8]

Errors: **Drawable**, **GContext**, **Match**, **Font**

The x and y coordinates are relative to the drawable's origin and specify the baseline starting position (the initial character origin). Each text item is processed in turn. A font item causes the font to be stored in gc and to be used for subsequent text. Switching among fonts does not affect the next character origin. A text element delta specifies an additional change in the position along the x axis before the string is drawn; the delta is always added to the character origin. Each character image, as defined by the font in gc, is treated as an additional mask for a fill operation on the drawable.

All contained FONTs are always transmitted most-significant byte first.

If a **Font** error is generated for an item, the previous items may have been drawn.

For fonts defined with 2-byte matrix indexing, each STRING8 byte is interpreted as a byte2 value of a CHAR2B with a byte1 value of zero.

GC components: function, plane-mask, fill-style, font, subwindow-mode, clip-x-origin, clip-y-origin, clip-mask

GC mode-dependent components: foreground, background, tile, stipple, tile-stipple-x-origin, tile-stipple-y-origin

PolyText16

drawable: DRAWABLE
gc: GCONTEXT
x, *y*: INT16
items: LISTofTEXTITEM16

where:

TEXTITEM16:	TEXTELT16 or FONT
TEXTELT16:	[delta: INT8 string: STRING16]

Errors: **Drawable**, **GContext**, **Match**, **Font**

This request is similar to **PolyText8**, except 2-byte (or 16-bit) characters are used. For fonts defined with linear indexing rather than 2-byte matrix indexing, the server will interpret each CHAR2B as a 16-bit number that has been transmitted most-significant byte first (that is, byte1 of the CHAR2B is taken as the most-significant byte).

ImageText8

drawable: DRAWABLE
gc: GCONTEXT
x, *y*: INT16
string: STRING8

Errors: **Drawable**, **GContext**, **Match**

The x and y coordinates are relative to the drawable's origin and specify the baseline starting position (the initial character origin). The effect is first to fill a destination rectangle with the background pixel defined in gc and then to paint the text with the foreground pixel. The upper-left corner of the filled rectangle is at:

[x, y – font-ascent]

the width is:

overall-width

and the height is:

font-ascent + font-descent

The overall-width, font-ascent, and font-descent are as they would be returned by a **QueryTextExtents** call using gc and string.

The function and fill-style defined in gc are ignored for this request. The effective function is **Copy**, and the effective fill-style **Solid**.

For fonts defined with 2-byte matrix indexing, each STRING8 byte is interpreted as a byte2 value of a CHAR2B with a byte1 value of zero.

GC components: plane-mask, foreground, background, font, subwindow-mode, clip-x-origin, clip-y-origin, clip-mask

ImageText16

drawable: DRAWABLE
gc: GCONTEXT
x, *y*: INT16
string: STRING16

Errors: **Drawable**, **GContext**, **Match**

This request is similar to **ImageText8**, except 2-byte (or 16-bit) characters are used. For fonts defined with linear indexing rather than 2-byte matrix indexing, the server will interpret each CHAR2B as a 16-bit number that has been transmitted most-significant byte first (that is, byte1 of the CHAR2B is taken as the most-significant byte).

CreateColormap

mid: COLORMAP
visual: VISUALID
window: WINDOW
alloc: {**None**, **All**}

Errors: **IDChoice**, **Window**, **Value**, **Match**, **Alloc**

This request creates a colormap of the specified visual type for the screen on which the window resides and associates the identifier mid with it. The visual type must be one supported by the screen (or a **Match** error results). The initial values of the colormap entries are undefined for classes **GrayScale**, **PseudoColor**, and **DirectColor**. For **StaticGray**, **StaticColor**, and **TrueColor**, the entries will have defined values, but those values are specific to the visual and are not defined by the core protocol. For **StaticGray**, **StaticColor**, and **TrueColor**, alloc must be specified as **None** (or a **Match** error results). For the other classes, if alloc is **None**, the colormap initially has no allocated entries, and clients can allocate entries.

If alloc is **All**, then the entire colormap is "allocated" writable. The initial values of all allocated entries are undefined. For **GrayScale** and **PseudoColor**, the effect is as if an **AllocColorCells** request returned all pixel values from zero to N – 1, where N is the colormap-entries value in the specified visual. For **DirectColor**, the effect is as if an **AllocColorPlanes** request returned a pixel value of zero and red-mask, green-mask, and blue-mask values containing the same bits as the corresponding masks in the specified visual. However, in all cases, none of these entries can be freed with **FreeColors**.

FreeColormap

cmap: COLORMAP

Errors: **Colormap**

This request deletes the association between the resource ID and the colormap and frees the colormap storage. If the colormap is an installed map for a screen, it is uninstalled (see **UninstallColormap** request). If the colormap is defined as the colormap for a window (by means of **CreateWindow** or **ChangeWindowAttributes**), the colormap for the window is changed to **None**, and a **ColormapNotify** event is generated. The protocol does not define the colors displayed for a window with a colormap of **None**.

This request has no effect on a default colormap for a screen.

CopyColormapAndFree

mid, src-cmap: COLORMAP

Errors: **IDChoice**, **Colormap**, **Alloc**

This request creates a colormap of the same visual type and for the same screen as src-cmap, and it associates identifier mid with it. It also moves all of the client's existing allocations from src-cmap to the new colormap with their color values intact and their read-only or writable characteristics intact, and it frees those entries in src-cmap. Color values in other entries in the new colormap are undefined. If src-cmap was created by the client with alloc **All** (see **CreateColormap** request), then the new colormap is also created with alloc **All**, all color values for all entries are copied from src-cmap, and then all entries in src-cmap are freed. If src-cmap was not created by the client with alloc **All**, then the allocations to be moved are all those pixels and planes that have been allocated by the client using either **AllocColor**, **AllocNamedColor**, **AllocColorCells**, or **AllocColorPlanes** and that have not been freed since they were allocated.

InstallColormap

cmap: COLORMAP

Errors: **Colormap**

This request makes this colormap an installed map for its screen. All windows associated with this colormap immediately display with true colors. As a side effect, additional colormaps might be implicitly installed or uninstalled by the server. Which other colormaps get installed or uninstalled is server-dependent except that the required list must remain installed.

If cmap is not already an installed map, a **ColormapNotify** event is generated on every window having cmap as an attribute. In addition, for every other colormap that is installed or uninstalled as a result of the request, a **ColormapNotify** event is generated on every window having that colormap as an attribute.

At any time, there is a subset of the installed maps that are viewed as an ordered list and are called the required list. The length of the required list is at most M, where M is the min-installed-maps specified for the screen in the connection setup. The required list is maintained as follows. When a colormap is an explicit argument to **InstallColormap**, it is added to the head of the list; the list is truncated at the tail, if necessary, to keep the length of the list to at most M. When a colormap is an explicit argument to **UninstallColormap** and it is in the required list, it is removed from the list. A colormap is not added to the required list when it is installed implicitly by the server, and the server cannot implicitly uninstall a colormap that is in the required list.

Initially the default colormap for a screen is installed (but is not in the required list).

UninstallColormap

cmap: COLORMAP

Errors: **Colormap**

If cmap is on the required list for its screen (see **InstallColormap** request), it is removed from the list. As a side effect, cmap might be uninstalled, and additional colormaps might be implicitly installed or uninstalled. Which colormaps get installed or uninstalled is server-dependent except that the required list must remain installed.

If cmap becomes uninstalled, a **ColormapNotify** event is generated on every window having cmap as an attribute. In addition, for every other colormap that is installed or uninstalled as a result of the request, a **ColormapNotify** event is generated on every window having that colormap as an attribute.

ListInstalledColormaps

window: WINDOW

=>

cmaps: LISTofCOLORMAP

Errors: **Window**

This request returns a list of the currently installed colormaps for the screen of the specified window. The order of colormaps is not significant, and there is no explicit indication of the required list (see **InstallColormap** request).

AllocColor

cmap: COLORMAP
red, green, blue: CARD16

=>

pixel: CARD32
red, green, blue: CARD16

Errors: **Colormap**, **Alloc**

This request allocates a read-only colormap entry corresponding to the closest RGB values provided by the hardware. It also returns the pixel and the RGB values actually used.

AllocNamedColor

cmap: COLORMAP
name: STRING8

=>

pixel: CARD32
exact-red, exact-green, exact-blue: CARD16
visual-red, visual-green, visual-blue: CARD16

Errors: **Colormap**, **Name**, **Alloc**

This request looks up the named color with respect to the screen associated with the colormap. Then, it does an **AllocColor** on cmap. The name should use the ISO Latin-1 encoding, and uppercase and lowercase do not matter. The exact RGB values specify the true values for the color, and the visual values specify the values actually used in the colormap.

AllocColorCells

cmap: COLORMAP
colors, planes: CARD16
contiguous: BOOL

=>

pixels, masks: LISTofCARD32

Errors: **Colormap**, **Value**, **Alloc**

The number of colors must be positive, and the number of planes must be nonnegative (or a **Value** error results). If C colors and P planes are requested, then C pixels and P masks are returned. No mask will have any bits in common with any other mask or with any of the pixels. By ORing together masks and pixels, $C*2^P$ distinct pixels can be produced; all of these are allocated writable by the request. For **GrayScale** or **PseudoColor**, each mask will have exactly one bit set to 1; for **DirectColor**, each will have exactly three bits set to 1. If contiguous is **True** and if all masks are ORed together, a single contiguous set of bits will be formed for **GrayScale** or **PseudoColor**, and three contiguous sets of bits (one within each pixel subfield) for **DirectColor**. The RGB values of the allocated entries are undefined.

AllocColorPlanes

cmap: COLORMAP
colors, reds, greens, blues: CARD16
contiguous: BOOL

=>

pixels: LISTofCARD32
red-mask, green-mask, blue-mask: CARD32

Errors: **Colormap**, **Value**, **Alloc**

The number of colors must be positive, and the reds, greens, and blues must be nonnegative (or a **Value** error results). If C colors, R reds, G greens, and B blues are requested, then C pixels are returned, and the masks have R, G, and B bits set, respectively. If contiguous is **True**, then each mask will have a contiguous set of bits. No mask will have any bits in common with any other mask or with any of the pixels. For **DirectColor**, each mask will lie within the corresponding pixel subfield. By ORing together subsets of masks with pixels, $C*2^{R+G+B}$ distinct pixels can be produced; all of these are allocated by the request. The initial RGB values of the allocated entries are undefined. In the colormap, there are only $C*2^R$ independent red entries, $C*2^G$ independent green entries, and $C*2^B$ independent blue entries. This is true even for **PseudoColor**. When the colormap entry for a pixel value is changed using **StoreColors** or **StoreNamedColor**, the pixel is decomposed according to the masks and the corresponding independent entries are updated.

FreeColors

cmap: COLORMAP
pixels: LISTofCARD32
plane-mask: CARD32

Errors: **Colormap**, **Access**, **Value**

The plane-mask should not have any bits in common with any of the pixels. The set of all pixels is produced by ORing together subsets of plane-mask with the pixels. The request frees all of these pixels that were allocated by the client (using **AllocColor**, **AllocNamedColor**, **AllocColorCells**, and **AllocColorPlanes**). Note that freeing an individual pixel obtained from **AllocColorPlanes** may not actually allow it to be reused until all of its related pixels are also freed.

All specified pixels that are allocated by the client in cmap are freed, even if one or more pixels produce an error. A **Value** error is generated if a specified pixel is not a valid index into cmap, and an **Access** error is generated if a specified pixel is not allocated by the client (that is, is unallocated or is only allocated by another client). If more than one pixel is in error, it is arbitrary as to which pixel is reported.

StoreColors

cmap: COLORMAP
items: LISTofCOLORITEM

where:

COLORITEM: [pixel: CARD32
do-red, do-green, do-blue: BOOL
red, green, blue: CARD16]

Errors: **Colormap**, **Access**, **Value**

This request changes the colormap entries of the specified pixels. The do-red, do-green, and do-blue fields indicate which components should actually be changed. If the colormap is an installed map for its screen, the changes are visible immediately.

All specified pixels that are allocated writable in cmap (by any client) are changed, even if one or more pixels produce an error. A **Value** error is generated if a specified pixel is not a valid index into cmap, and an **Access** error is generated if a specified pixel is unallocated or is allocated read-only. If more than one pixel is in error, it is arbitrary as to which pixel is reported.

StoreNamedColor

cmap: COLORMAP
pixel: CARD32
name: STRING8
do-red, do-green, do-blue: BOOL

Errors: **Colormap**, **Name**, **Access**, **Value**

This request looks up the named color with respect to the screen associated with cmap and then does a **StoreColors** in cmap. The name should use the ISO Latin-1 encoding, and uppercase and lowercase do not matter. The **Access** and **Value** errors are the same as in **StoreColors**.

QueryColors

cmap: COLORMAP
pixels: LISTofCARD32

=>

colors: LISTofRGB

where:

RGB: [red, green, blue: CARD16]

Errors: **Colormap**, **Value**

This request returns the color values stored in cmap for the specified pixels. The values returned for an unallocated entry are undefined. A **Value** error is generated if a pixel is not a valid index into cmap. If more than one pixel is in error, it is arbitrary as to which pixel is reported.

LookupColor

cmap: COLORMAP
name: STRING8

=>

exact-red, exact-green, exact-blue: CARD16
visual-red, visual-green, visual-blue: CARD16

Errors: **Colormap**, **Name**

This request looks up the string name of a color with respect to the screen associated with cmap and returns both the exact color values and the closest values provided by the hardware with respect to the visual type of cmap. The name should use the ISO Latin-1 encoding, and uppercase and lowercase do not matter.

CreateCursor

cid: CURSOR
source: PIXMAP
mask: PIXMAP or **None**
fore-red, fore-green, fore-blue: CARD16
back-red, back-green, back-blue: CARD16
x, y: CARD16

Errors: **IDChoice**, **Pixmap**, **Match**, **Alloc**

This request creates a cursor and associates identifier cid with it. The foreground and background RGB values must be specified, even if the server only has a **StaticGray** or **GrayScale** screen. The foreground is used for the bits set to 1 in the source, and the background is used for the bits set to 0. Both source and mask (if specified) must have depth one (or a **Match** error results), but they can have any root. The mask pixmap defines the shape of the cursor. That is, the bits set to 1 in the mask define which source pixels will be displayed, and where the mask has bits set to 0, the corresponding bits of the source pixmap are ignored. If no mask is given, all pixels of the source are displayed. The mask, if present, must be the same size as the source (or a **Match** error results). The x and y coordinates define the hotspot relative to the source's origin and must be a point within the source (or a **Match** error results).

The components of the cursor may be transformed arbitrarily to meet display limitations.

The pixmaps can be freed immediately if no further explicit references to them are to be made.

Subsequent drawing in the source or mask pixmap has an undefined effect on the cursor. The server might or might not make a copy of the pixmap.

CreateGlyphCursor

cid: CURSOR
source-font: FONT
mask-font: FONT or **None**
source-char, mask-char: CARD16
fore-red, fore-green, fore-blue: CARD16
back-red, back-green, back-blue: CARD16

Errors: **IDChoice**, **Font**, **Value**, **Alloc**

This request is similar to **CreateCursor**, except the source and mask bitmaps are obtained from the specified font glyphs. The source-char must be a defined glyph in source-font, and if mask-font is given, mask-char must be a defined glyph in mask-font (or a **Value** error results). The mask font and character are optional. The origins of the source and mask (if it is defined) glyphs are positioned coincidently and define the hotspot. The source and mask need not have the same bounding box metrics, and there is no restriction on the placement of the hotspot relative to the bounding boxes. If no mask is given, all pixels of the source are displayed. Note that source-char and mask-char are CARD16, not CHAR2B. For 2-byte matrix fonts, the 16-bit value should be formed with byte1 in the most-significant byte and byte2 in the least-significant byte.

The components of the cursor may be transformed arbitrarily to meet display limitations.

The fonts can be freed immediately if no further explicit references to them are to be made.

FreeCursor

cursor: CURSOR

Errors: **Cursor**

This request deletes the association between the resource ID and the cursor. The cursor storage will be freed when no other resource references it.

RecolorCursor

cursor: CURSOR
fore-red, fore-green, fore-blue: CARD16
back-red, back-green, back-blue: CARD16

Errors: **Cursor**

This request changes the color of a cursor. If the cursor is being displayed on a screen, the change is visible immediately.

QueryBestSize

class: {**Cursor**, **Tile**, **Stipple**}
drawable: DRAWABLE
width, height: CARD16

=>

width, height: CARD16

Errors: **Drawable**, **Value**, **Match**

This request returns the best size that is closest to the argument size. For **Cursor**, this is the largest size that can be fully displayed. For **Tile**, this is the size that can be tiled fastest. For **Stipple**, this is the size that can be stippled fastest.

For **Cursor**, the drawable indicates the desired screen. For **Tile** and **Stipple**, the drawable indicates the screen and also possibly the window class and depth. An **InputOnly** window cannot be used as the drawable for **Tile** or **Stipple** (or a **Match** error results).

QueryExtension

name: STRING8

=>

present: BOOL
major-opcode: CARD8
first-event: CARD8
first-error: CARD8

This request determines if the named extension is present. If so, the major opcode for the extension is returned, if it has one. Otherwise, zero is returned. Any minor opcode and the request formats are specific to the extension. If the extension involves additional event types, the base event type code is returned. Otherwise, zero is returned. The format of the events is specific to the extension. If the extension involves additional error codes, the base error code is returned. Otherwise, zero is returned. The format of additional data in the errors is specific to the extension.

The extension name should use the ISO Latin-1 encoding, and uppercase and lowercase matter.

ListExtensions

=>

names: LISTofSTRING8

This request returns a list of all extensions supported by the server.

SetModifierMapping

keycodes-per-modifier: CARD8
keycodes: LISTofKEYCODE

=>

status: {**Success**, **Busy**, **Failed**}

Errors: **Value**, **Alloc**

This request specifies the keycodes (if any) of the keys to be used as modifiers. The number of keycodes in the list must be 8*keycodes-per-modifier (or a **Length** error results). The keycodes are divided into eight sets, with each set containing keycodes-per-modifier elements. The sets are assigned to the modifiers **Shift**, **Lock**, **Control**, **Mod1**, **Mod2**, **Mod3**, **Mod4**, and **Mod5**, in order. Only nonzero keycode values are used within each set; zero values are ignored. All of the nonzero keycodes must be in the range specified by min-keycode and max-keycode in the connection setup (or a **Value** error results). The order of keycodes within a set does not matter. If no nonzero values are specified in a set, the use of the corresponding modifier is disabled, and the modifier bit will always be zero. Otherwise, the modifier bit will be one whenever at least one of the keys in the corresponding set is in the down position.

A server can impose restrictions on how modifiers can be changed (for example, if certain keys do not generate up transitions in hardware, if auto-repeat cannot be disabled on certain keys, or if multiple keys per modifier are not supported). The status reply is **Failed** if some such restriction is violated, and none of the modifiers are changed.

If the new nonzero keycodes specified for a modifier differ from those currently defined and any (current or new) keys for that modifier are logically in the down state, then the status reply is **Busy**, and none of the modifiers is changed.

This request generates a **MappingNotify** event on a **Success** status.

GetModifierMapping

=>

keycodes-per-modifier: CARD8
keycodes: LISTofKEYCODE

This request returns the keycodes of the keys being used as modifiers. The number of keycodes in the list is 8*keycodes-per-modifier. The keycodes are divided into eight sets, with each set containing keycodes-per-modifier elements. The sets are assigned to the modifiers **Shift**, **Lock**, **Control**, **Mod1**, **Mod2**, **Mod3**, **Mod4**, and **Mod5**, in order. The keycodes-per-modifier value is chosen arbitrarily by the server; zeroes are used to fill in unused elements within each set. If only zero values are given in a set, the use of the corresponding modifier has been disabled. The order of keycodes within each set is chosen arbitrarily by the server.

ChangeKeyboardMapping

first-keycode: KEYCODE
keysyms-per-keycode: CARD8
keysyms: LISTofKEYSYM

Errors: **Value**, **Alloc**

This request defines the symbols for the specified number of keycodes, starting with the specified keycode. The symbols for keycodes outside this range remained unchanged. The number of elements in the keysyms list must be a multiple of keysyms-per-keycode (or a **Length** error results). The first-keycode must be greater than or equal to min-keycode as returned in the connection setup (or a **Value** error results) and:

first-keycode + (keysyms-length / keysyms-per-keycode) – 1

must be less than or equal to max-keycode as returned in the connection setup (or a **Value** error results). KEYSYM number N (counting from zero) for keycode K has an index (counting from zero) of:

(K – first-keycode) * keysyms-per-keycode + N

in keysyms. The keysyms-per-keycode can be chosen arbitrarily by the client to be large enough to hold all desired symbols. A special KEYSYM value of **NoSymbol** should be used to fill in unused elements for individual keycodes. It is legal for **NoSymbol** to appear in nontrailing positions of the effective list for a keycode.

This request generates a **MappingNotify** event.

There is no requirement that the server interpret this mapping; it is merely stored for reading and writing by clients (see section 6).

GetKeyboardMapping

first-keycode: KEYCODE
count: CARD8

=>

keysyms-per-keycode: CARD8
keysyms: LISTofKEYSYM

Errors: **Value**

This request returns the symbols for the specified number of keycodes, starting with the specified keycode. The first-keycode must be greater than or equal to min-keycode as returned in the connection setup (or a **Value** error results), and:

first-keycode + count – 1

must be less than or equal to max-keycode as returned in the connection setup (or a **Value** error results). The number of elements in the keysyms list is:

count * keysyms-per-keycode

and KEYSYM number N (counting from zero) for keycode K has an index (counting from zero) of:

(K – first-keycode) * keysyms-per-keycode + N

in keysyms. The keysyms-per-keycode value is chosen arbitrarily by the server to be large enough to report all requested symbols. A special KEYSYM value of **NoSymbol** is used to fill in unused elements for individual keycodes.

ChangeKeyboardControl

value-mask: BITMASK
value-list: LISTofVALUE

Errors: **Match**, **Value**

This request controls various aspects of the keyboard. The value-mask and value-list specify which controls are to be changed. The possible values are:

Control	Type
key-click-percent	INT8
bell-percent	INT8
bell-pitch	INT16
bell-duration	INT16
led	CARD8
led-mode	{**On**, **Off**}
key	KEYCODE
auto-repeat-mode	{**On**, **Off**, **Default**}

The key-click-percent sets the volume for key clicks between 0 (off) and 100 (loud) inclusive, if possible. Setting to –1 restores the default. Other negative values generate a **Value** error.

The bell-percent sets the base volume for the bell between 0 (off) and 100 (loud) inclusive, if possible. Setting to –1 restores the default. Other negative values generate a **Value** error.

The bell-pitch sets the pitch (specified in Hz) of the bell, if possible. Setting to –1 restores the default. Other negative values generate a **Value** error.

The bell-duration sets the duration of the bell (specified in milliseconds), if possible. Setting to –1 restores the default. Other negative values generate a **Value** error.

If both led-mode and led are specified, then the state of that LED is changed, if possible. If only led-mode is specified, then the state of all LEDs are changed, if possible. At most 32 LEDs, numbered from one, are supported. No standard interpretation of LEDs is defined. It is a **Match** error if an led is specified without an led-mode.

If both auto-repeat-mode and key are specified, then the auto-repeat mode of that key is changed, if possible. If only auto-repeat-mode is specified, then the global auto-repeat mode for the entire keyboard is changed, if possible, without affecting the per-key settings. It is a **Match** error if a key is specified without an auto-repeat-mode. Each key has an individual mode of whether or not it should auto-repeat and a default setting for that mode. In addition, there is a global mode of whether auto-repeat should be enabled or not and a default setting for that mode. When the global mode is **On**, keys should obey their individual auto-repeat modes. When the global mode is **Off**, no keys should auto-repeat. An auto-repeating key generates alternating **KeyPress** and **KeyRelease** events. When a key is used as a modifier, it is desirable for the key not to auto-repeat, regardless of the auto-repeat setting for that key.

A bell generator connected with the console but not directly on the keyboard is treated as if it were part of the keyboard.

The order in which controls are verified and altered is server-dependent. If an error is generated, a subset of the controls may have been altered.

GetKeyboardControl

=>

key-click-percent: CARD8
bell-percent: CARD8
bell-pitch: CARD16
bell-duration: CARD16

led-mask: CARD32
global-auto-repeat: { **On** , **Off** }
auto-repeats: LISTofCARD8

This request returns the current control values for the keyboard. For the LEDs, the least-significant bit of led-mask corresponds to LED one, and each one bit in led-mask indicates an LED that is lit. The auto-repeats is a bit vector; each one bit indicates that auto-repeat is enabled for the corresponding key. The vector is represented as 32 bytes. Byte N (from 0) contains the bits for keys 8N to 8N + 7, with the least-significant bit in the byte representing key 8N.

Bell

percent: INT8

Errors: **Value**

This request rings the bell on the keyboard at a volume relative to the base volume for the keyboard, if possible. Percent can range from –100 to 100 inclusive (or a **Value** error results). The volume at which the bell is rung when percent is nonnegative is:

base – [(base * percent) / 100] + percent

When percent is negative, it is:

base + [(base * percent) / 100]

SetPointerMapping

map: LISTofCARD8

=>

status: { **Success** , **Busy** }

Errors: **Value**

This request sets the mapping of the pointer. Elements of the list are indexed starting from one. The length of the list must be the same as **GetPointerMapping** would return (or a **Value** error results). The index is a core button number, and the element of the list defines the effective number.

A zero element disables a button. Elements are not restricted in value by the number of physical buttons, but no two elements can have the same nonzero value (or a **Value** error results).

If any of the buttons to be altered are logically in the down state, the status reply is **Busy** , and the mapping is not changed.

This request generates a **MappingNotify** event on a **Success** status.

GetPointerMapping

=>

map: LISTofCARD8

This request returns the current mapping of the pointer. Elements of the list are indexed starting from one. The length of the list indicates the number of physical buttons.

The nominal mapping for a pointer is the identity mapping: map[i]=i.

ChangePointerControl

do-acceleration, *do-threshold*: BOOL
acceleration-numerator, *acceleration-denominator*: INT16
threshold: INT16

Errors: **Value**

This request defines how the pointer moves. The acceleration is a multiplier for movement expressed as a fraction. For example, specifying 3/1 means the pointer moves three times as fast as normal. The fraction can be rounded arbitrarily by the server. Acceleration only takes effect if the pointer moves more than threshold number of pixels at once and only applies to the amount beyond the threshold. Setting a value to –1 restores the default. Other negative values generate a **Value** error, as does a zero value for acceleration-denominator.

GetPointerControl

=>

acceleration-numerator, acceleration-denominator: CARD16
threshold: CARD16

This request returns the current acceleration and threshold for the pointer.

SetScreenSaver

timeout, interval: INT16
prefer-blanking: {**Yes**, **No**, **Default**}
allow-exposures: {**Yes**, **No**, **Default**}

Errors: **Value**

The timeout and interval are specified in seconds; setting a value to –1 restores the default. Other negative values generate a **Value** error. If the timeout value is zero, screen-saver is disabled. If the timeout value is nonzero, screen-saver is enabled. Once screen-saver is enabled, if no input from the keyboard or pointer is generated for timeout seconds, screen-saver is activated. For each screen, if blanking is preferred and the hardware supports video blanking, the screen will simply go blank. Otherwise, if either exposures are allowed or the screen can be regenerated without sending exposure events to clients, the screen is changed in a server-dependent fashion to avoid phosphor burn. Otherwise, the state of the screens does not change, and screen-saver is not activated. At the next keyboard or pointer input or at the next **ForceScreenSaver** with mode **Reset**, screen-saver is deactivated, and all screen states are restored.

If the server-dependent screen-saver method is amenable to periodic change, interval serves as a hint about how long the change period should be, with zero hinting that no periodic change should be make. Examples of ways to change the screen include scrambling the color map periodically, moving an icon image about the screen periodically, or tiling the screen with the root window background tile, randomly reorigined periodically.

GetScreenSaver

=>

timeout, interval: CARD16
prefer-blanking: {**Yes**, **No**}
allow-exposures: {**Yes**, **No**}

This request returns the current screen-saver control values.

ForceScreenSaver

mode: {**Activate**, **Reset**}

Errors: **Value**

If the mode is **Activate** and screen-saver is currently deactivated, then screen-saver is activated (even if screen-saver has been disabled with a timeout value of zero). If the mode is **Reset** and screen-saver is currently enabled, then screen-saver is deactivated (if it was activated), and the activation timer is reset to its initial state as if device input had just been received.

ChangeHosts

mode: {**Insert**, **Delete**}
host: HOST

Errors: **Access**, **Value**

This request adds or removes the specified host from the access control list. When the access control mechanism is enabled and a host attempts to establish a connection to the server, the host must be in this list, or the server will refuse the connection.

The client must reside on the same host as the server and/or have been granted permission by a server-dependent method to execute this request (or an **Access** error results).

An initial access control list can usually be specified, typically by naming a file that the server reads at startup and reset.

The following address families are defined. A server is not required to support these families and may support families not listed here. Use of an unsupported family, an improper address format, or an improper address length within a supported family results in a **Value** error.

For the Internet family, the address must be four bytes long. The address bytes are in standard IP order; the server performs no automatic swapping on the address bytes. For a Class A address, the network number is the first byte in the address, and the host number is the remaining three bytes, most-significant byte first. For a Class B address, the network number is the first two bytes and the host number is the last two bytes, each most-significant byte first. For a Class C address, the network number is the first three bytes, most-significant byte first, and the last byte is the host number.

For the DECnet family, the server performs no automatic swapping on the address bytes. A Phase IV address is two bytes long: the first byte contains the least-significant eight bits of the node number, and the second byte contains the most-significant two bits of the node number in the least-significant two bits of the byte and the area in the most significant six bits of the byte.

For the Chaos family, the address must be two bytes long. The host number is always the first byte in the address, and the subnet number is always the second byte. The server performs no automatic swapping on the address bytes.

ListHosts

=>

mode: {**Enabled**, **Disabled**}
hosts: LISTofHOST

This request returns the hosts on the access control list and whether use of the list at connection setup is currently enabled or disabled.

Each HOST is padded to a multiple of four bytes.

SetAccessControl

mode: {**Enable**, **Disable**}

Errors: **Value**, **Access**

This request enables or disables the use of the access control list at connection setups.

The client must reside on the same host as the server and/or have been granted permission by a server-dependent method to execute this request (or an **Access** error results).

SetCloseDownMode

mode: {**Destroy**, **RetainPermanent**, **RetainTemporary**}

Errors: **Value**

This request defines what will happen to the client's resources at connection close. A connection starts in **Destroy** mode. The meaning of the close-down mode is described in section 11.

KillClient

resource: CARD32 or **AllTemporary**

Errors: **Value**

If a valid resource is specified, **KillClient** forces a close-down of the client that created the resource. If the client has already terminated in either **RetainPermanent** or **RetainTemporary** mode, all of the client's resources are destroyed (see section 11). If **AllTemporary** is specified, then the resources of all clients that have terminated in **RetainTemporary** are destroyed.

NoOperation

This request has no arguments and no results, but the request length field can be nonzero, which allows the request to be any multiple of four bytes in length. The bytes contained in the request are uninterpreted by the server.

This request can be used in its minimum four byte form as padding where necessary by client libraries that find it convenient to force requests to begin on 64-bit boundaries.

11. Connection Close

At connection close, all event selections made by the client are discarded. If the client has the pointer actively grabbed, an **UngrabPointer** is performed. If the client has the keyboard actively grabbed, an **UngrabKeyboard** is performed. All passive grabs by the client are released. If the client has the server grabbed, an **UngrabServer** is performed. All selections (see **SetSelectionOwner** request) owned by the client are disowned. If close-down mode (see **SetCloseDownMode** request) is **RetainPermanent** or **RetainTemporary**, then all resources (including colormap entries) allocated by the client are marked as permanent or temporary, respectively (but this does not prevent other clients from explicitly destroying them). If the mode is **Destroy**, all of the client's resources are destroyed.

When a client's resources are destroyed, for each window in the client's save-set, if the window is an inferior of a window created by the client, the save-set window is reparented to the closest ancestor such that the save-set window is not an inferior of a window created by the client. If the save-set window is unmapped, a **MapWindow** request is performed on it (even if it was not an inferior of a window created by the client). The reparenting leaves unchanged the absolute coordinates (with respect to the root window) of the upper-left outer corner of the save-set window. After save-set processing, all windows created by the client are destroyed. For each nonwindow resource created by the client, the appropriate **Free** request is performed. All colors and colormap entries allocated by the client are freed.

A server goes through a cycle of having no connections and having some connections. At every transition to the state of having no connections as a result of a connection closing with a **Destroy** close-down mode, the server resets its state as if it had just been started. This starts by destroying all lingering resources from clients that have terminated in **RetainPermanent** or **RetainTemporary** mode. It additionally includes deleting all but the predefined atom identifiers, deleting all properties on all root windows, resetting all device maps and attributes (key click, bell volume, acceleration), resetting the access control list, restoring the standard root tiles and cursors, restoring the default font path, and restoring the input focus to state **PointerRoot**.

Note that closing a connection with a close-down mode of **RetainPermanent** or **RetainTemporary** will not cause the server to reset.

12. Events

When a button press is processed with the pointer in some window W and no active pointer grab is in progress, the ancestors of W are searched from the root down, looking for a passive grab to activate. If no matching passive grab on the button exists, then an active grab is started automatically for the client receiving the event, and the last-pointer-grab time is set to the current server time. The effect is essentially equivalent to a **GrabButton** with arguments:

Argument	Value
event-window	Event window
event-mask	Client's selected pointer events on the event window
pointer-mode and keyboard-mode	**Asynchronous**
owner-events	**True** if the client has **OwnerGrabButton** selected on the event window, otherwise **False**
confine-to	**None**
cursor	**None**

The grab is terminated automatically when the logical state of the pointer has all buttons released. **UngrabPointer** and **ChangeActivePointerGrab** can both be used to modify the active grab.

KeyPress
KeyRelease
ButtonPress
ButtonRelease
MotionNotify

root, event: WINDOW
child: WINDOW or **None**
same-screen: BOOL
root-x, root-y, event-x, event-y: INT16
detail: <see below>
state: SETofKEYBUTMASK
time: TIMESTAMP

These events are generated either when a key or button logically changes state or when the pointer logically moves. The generation of these logical changes may lag the physical changes if device event processing is frozen. Note that **KeyPress** and **KeyRelease** are generated for all keys, even those mapped to modifier bits. The source of the event is the window the pointer is in. The window the event is reported with respect to is called the event window. The event window is found by starting with the source window and looking up the hierarchy for the first window on which any client has selected interest in the event (provided no intervening window prohibits event generation by including the event type in its do-not-propagate-mask). The actual window used for reporting can be modified by active grabs and, in the case of keyboard events, can be modified by the focus window.

The root is the root window of the source window, and root-x and root-y are the pointer coordinates relative to root's origin at the time of the event. Event is the event window. If the event window is on the same screen as root, then event-x and event-y are the pointer coordinates relative to the event window's origin. Otherwise, event-x and event-y are zero. If the source window is an inferior of the event window, then child is set to the child of the event window that is an ancestor of (or is) the source window. Otherwise, it is set to **None**. The state component gives the logical state of the buttons and modifier keys just before the event. The detail component type varies with the event type:

Event	Component
KeyPress, **KeyRelease**	KEYCODE
ButtonPress, **Button-Release**	BUTTON
MotionNotify	{**Normal**, **Hint**}

MotionNotify events are only generated when the motion begins and ends in the window. The granularity of motion events is not guaranteed, but a client selecting for motion events is guaranteed to get at least one event when the pointer moves and comes to rest. Selecting **PointerMotion** receives events independent of the state of the pointer buttons. By selecting some subset of **Button[1-5]Motion** instead, **MotionNotify** events will only be received when one or more of the specified buttons are pressed. By selecting **ButtonMotion**, **MotionNotify** events will be received only when at least one button is pressed. The events are always of type **MotionNotify**, independent of the selection. If **PointerMotionHint** is selected, the server is free to send only one **MotionNotify** event (with detail **Hint**) to the client for the event window until either the key or button state changes, the pointer leaves the event window, or the client issues a **QueryPointer** or **GetMotionEvents** request.

EnterNotify
LeaveNotify

root, event: WINDOW
child: WINDOW or **None**
same-screen: BOOL
root-x, root-y, event-x, event-y: INT16
mode: {**Normal**, **Grab**, **Ungrab**}
detail: {**Ancestor**, **Virtual**, **Inferior**, **Nonlinear**, **NonlinearVirtual**}
focus: BOOL
state: SETofKEYBUTMASK
time: TIMESTAMP

If pointer motion or window hierarchy change causes the pointer to be in a different window than before, **EnterNotify** and **LeaveNotify** events are generated instead of a **MotionNotify** event. Only clients selecting **EnterWindow** on a window receive **EnterNotify** events, and only clients selecting **LeaveNotify** receive **LeaveNotify** events. The pointer position reported in the event is always the final position, not the initial position of the pointer. The root is the root window for this position, and root-x and root-y are the pointer coordinates relative to root's origin at the time of the event. Event is the event window. If the event window is on the same screen as root, then event-x and event-y are the pointer coordinates relative to the event window's origin. Otherwise, event-x and event-y are zero. In a **LeaveNotify** event, if a child of the event window contains the initial position of the pointer, then the child component is set to that child. Otherwise, it is **None**. For an **EnterNotify** event, if a child of the event window contains the final pointer position, then the child component is set to that child. Otherwise, it is **None**. If the event window is the focus window or an inferior of the focus window, then focus is **True**. Otherwise, focus is **False**.

Normal pointer motion events have mode **Normal**. Pseudo-motion events when a grab activates have mode **Grab**, and pseudo-motion events when a grab deactivates have mode **Ungrab**.

All **EnterNotify** and **LeaveNotify** events caused by a hierarchy change are generated after any hierarchy event caused by that change (that is, **UnmapNotify**, **MapNotify**, **ConfigureNotify**, **GravityNotify**, **CirculateNotify**), but the ordering of **EnterNotify** and **LeaveNotify** events with respect to **FocusOut**, **VisibilityNotify**, and **Expose** events is not constrained.

Normal events are generated as follows:

When the pointer moves from window A to window B and A is an inferior of B:

- **LeaveNotify** with detail **Ancestor** is generated on A.
- **LeaveNotify** with detail **Virtual** is generated on each window between A and B exclusive (in that order).
- **EnterNotify** with detail **Inferior** is generated on B.

When the pointer moves from window A to window B and B is an inferior of A:

- **LeaveNotify** with detail **Inferior** is generated on A.
- **EnterNotify** with detail **Virtual** is generated on each window between A and B exclusive (in that order).
- **EnterNotify** with detail **Ancestor** is generated on B.

When the pointer moves from window A to window B and window C is their least common ancestor:

- **LeaveNotify** with detail **Nonlinear** is generated on A.
- **LeaveNotify** with detail **NonlinearVirtual** is generated on each window between A and C exclusive (in that order).
- **EnterNotify** with detail **NonlinearVirtual** is generated on each window between C and B exclusive (in that order).
- **EnterNotify** with detail **Nonlinear** is generated on B.

When the pointer moves from window A to window B on different screens:

- **LeaveNotify** with detail **Nonlinear** is generated on A.
- If A is not a root window, **LeaveNotify** with detail **NonlinearVirtual** is generated on each window above A up to and including its root (in order).
- If B is not a root window, **EnterNotify** with detail **NonlinearVirtual** is generated on each window from B's root down to but not including B (in order).
- **EnterNotify** with detail **Nonlinear** is generated on B.

When a pointer grab activates (but after any initial warp into a confine-to window and before generating any actual **ButtonPress** event that activates the grab), G is the grab-window for the grab, and P is the window the pointer is in:

- **EnterNotify** and **LeaveNotify** events with mode **Grab** are generated (as for **Normal** above) as if the pointer were to suddenly warp from its current position in P to some position in G. However, the pointer does not warp, and the pointer position is used as both the initial and final positions for the events.

When a pointer grab deactivates (but after generating any actual **ButtonRelease** event that deactivates the grab), G is the grab-window for the grab, and P is the window the pointer is in:

- **EnterNotify** and **LeaveNotify** events with mode **Ungrab** are generated (as for **Normal** above) as if the pointer were to suddenly warp from some position in G to its current position in P. However, the pointer does not warp, and the current pointer position is used as both the initial and final positions for the events.

FocusIn
FocusOut

event: WINDOW
mode: {**Normal**, **WhileGrabbed**, **Grab**, **Ungrab**}
detail: {**Ancestor**, **Virtual**, **Inferior**, **Nonlinear**, **NonlinearVirtual**, **Pointer**,
PointerRoot, **None**}

These events are generated when the input focus changes and are reported to clients selecting **FocusChange** on the window. Events generated by **SetInputFocus** when the keyboard is not grabbed have mode **Normal**. Events generated by **SetInputFocus** when the keyboard is grabbed have mode **WhileGrabbed**. Events generated when a keyboard grab activates have mode **Grab**, and events generated when a keyboard grab deactivates have mode **Ungrab**.

All **FocusOut** events caused by a window unmap are generated after any **UnmapNotify** event, but the ordering of **FocusOut** with respect to generated **EnterNotify**, **LeaveNotify**, **VisibilityNotify**, and **Expose** events is not constrained.

Normal and **WhileGrabbed** events are generated as follows:

When the focus moves from window A to window B, A is an inferior of B, and the pointer is in window P:

- **FocusOut** with detail **Ancestor** is generated on A.
- **FocusOut** with detail **Virtual** is generated on each window between A and B exclusive (in order).
- **FocusIn** with detail **Inferior** is generated on B.
- If P is an inferior of B but P is not A or an inferior of A or an ancestor of A, **FocusIn** with detail **Pointer** is generated on each window below B down to and including P (in order).

When the focus moves from window A to window B, B is an inferior of A, and the pointer is in window P:

- If P is an inferior of A but P is not an inferior of B or an ancestor of B, **FocusOut** with detail **Pointer** is generated on each window from P up to but not including A (in order).
- **FocusOut** with detail **Inferior** is generated on A.
- **FocusIn** with detail **Virtual** is generated on each window between A and B exclusive (in order).
- **FocusIn** with detail **Ancestor** is generated on B.

When the focus moves from window A to window B, window C is their least common ancestor, and the pointer is in window P:

- If P is an inferior of A, **FocusOut** with detail **Pointer** is generated on each window from P up to but not including A (in order).

- **FocusOut** with detail **Nonlinear** is generated on A.
- **FocusOut** with detail **NonlinearVirtual** is generated on each window between A and C exclusive (in order).
- **FocusIn** with detail **NonlinearVirtual** is generated on each window between C and B exclusive (in order).
- **FocusIn** with detail **Nonlinear** is generated on B.
- If P is an inferior of B, **FocusIn** with detail **Pointer** is generated on each window below B down to and including P (in order).

When the focus moves from window A to window B on different screens and the pointer is in window P:

- If P is an inferior of A, **FocusOut** with detail **Pointer** is generated on each window from P up to but not including A (in order).
- **FocusOut** with detail **Nonlinear** is generated on A.
- If A is not a root window, **FocusOut** with detail **NonlinearVirtual** is generated on each window above A up to and including its root (in order).
- If B is not a root window, **FocusIn** with detail **NonlinearVirtual** is generated on each window from B's root down to but not including B (in order).
- **FocusIn** with detail **Nonlinear** is generated on B.
- If P is an inferior of B, **FocusIn** with detail **Pointer** is generated on each window below B down to and including P (in order).

When the focus moves from window A to **PointerRoot** (or **None**) and the pointer is in window P:

- If P is an inferior of A, **FocusOut** with detail **Pointer** is generated on each window from P up to but not including A (in order).
- **FocusOut** with detail **Nonlinear** is generated on A.
- If A is not a root window, **FocusOut** with detail **NonlinearVirtual** is generated on each window above A up to and including its root (in order).
- **FocusIn** with detail **PointerRoot** (or **None**) is generated on all root windows.
- If the new focus is **PointerRoot**, **FocusIn** with detail **Pointer** is generated on each window from P's root down to and including P (in order).

When the focus moves from **PointerRoot** (or **None**) to window A and the pointer is in window P:

- If the old focus is **PointerRoot**, **FocusOut** with detail **Pointer** is generated on each window from P up to and including P's root (in order).
- **FocusOut** with detail **PointerRoot** (or **None**) is generated on all root windows.
- If A is not a root window, **FocusIn** with detail **NonlinearVirtual** is generated on each window from A's root down to but not including A (in order).
- **FocusIn** with detail **Nonlinear** is generated on A.
- If P is an inferior of A, **FocusIn** with detail **Pointer** is generated on each window below A down to and including P (in order).

When the focus moves from **PointerRoot** to **None** (or vice versa) and the pointer is in window P:

- If the old focus is **PointerRoot**, **FocusOut** with detail **Pointer** is generated on each window from P up to and including P's root (in order).

- **FocusOut** with detail **PointerRoot** (or **None**) is generated on all root windows.
- **FocusIn** with detail **None** (or **PointerRoot**) is generated on all root windows.
- If the new focus is **PointerRoot**, **FocusIn** with detail **Pointer** is generated on each window from P's root down to and including P (in order).

When a keyboard grab activates (but before generating any actual **KeyPress** event that activates the grab), G is the grab-window for the grab, and F is the current focus:

- **FocusIn** and **FocusOut** events with mode **Grab** are generated (as for **Normal** above) as if the focus were to change from F to G.

When a keyboard grab deactivates (but after generating any actual **KeyRelease** event that deactivates the grab), G is the grab-window for the grab, and F is the current focus:

- **FocusIn** and **FocusOut** events with mode **Ungrab** are generated (as for **Normal** above) as if the focus were to change from G to F.

KeymapNotify

keys: LISTofCARD8

The value is a bit vector as described in **QueryKeymap**. This event is reported to clients selecting **KeymapState** on a window and is generated immediately after every **EnterNotify** and **FocusIn**.

Expose

window: WINDOW
x, y, width, height: CARD16
count: CARD16

This event is reported to clients selecting **Exposure** on the window. It is generated when no valid contents are available for regions of a window, and either the regions are visible, the regions are viewable and the server is (perhaps newly) maintaining backing store on the window, or the window is not viewable but the server is (perhaps newly) honoring window's backing-store attribute of **Always** or **WhenMapped**. The regions are decomposed into an arbitrary set of rectangles, and an **Expose** event is generated for each rectangle.

For a given action causing exposure events, the set of events for a given window are guaranteed to be reported contiguously. If count is zero, then no more **Expose** events for this window follow. If count is nonzero, then at least that many more **Expose** events for this window follow (and possibly more).

The x and y coordinates are relative to window's origin and specify the upper-left corner of a rectangle. The width and height specify the extent of the rectangle.

Expose events are never generated on **InputOnly** windows.

All **Expose** events caused by a hierarchy change are generated after any hierarchy event caused by that change (for example, **UnmapNotify**, **MapNotify**, **ConfigureNotify**, **GravityNotify**, **CirculateNotify**). All **Expose** events on a given window are generated after any **VisibilityNotify** event on that window, but it is not required that all **Expose** events on all windows be generated after all **Visibilitity** events on all windows. The ordering of **Expose** events with respect to **FocusOut**, **EnterNotify**, and **LeaveNotify** events is not constrained.

GraphicsExposure

drawable: DRAWABLE
x, y, width, height: CARD16

count: CARD16
major-opcode: CARD8
minor-opcode: CARD16

This event is reported to clients selecting graphics-exposures in a graphics context and is generated when a destination region could not be computed due to an obscured or out-of-bounds source region. All of the regions exposed by a given graphics request are guaranteed to be reported contiguously. If count is zero then no more **GraphicsExposure** events for this window follow. If count is nonzero, then at least that many more **GraphicsExposure** events for this window follow (and possibly more).

The x and y coordinates are relative to drawable's origin and specify the upper-left corner of a rectangle. The width and height specify the extent of the rectangle.

The major and minor opcodes identify the graphics request used. For the core protocol, major-opcode is always **CopyArea** or **CopyPlane**, and minor-opcode is always zero.

NoExposure

drawable: DRAWABLE
major-opcode: CARD8
minor-opcode: CARD16

This event is reported to clients selecting graphics-exposures in a graphics context and is generated when a graphics request that might produce **GraphicsExposure** events does not produce any. The drawable specifies the destination used for the graphics request.

The major and minor opcodes identify the graphics request used. For the core protocol, major-opcode is always **CopyArea** or **CopyPlane**, and the minor-opcode is always zero.

VisibilityNotify

window: WINDOW
state: {**Unobscured**, **PartiallyObscured**, **FullyObscured**}

This event is reported to clients selecting **VisibilityChange** on the window. In the following, the state of the window is calculated ignoring all of the window's subwindows. When a window changes state from partially or fully obscured or not viewable to viewable and completely unobscured, an event with **Unobscured** is generated. When a window changes state from viewable and completely unobscured or not viewable, to viewable and partially obscured, an event with **PartiallyObscured** is generated. When a window changes state from viewable and completely unobscured, from viewable and partially obscured, or from not viewable to viewable and fully obscured, an event with **FullyObscured** is generated.

VisibilityNotify events are never generated on **InputOnly** windows.

All **VisibilityNotify** events caused by a hierarchy change are generated after any hierarchy event caused by that change (for example, **UnmapNotify**, **MapNotify**, **ConfigureNotify**, **GravityNotify**, **CirculateNotify**). Any **VisibilityNotify** event on a given window is generated before any **Expose** events on that window, but it is not required that all **VisibilityNotify** events on all windows be generated before all **Expose** events on all windows. The ordering of **VisibilityNotify** events with respect to **FocusOut**, **EnterNotify**, and **LeaveNotify** events is not constrained.

CreateNotify

parent, window: WINDOW
x, y: INT16

width, height, border-width: CARD16
override-redirect: BOOL

This event is reported to clients selecting **SubstructureNotify** on the parent and is generated when the window is created. The arguments are as in the **CreateWindow** request.

DestroyNotify

event, window: WINDOW

This event is reported to clients selecting **StructureNotify** on the window and to clients selecting **SubstructureNotify** on the parent. It is generated when the window is destroyed. The event is the window on which the event was generated, and the window is the window that is destroyed.

The ordering of the **DestroyNotify** events is such that for any given window, **DestroyNotify** is generated on all inferiors of the window before being generated on the window itself. The ordering among siblings and across subhierarchies is not otherwise constrained.

UnmapNotify

event, window: WINDOW
from-configure: BOOL

This event is reported to clients selecting **StructureNotify** on the window and to clients selecting **SubstructureNotify** on the parent. It is generated when the window changes state from mapped to unmapped. The event is the window on which the event was generated, and the window is the window that is unmapped. The from-configure flag is **True** if the event was generated as a result of the window's parent being resized when the window itself had a win-gravity of **Unmap**.

MapNotify

event, window: WINDOW
override-redirect: BOOL

This event is reported to clients selecting **StructureNotify** on the window and to clients selecting **SubstructureNotify** on the parent. It is generated when the window changes state from unmapped to mapped. The event is the window on which the event was generated, and the window is the window that is mapped. The override-redirect flag is from the window's attribute.

MapRequest

parent, window: WINDOW

This event is reported to the client selecting **SubstructureRedirect** on the parent and is generated when a **MapWindow** request is issued on an unmapped window with an override-redirect attribute of **False**.

ReparentNotify

event, window, parent: WINDOW
x, y: INT16
override-redirect: BOOL

This event is reported to clients selecting **SubstructureNotify** on either the old or the new parent and to clients selecting **StructureNotify** on the window. It is generated when the window is reparented. The event is the window on which the event was generated. The window is the window that has been rerooted. The parent specifies the new parent. The x and y coordinates are relative to the new parent's origin and specify the position of the upper-left outer corner of the window. The override-redirect flag is from the window's attribute.

ConfigureNotify

event, window: WINDOW
x, y: INT16
width, height, border-width: CARD16
above-sibling: WINDOW or **None**
override-redirect: BOOL

This event is reported to clients selecting **StructureNotify** on the window and to clients selecting **SubstructureNotify** on the parent. It is generated when a **ConfigureWindow** request actually changes the state of the window. The event is the window on which the event was generated, and the window is the window that is changed. The x and y coordinates are relative to the new parent's origin and specify the position of the upper-left outer corner of the window. The width and height specify the inside size, not including the border. If above-sibling is **None**, then the window is on the bottom of the stack with respect to siblings. Otherwise, the window is immediately on top of the specified sibling. The override-redirect flag is from the window's attribute.

GravityNotify

event, window: WINDOW
x, y: INT16

This event is reported to clients selecting **SubstructureNotify** on the parent and to clients selecting **StructureNotify** on the window. It is generated when a window is moved because of a change in size of the parent. The event is the window on which the event was generated, and the window is the window that is moved. The x and y coordinates are relative to the new parent's origin and specify the position of the upper-left outer corner of the window.

ResizeRequest

window: WINDOW
width, height: CARD16

This event is reported to the client selecting **ResizeRedirect** on the window and is generated when a **ConfigureWindow** request by some other client on the window attempts to change the size of the window. The width and height are the inside size, not including the border.

ConfigureRequest

parent, window: WINDOW
x, y: INT16
width, height, border-width: CARD16
sibling: WINDOW or **None**
stack-mode: {**Above**, **Below**, **TopIf**, **BottomIf**, **Opposite**}
value-mask: BITMASK

This event is reported to the client selecting **SubstructureRedirect** on the parent and is generated when a **ConfigureWindow** request is issued on the window by some other client. The value-mask indicates which components were specified in the request. The value-mask and the corresponding values are reported as given in the request. The remaining values are filled in from the current geometry of the window, except in the case of sibling and stack-mode, which are reported as **None** and **Above** (respectively) if not given in the request.

CirculateNotify

event, window: WINDOW
place: {**Top**, **Bottom**}

This event is reported to clients selecting **StructureNotify** on the window and to clients selecting **SubstructureNotify** on the parent. It is generated when the window is actually restacked from a **CirculateWindow** request. The event is the window on which the event was generated, and the window is the window that is restacked. If place is **Top**, the window is now on top of all siblings. Otherwise, it is below all siblings.

CirculateRequest

parent, *window*: WINDOW
place: {**Top**, **Bottom**}

This event is reported to the client selecting **SubstructureRedirect** on the parent and is generated when a **CirculateWindow** request is issued on the parent and a window actually needs to be restacked. The window specifies the window to be restacked, and the place specifies what the new position in the stacking order should be.

PropertyNotify

window: WINDOW
atom: ATOM
state: {**NewValue**, **Deleted**}
time: TIMESTAMP

This event is reported to clients selecting **PropertyChange** on the window and is generated with state **NewValue** when a property of the window is changed using **ChangeProperty** or **RotateProperties**, even when adding zero-length data using **ChangeProperty** and when replacing all or part of a property with identical data using **ChangeProperty** or **RotateProperties**. It is generated with state **Deleted** when a property of the window is deleted using request **DeleteProperty** or **GetProperty**. The timestamp indicates the server time when the property was changed.

SelectionClear

owner: WINDOW
selection: ATOM
time: TIMESTAMP

This event is reported to the current owner of a selection and is generated when a new owner is being defined by means of **SetSelectionOwner**. The timestamp is the last-change time recorded for the selection. The owner argument is the window that was specified by the current owner in its **SetSelectionOwner** request.

SelectionRequest

owner: WINDOW
selection: ATOM
target: ATOM
property: ATOM or **None**
requestor: WINDOW
time: TIMESTAMP or **CurrentTime**

This event is reported to the owner of a selection and is generated when a client issues a **ConvertSelection** request. The owner argument is the window that was specified in the **SetSelectionOwner** request. The remaining arguments are as in the **ConvertSelection** request.

The owner should convert the selection based on the specified target type. If a property is specified, the owner should store the result as that property on the requestor window and then send a **SelectionNotify** event to the requestor using **SendEvent** with an empty event-mask (that is, the event should be sent to the creator of the requestor window). If **None** is specified as the property, the owner should choose a property name, store the result as that property on the requestor window, and then send a **SelectionNotify** giving that actual property name. If the selection cannot be converted as requested, the owner should send a **SelectionNotify** with the property set to **None**.

SelectionNotify

requestor: WINDOW
selection, *target*: ATOM
property: ATOM or **None**
time: TIMESTAMP or **CurrentTime**

This event is generated by the server in response to a **ConvertSelection** request when there is no owner for the selection. When there is an owner, it should be generated by the owner using **SendEvent**. The owner of a selection should send this event to a requestor either when a selection has been converted and stored as a property or when a selection conversion could not be performed (indicated with property **None**).

ColormapNotify

window: WINDOW
colormap: COLORMAP or **None**
new: BOOL
state: {**Installed**, **Uninstalled**}

This event is reported to clients selecting **ColormapChange** on the window. It is generated with value **True** for new when the colormap attribute of the window is changed and is generated with value **False** for new when the colormap of a window is installed or uninstalled. In either case, the state indicates whether the colormap is currently installed.

MappingNotify

request: {**Modifier**, **Keyboard**, **Pointer**}
first-keycode, *count*: CARD8

This event is sent to all clients. There is no mechanism to express disinterest in this event. The detail indicates the kind of change that occurred: **Modifiers** for a successful **SetModifierMapping**, **Keyboard** for a successful **ChangeKeyboardMapping**, and **Pointer** for a successful **SetPointerMapping**. If the detail is **Keyboard**, then first-keycode and count indicate the range of altered keycodes.

ClientMessage

window: WINDOW
type: ATOM
format: {8, 16, 32}
data: LISTofINT8 or LISTofINT16 or LISTofINT32

This event is only generated by clients using **SendEvent**. The type specifies how the data is to be interpreted by the receiving client; the server places no interpretation on the type or the data. The format specifies whether the data should be viewed as a list of 8-bit, 16-bit, or 32-bit quantities, so that the server can correctly byte-swap, as necessary. The data always consists of either 20 8-bit values or 10 16-bit values or 5 32-bit values, although particular message types might not make use of all of these values.

13. Flow Control and Concurrency

Whenever the server is writing to a given connection, it is permissible for the server to stop reading from that connection (but if the writing would block, it must continue to service other connections). The server is not required to buffer more than a single request per connection at one time. For a given connection to the server, a client can block while reading from the connection but should undertake to read (events and errors) when writing would block. Failure on the part of a client to obey this rule could result in a deadlocked connection, although deadlock is probably unlikely unless either the transport layer has very little buffering or the client attempts to send large numbers of requests without ever reading replies or checking for errors and events.

If a server is implemented with internal concurrency, the overall effect must be as if individual requests are executed to completion in some serial order, and requests from a given connection must be executed in delivery order (that is, the total execution order is a shuffle of the individual streams). The execution of a request includes validating all arguments, collecting all data for any reply, and generating and queueing all required events. However, it does not include the actual transmission of the reply and the events. In addition, the effect of any other cause that can generate multiple events (for example, activation of a grab or pointer motion) must effectively generate and queue all required events indivisibly with respect to all other causes and requests. For a request from a given client, any events destined for that client that are caused by executing the request must be sent to the client before any reply or error is sent.

Appendix A

KEYSYM Encoding

For convenience, KEYSYM values are viewed as split into four bytes:

- Byte 1 (for the purposes of this encoding) is the most-significant 5 bits (because of the 29-bit effective values)
- Byte 2 is the next most-significant 8 bits
- Byte 3 is the next most-significant 8 bits
- Byte 4 is the least-significant 8 bits

The standard KEYSYM values all have the zero values for bytes 1 and 2. Byte 3 indicates a character code set, and byte 4 indicates a particular character within that set.

Byte 3	Byte 4
0	Latin 1
1	Latin 2
2	Latin 3
3	Latin 4
4	Kana
5	Arabic
6	Cyrillic
7	Greek
8	Technical
9	Special
10	Publishing
11	APL
12	Hebrew
255	Keyboard

Each character set contains gaps where codes have been removed that were duplicates with codes in previous character sets (that is, character sets with lesser byte 3 value).

The 94 and 96 character code sets have been moved to occupy the right-hand quadrant (decimal 129 through 256), so the ASCII subset has a unique encoding across byte 4, which corresponds to the ASCII character code. However, this cannot be guaranteed with future registrations and does not apply to all of the Keyboard set.

To the best of our knowledge, the Latin, Kana, Arabic, Cyrillic, Greek, APL, and Hebrew sets are from the appropriate ISO and/or ECMA international standards. There are no Technical, Special, or Publishing international standards, so these sets are based on Digital Equipment Corporation standards.

The ordering between the sets (byte 3) is essentially arbitrary. Although the national and international standards bodies are commencing deliberations regarding international 2-byte and 4-byte character sets, we do not know of any proposed layouts.

The order may be arbitrary, but it is important in dealing with duplicate coding. As far as possible, KEYSYM values are the same as the character code. In the Latin-1 to Latin-4 sets, all duplicate glyphs occupy the same code position. However, duplicates between Greek and Technical do not occupy the same code position. Thus, applications wishing to use the technical character set must transform the keysym by means of an array.

There is a difference between European and US usage of the names Pilcrow, Paragraph, and Section, as follows:

US name	European name	code position in Latin-1
Section sign	Paragraph sign	10/07
Paragraph sign	Pilcrow sign	11/06

We have adopted the names used by both the ISO and ECMA standards. Thus, 11/06 is the Pilcrow sign, and 10/07 is the Paragraph sign (Section sign). This favors the European usage.

The Keyboard set is a miscellaneous collection of commonly occurring keys on keyboards. Within this set, the keypad symbols are generally duplicates of symbols found on keys on the main part of the keyboard, but they are distinguished here because they often have a distinguishable semantics associated with them.

Keyboards tend to be comparatively standard with respect to the alphanumeric keys, but they differ radically on the miscellaneous function keys. Many function keys are left over from early timesharing days or are designed for a specific application. Keyboard layouts from large manufacturers tend to have lots of keys for every conceivable purpose, whereas small workstation manufacturers often add keys that are solely for support of some of their unique functionality. There are two ways of thinking about how to define keysyms for such a world:

- The Engraving approach
- The Common approach

The Engraving approach is to create a keysym for every unique key engraving. This is effectively taking the union of all key engravings on all keyboards. For example, some keyboards label function keys across the top as F1 through Fn, and others label them as PF1 through PFn. These would be different keys under the Engraving approach. Likewise, Lock would differ from Shift Lock, which is different from the up-arrow symbol that has the effect of changing lowercase to uppercase. There are lots of other aliases such as Del, DEL, Delete, Remove, and so forth. The Engraving approach makes it easy to decide if a new entry should be added to the keysym set: if it does not exactly match an existing one, then a new one is created. One estimate is that there would be on the order of 300–500 Keyboard keysyms using this approach, without counting foreign translations and variations.

The Common approach tries to capture all of the keys present on an interesting number of keyboards, folding likely aliases into the same keysym. For example, Del, DEL, and Delete are all merged into a single keysym. Vendors would be expected to augment the keysym set (using the vendor-specific encoding space) to include all of their unique keys that were not included in the standard set. Each vendor decides which of its keys map into the standard keysyms, which presumably can be overridden by a user. It is more difficult to implement this approach, because judgment is required about when a sufficient set of keyboards implements an engraving to justify making it a keysym in the standard set and about which engravings should be merged into a single keysym. Under this scheme there are an estimated 100–150 keysyms.

Although neither scheme is perfect or elegant, the Common approach has been selected because it makes it easier to write a portable application. Having the Delete functionality merged into a single keysym allows an application to implement a deletion function and expect reasonable bindings on a wide set of workstations. Under the Common approach, application writers are still free to look for and interpret vendor-specific keysyms, but because they are in the extended set, the application developer is more conscious that they are writing the application in a nonportable fashion.

In the listings below, Code Pos is a representation of byte 4 of the KEYSYM value, expressed as most-significant/least-significant 4-bit values. The Code Pos numbers are for reference only and do not affect the KEYSYM value. In all cases, the KEYSYM value is:

byte3 * 256 + byte4

Byte 3	Byte 4	Code Pos	Name	Set
000	032	02/00	SPACE	Latin-1
000	033	02/01	EXCLAMATION POINT	Latin-1
000	034	02/02	QUOTATION MARK	Latin-1
000	035	02/03	NUMBER SIGN	Latin-1
000	036	02/04	DOLLAR SIGN	Latin-1
000	037	02/05	PERCENT SIGN	Latin-1
000	038	02/06	AMPERSAND	Latin-1
000	039	02/07	APOSTROPHE	Latin-1
000	040	02/08	LEFT PARENTHESIS	Latin-1
000	041	02/09	RIGHT PARENTHESIS	Latin-1
000	042	02/10	ASTERISK	Latin-1
000	043	02/11	PLUS SIGN	Latin-1
000	044	02/12	COMMA	Latin-1
000	045	02/13	HYPHEN, MINUS SIGN	Latin-1
000	046	02/14	FULL STOP	Latin-1
000	047	02/15	SOLIDUS	Latin-1

Byte 3	Byte 4	Code Pos	Name	Set
000	048	03/00	DIGIT ZERO	Latin-1
000	049	03/01	DIGIT ONE	Latin-1
000	050	03/02	DIGIT TWO	Latin-1
000	051	03/03	DIGIT THREE	Latin-1
000	052	03/04	DIGIT FOUR	Latin-1
000	053	03/05	DIGIT FIVE	Latin-1
000	054	03/06	DIGIT SIX	Latin-1
000	055	03/07	DIGIT SEVEN	Latin-1
000	056	03/08	DIGIT EIGHT	Latin-1
000	057	03/09	DIGIT NINE	Latin-1
000	058	03/10	COLON	Latin-1
000	059	03/11	SEMICOLON	Latin-1
000	060	03/12	LESS THAN SIGN	Latin-1
000	061	03/13	EQUALS SIGN	Latin-1
000	062	03/14	GREATER THAN SIGN	Latin-1
000	063	03/15	QUESTION MARK	Latin-1
000	064	04/00	COMMERCIAL AT	Latin-1
000	065	04/01	LATIN CAPITAL LETTER A	Latin-1
000	066	04/02	LATIN CAPITAL LETTER B	Latin-1
000	067	04/03	LATIN CAPITAL LETTER C	Latin-1
000	068	04/04	LATIN CAPITAL LETTER D	Latin-1
000	069	04/05	LATIN CAPITAL LETTER E	Latin-1
000	070	04/06	LATIN CAPITAL LETTER F	Latin-1
000	071	04/07	LATIN CAPITAL LETTER G	Latin-1
000	072	04/08	LATIN CAPITAL LETTER H	Latin-1
000	073	04/09	LATIN CAPITAL LETTER I	Latin-1
000	074	04/10	LATIN CAPITAL LETTER J	Latin-1
000	075	04/11	LATIN CAPITAL LETTER K	Latin-1
000	076	04/12	LATIN CAPITAL LETTER L	Latin-1
000	077	04/13	LATIN CAPITAL LETTER M	Latin-1
000	078	04/14	LATIN CAPITAL LETTER N	Latin-1
000	079	04/15	LATIN CAPITAL LETTER O	Latin-1
000	080	05/00	LATIN CAPITAL LETTER P	Latin-1
000	081	05/01	LATIN CAPITAL LETTER Q	Latin-1
000	082	05/02	LATIN CAPITAL LETTER R	Latin-1
000	083	05/03	LATIN CAPITAL LETTER S	Latin-1
000	084	05/04	LATIN CAPITAL LETTER T	Latin-1
000	085	05/05	LATIN CAPITAL LETTER U	Latin-1
000	086	05/06	LATIN CAPITAL LETTER V	Latin-1
000	087	05/07	LATIN CAPITAL LETTER W	Latin-1
000	088	05/08	LATIN CAPITAL LETTER X	Latin-1
000	089	05/09	LATIN CAPITAL LETTER Y	Latin-1
000	090	05/10	LATIN CAPITAL LETTER Z	Latin-1
000	091	05/11	LEFT SQUARE BRACKET	Latin-1
000	092	05/12	REVERSE SOLIDUS	Latin-1
000	093	05/13	RIGHT SQUARE BRACKET	Latin-1
000	094	05/14	CIRCUMFLEX ACCENT	Latin-1
000	095	05/15	LOW LINE	Latin-1
000	096	06/00	GRAVE ACCENT	Latin-1
000	097	06/01	LATIN SMALL LETTER a	Latin-1
000	098	06/02	LATIN SMALL LETTER b	Latin-1
000	099	06/03	LATIN SMALL LETTER c	Latin-1
000	100	06/04	LATIN SMALL LETTER d	Latin-1
000	101	06/05	LATIN SMALL LETTER e	Latin-1
000	102	06/06	LATIN SMALL LETTER f	Latin-1
000	103	06/07	LATIN SMALL LETTER g	Latin-1
000	104	06/08	LATIN SMALL LETTER h	Latin-1
000	105	06/09	LATIN SMALL LETTER i	Latin-1
000	106	06/10	LATIN SMALL LETTER j	Latin-1
000	107	06/11	LATIN SMALL LETTER k	Latin-1
000	108	06/12	LATIN SMALL LETTER l	Latin-1

Byte 3	Byte 4	Code Pos	Name	Set
000	109	06/13	LATIN SMALL LETTER m	Latin-1
000	110	06/14	LATIN SMALL LETTER n	Latin-1
000	111	06/15	LATIN SMALL LETTER o	Latin-1
000	112	07/00	LATIN SMALL LETTER p	Latin-1
000	113	07/01	LATIN SMALL LETTER q	Latin-1
000	114	07/02	LATIN SMALL LETTER r	Latin-1
000	115	07/03	LATIN SMALL LETTER s	Latin-1
000	116	07/04	LATIN SMALL LETTER t	Latin-1
000	117	07/05	LATIN SMALL LETTER u	Latin-1
000	118	07/06	LATIN SMALL LETTER v	Latin-1
000	119	07/07	LATIN SMALL LETTER w	Latin-1
000	120	07/08	LATIN SMALL LETTER x	Latin-1
000	121	07/09	LATIN SMALL LETTER y	Latin-1
000	122	07/10	LATIN SMALL LETTER z	Latin-1
000	123	07/11	LEFT CURLY BRACKET	Latin-1
000	124	07/12	VERTICAL LINE	Latin-1
000	125	07/13	RIGHT CURLY BRACKET	Latin-1
000	126	07/14	TILDE	Latin-1
000	160	10/00	NO-BREAK SPACE	Latin-1
000	161	10/01	INVERTED EXCLAMATION MARK	Latin-1
000	162	10/02	CENT SIGN	Latin-1
000	163	10/03	POUND SIGN	Latin-1
000	164	10/04	CURRENCY SIGN	Latin-1
000	165	10/05	YEN SIGN	Latin-1
000	166	10/06	BROKEN VERTICAL BAR	Latin-1
000	167	10/07	PARAGRAPH SIGN, SECTION SIGN	Latin-1
000	168	10/08	DIAERESIS	Latin-1
000	169	10/09	COPYRIGHT SIGN	Latin-1
000	170	10/10	FEMININE ORDINAL INDICATOR	Latin-1
000	171	10/11	LEFT ANGLE QUOTATION MARK	Latin-1
000	172	10/12	NOT SIGN	Latin-1
000	174	10/14	REGISTERED TRADEMARK SIGN	Latin-1
000	175	10/15	MACRON	Latin-1
000	176	11/00	DEGREE SIGN, RING ABOVE	Latin-1
000	177	11/01	PLUS-MINUS SIGN	Latin-1
000	178	11/02	SUPERSCRIPT TWO	Latin-1
000	179	11/03	SUPERSCRIPT THREE	Latin-1
000	180	11/04	ACUTE ACCENT	Latin-1
000	181	11/05	MICRO SIGN	Latin-1
000	182	11/06	PILCROW SIGN	Latin-1
000	183	11/07	MIDDLE DOT	Latin-1
000	184	11/08	CEDILLA	Latin-1
000	185	11/09	SUPERSCRIPT ONE	Latin-1
000	186	11/10	MASCULINE ORDINAL INDICATOR	Latin-1
000	187	11/11	RIGHT ANGLE QUOTATION MARK	Latin-1
000	188	11/12	VULGAR FRACTION ONE QUARTER	Latin-1
000	189	11/13	VULGAR FRACTION ONE HALF	Latin-1
000	190	11/14	VULGAR FRACTION THREE QUARTERS	Latin-1
000	191	11/15	INVERTED QUESTION MARK	Latin-1
000	192	12/00	LATIN CAPITAL LETTER A WITH GRAVE ACCENT	Latin-1
000	193	12/01	LATIN CAPITAL LETTER A WITH ACUTE ACCENT	Latin-1
000	194	12/02	LATIN CAPITAL LETTER A WITH CIRCUMFLEX ACCENT	Latin-1
000	195	12/03	LATIN CAPITAL LETTER A WITH TILDE	Latin-1
000	196	12/04	LATIN CAPITAL LETTER A WITH DIAERESIS	Latin-1
000	197	12/05	LATIN CAPITAL LETTER A WITH RING ABOVE	Latin-1
000	198	12/06	LATIN CAPITAL DIPHTHONG AE	Latin-1
000	199	12/07	LATIN CAPITAL LETTER C WITH CEDILLA	Latin-1
000	200	12/08	LATIN CAPITAL LETTER E WITH GRAVE ACCENT	Latin-1
000	201	12/09	LATIN CAPITAL LETTER E WITH ACUTE ACCENT	Latin-1
000	202	12/10	LATIN CAPITAL LETTER E WITH CIRCUMFLEX ACCENT	Latin-1
000	203	12/11	LATIN CAPITAL LETTER E WITH DIAERESIS	Latin-1

Byte 3	Byte 4	Code Pos	Name	Set
000	204	12/12	LATIN CAPITAL LETTER I WITH GRAVE ACCENT	Latin-1
000	205	12/13	LATIN CAPITAL LETTER I WITH ACUTE ACCENT	Latin-1
000	206	12/14	LATIN CAPITAL LETTER I WITH CIRCUMFLEX ACCENT	Latin-1
000	207	12/15	LATIN CAPITAL LETTER I WITH DIAERESIS	Latin-1
000	208	13/00	ICELANDIC CAPITAL LETTER ETH	Latin-1
000	209	13/01	LATIN CAPITAL LETTER N WITH TILDE	Latin-1
000	210	13/02	LATIN CAPITAL LETTER O WITH GRAVE ACCENT	Latin-1
000	211	13/03	LATIN CAPITAL LETTER O WITH ACUTE ACCENT	Latin-1
000	212	13/04	LATIN CAPITAL LETTER O WITH CIRCUMFLEX ACCENT	Latin-1
000	213	13/05	LATIN CAPITAL LETTER O WITH TILDE	Latin-1
000	214	13/06	LATIN CAPITAL LETTER O WITH DIAERESIS	Latin-1
000	215	13/07	MULTIPLICATION SIGN	Latin-1
000	216	13/08	LATIN CAPITAL LETTER O WITH OBLIQUE STROKE	Latin-1
000	217	13/09	LATIN CAPITAL LETTER U WITH GRAVE ACCENT	Latin-1
000	218	13/10	LATIN CAPITAL LETTER U WITH ACUTE ACCENT	Latin-1
000	219	13/11	LATIN CAPITAL LETTER U WITH CIRCUMFLEX ACCENT	Latin-1
000	220	13/12	LATIN CAPITAL LETTER U WITH DIAERESIS	Latin-1
000	221	13/13	LATIN CAPITAL LETTER Y WITH ACUTE ACCENT	Latin-1
000	222	13/14	ICELANDIC CAPITAL LETTER THORN	Latin-1
000	223	13/15	GERMAN SMALL LETTER SHARP s	Latin-1
000	224	14/00	LATIN SMALL LETTER a WITH GRAVE ACCENT	Latin-1
000	225	14/01	LATIN SMALL LETTER a WITH ACUTE ACCENT	Latin-1
000	226	14/02	LATIN SMALL LETTER a WITH CIRCUMFLEX ACCENT	Latin-1
000	227	14/03	LATIN SMALL LETTER a WITH TILDE	Latin-1
000	228	14/04	LATIN SMALL LETTER a WITH DIAERESIS	Latin-1
000	229	14/05	LATIN SMALL LETTER a WITH RING ABOVE	Latin-1
000	230	14/06	LATIN SMALL DIPHTHONG ae	Latin-1
000	231	14/07	LATIN SMALL LETTER c WITH CEDILLA	Latin-1
000	232	14/08	LATIN SMALL LETTER e WITH GRAVE ACCENT	Latin-1
000	233	14/09	LATIN SMALL LETTER e WITH ACUTE ACCENT	Latin-1
000	234	14/10	LATIN SMALL LETTER e WITH CIRCUMFLEX ACCENT	Latin-1
000	235	14/11	LATIN SMALL LETTER e WITH DIAERESIS	Latin-1
000	236	14/12	LATIN SMALL LETTER i WITH GRAVE ACCENT	Latin-1
000	237	14/13	LATIN SMALL LETTER i WITH ACUTE ACCENT	Latin-1
000	238	14/14	LATIN SMALL LETTER i WITH CIRCUMFLEX ACCENT	Latin-1
000	239	14/15	LATIN SMALL LETTER i WITH DIAERESIS	Latin-1
000	240	15/00	ICELANDIC SMALL LETTER ETH	Latin-1
000	241	15/01	LATIN SMALL LETTER n WITH TILDE	Latin-1
000	242	15/02	LATIN SMALL LETTER o WITH GRAVE ACCENT	Latin-1
000	243	15/03	LATIN SMALL LETTER o WITH ACUTE ACCENT	Latin-1
000	244	15/04	LATIN SMALL LETTER o WITH CIRCUMFLEX ACCENT	Latin-1
000	245	15/05	LATIN SMALL LETTER o WITH TILDE	Latin-1
000	246	15/06	LATIN SMALL LETTER o WITH DIAERESIS	Latin-1
000	247	15/07	DIVISION SIGN	Latin-1
000	248	15/08	LATIN SMALL LETTER o WITH OBLIQUE STROKE	Latin-1
000	249	15/09	LATIN SMALL LETTER u WITH GRAVE ACCENT	Latin-1
000	250	15/10	LATIN SMALL LETTER u WITH ACUTE ACCENT	Latin-1
000	251	15/11	LATIN SMALL LETTER u WITH CIRCUMFLEX ACCENT	Latin-1
000	252	15/12	LATIN SMALL LETTER u WITH DIAERESIS	Latin-1
000	253	15/13	LATIN SMALL LETTER y WITH ACUTE ACCENT	Latin-1
000	254	15/14	ICELANDIC SMALL LETTER THORN	Latin-1
000	255	15/15	LATIN SMALL LETTER y WITH DIAERESIS	Latin-1
001	161	10/01	LATIN CAPITAL LETTER A WITH OGONEK	Latin-2
001	162	10/02	BREVE	Latin-2
001	163	10/03	LATIN CAPITAL LETTER L WITH STROKE	Latin-2
001	165	10/05	LATIN CAPITAL LETTER L WITH CARON	Latin-2
001	166	10/06	LATIN CAPITAL LETTER S WITH ACUTE ACCENT	Latin-2
001	169	10/09	LATIN CAPITAL LETTER S WITH CARON	Latin-2
001	170	10/10	LATIN CAPITAL LETTER S WITH CEDILLA	Latin-2

Byte 3	Byte 4	Code Pos	Name	Set
001	171	10/11	LATIN CAPITAL LETTER T WITH CARON	Latin-2
001	172	10/12	LATIN CAPITAL LETTER Z WITH ACUTE ACCENT	Latin-2
001	174	10/14	LATIN CAPITAL LETTER Z WITH CARON	Latin-2
001	175	10/15	LATIN CAPITAL LETTER Z WITH DOT ABOVE	Latin-2
001	177	11/01	LATIN SMALL LETTER a WITH OGONEK	Latin-2
001	178	11/02	OGONEK	Latin-2
001	179	11/03	LATIN SMALL LETTER l WITH STROKE	Latin-2
001	181	11/05	LATIN SMALL LETTER l WITH CARON	Latin-2
001	182	11/06	LATIN SMALL LETTER s WITH ACUTE ACCENT	Latin-2
001	183	11/07	CARON	Latin-2
001	185	11/09	LATIN SMALL LETTER s WITH CARON	Latin-2
001	186	11/10	LATIN SMALL LETTER s WITH CEDILLA	Latin-2
001	187	11/11	LATIN SMALL LETTER t WITH CARON	Latin-2
001	188	11/12	LATIN SMALL LETTER z WITH ACUTE ACCENT	Latin-2
001	189	11/13	DOUBLE ACUTE ACCENT	Latin-2
001	190	11/14	LATIN SMALL LETTER z WITH CARON	Latin-2
001	191	11/15	LATIN SMALL LETTER z WITH DOT ABOVE	Latin-2
001	192	12/00	LATIN CAPITAL LETTER R WITH ACUTE ACCENT	Latin-2
001	195	12/03	LATIN CAPITAL LETTER A WITH BREVE	Latin-2
001	197	12/05	LATIN CAPITAL LETTER L WITH ACUTE ACCENT	Latin-2
001	198	12/06	LATIN CAPITAL LETTER C WITH ACUTE ACCENT	Latin-2
001	200	12/08	LATIN CAPITAL LETTER C WITH CARON	Latin-2
001	202	12/10	LATIN CAPITAL LETTER E WITH OGONEK	Latin-2
001	204	12/12	LATIN CAPITAL LETTER E WITH CARON	Latin-2
001	207	12/15	LATIN CAPITAL LETTER D WITH CARON	Latin-2
001	208	13/00	LATIN CAPITAL LETTER D WITH STROKE	Latin-2
001	209	13/01	LATIN CAPITAL LETTER N WITH ACUTE ACCENT	Latin-2
001	210	13/02	LATIN CAPITAL LETTER N WITH CARON	Latin-2
001	213	13/05	LATIN CAPITAL LETTER O WITH DOUBLE ACUTE ACCENT	Latin-2
001	216	13/08	LATIN CAPITAL LETTER R WITH CARON	Latin-2
001	217	13/09	LATIN CAPITAL LETTER U WITH RING ABOVE	Latin-2
001	219	13/11	LATIN CAPITAL LETTER U WITH DOUBLE ACUTE ACCENT	Latin-2
001	222	13/14	LATIN CAPITAL LETTER T WITH CEDILLA	Latin-2
001	224	14/00	LATIN SMALL LETTER r WITH ACUTE ACCENT	Latin-2
001	227	14/03	LATIN SMALL LETTER a WITH BREVE	Latin-2
001	229	14/05	LATIN SMALL LETTER l WITH ACUTE ACCENT	Latin-2
001	230	14/06	LATIN SMALL LETTER c WITH ACUTE ACCENT	Latin-2
001	232	14/08	LATIN SMALL LETTER c WITH CARON	Latin-2
001	234	14/10	LATIN SMALL LETTER e WITH OGONEK	Latin-2
001	236	14/12	LATIN SMALL LETTER e WITH CARON	Latin-2
001	239	14/15	LATIN SMALL LETTER d WITH CARON	Latin-2
001	240	15/00	LATIN SMALL LETTER d WITH STROKE	Latin-2
001	241	15/01	LATIN SMALL LETTER n WITH ACUTE ACCENT	Latin-2
001	242	15/02	LATIN SMALL LETTER n WITH CARON	Latin-2
001	245	15/05	LATIN SMALL LETTER o WITH DOUBLE ACUTE ACCENT	Latin-2
001	248	15/08	LATIN SMALL LETTER r WITH CARON	Latin-2
001	249	15/09	LATIN SMALL LETTER u WITH RING ABOVE	Latin-2
001	251	15/11	LATIN SMALL LETTER u WITH DOUBLE ACUTE ACCENT	Latin-2
001	254	15/14	LATIN SMALL LETTER t WITH CEDILLA	Latin-2
001	255	15/15	DOT ABOVE	Latin-2
002	161	10/01	LATIN CAPITAL LETTER H WITH STROKE	Latin-3
002	166	10/06	LATIN CAPITAL LETTER H WITH CIRCUMFLEX ACCENT	Latin-3
002	169	10/09	LATIN CAPITAL LETTER I WITH DOT ABOVE	Latin-3
002	171	10/11	LATIN CAPITAL LETTER G WITH BREVE	Latin-3
002	172	10/12	LATIN CAPITAL LETTER J WITH CIRCUMFLEX ACCENT	Latin-3
002	177	11/01	LATIN SMALL LETTER h WITH STROKE	Latin-3
002	182	11/06	LATIN SMALL LETTER h WITH CIRCUMFLEX ACCENT	Latin-3
002	185	11/09	SMALL DOTLESS LETTER i	Latin-3
002	187	11/11	LATIN SMALL LETTER g WITH BREVE	Latin-3

Byte 3	Byte 4	Code Pos	Name	Set
002	188	11/12	LATIN SMALL LETTER j WITH CIRCUMFLEX ACCENT	Latin-3
002	197	12/05	LATIN CAPITAL LETTER C WITH DOT ABOVE	Latin-3
002	198	12/06	LATIN CAPITAL LETTER C WITH CIRCUMFLEX ACCENT	Latin-3
002	213	13/05	LATIN CAPITAL LETTER G WITH DOT ABOVE	Latin-3
002	216	13/08	LATIN CAPITAL LETTER G WITH CIRCUMFLEX ACCENT	Latin-3
002	221	13/13	LATIN CAPITAL LETTER U WITH BREVE	Latin-3
002	222	13/14	LATIN CAPITAL LETTER S WITH CIRCUMFLEX ACCENT	Latin-3
002	229	14/05	LATIN SMALL LETTER c WITH DOT ABOVE	Latin-3
002	230	14/06	LATIN SMALL LETTER c WITH CIRCUMFLEX ACCENT	Latin-3
002	245	15/05	LATIN SMALL LETTER g WITH DOT ABOVE	Latin-3
002	248	15/08	LATIN SMALL LETTER g WITH CIRCUMFLEX ACCENT	Latin-3
002	253	15/13	LATIN SMALL LETTER u WITH BREVE	Latin-3
002	254	15/14	LATIN SMALL LETTER s WITH CIRCUMFLEX ACCENT	Latin-3
003	162	10/02	LATIN SMALL LETTER KAPPA	Latin-4
003	163	10/03	LATIN CAPITAL LETTER R WITH CEDILLA	Latin-4
003	165	10/05	LATIN CAPITAL LETTER I WITH TILDE	Latin-4
003	166	10/06	LATIN CAPITAL LETTER L WITH CEDILLA	Latin-4
003	170	10/10	LATIN CAPITAL LETTER E WITH MACRON	Latin-4
003	171	10/11	LATIN CAPITAL LETTER G WITH CEDILLA	Latin-4
003	172	10/12	LATIN CAPITAL LETTER T WITH OBLIQUE STROKE	Latin-4
003	179	11/03	LATIN SMALL LETTER r WITH CEDILLA	Latin-4
003	181	11/05	LATIN SMALL LETTER i WITH TILDE	Latin-4
003	182	11/06	LATIN SMALL LETTER l WITH CEDILLA	Latin-4
003	186	11/10	LATIN SMALL LETTER e WITH MACRON	Latin-4
003	187	11/11	LATIN SMALL LETTER g WITH ACUTE ACCENT	Latin-4
003	188	11/12	LATIN SMALL LETTER t WITH OBLIQUE STROKE	Latin-4
003	189	11/13	LAPPISH CAPITAL LETTER ENG	Latin-4
003	191	11/15	LAPPISH SMALL LETTER ENG	Latin-4
003	192	12/00	LATIN CAPITAL LETTER A WITH MACRON	Latin-4
003	199	12/07	LATIN CAPITAL LETTER I WITH OGONEK	Latin-4
003	204	12/12	LATIN CAPITAL LETTER E WITH DOT ABOVE	Latin-4
003	207	12/15	LATIN CAPITAL LETTER I WITH MACRON	Latin-4
003	209	13/01	LATIN CAPITAL LETTER N WITH CEDILLA	Latin-4
003	210	13/02	LATIN CAPITAL LETTER O WITH MACRON	Latin-4
003	211	13/03	LATIN CAPITAL LETTER K WITH CEDILLA	Latin-4
003	217	13/09	LATIN CAPITAL LETTER U WITH OGONEK	Latin-4
003	221	13/13	LATIN CAPITAL LETTER U WITH TILDE	Latin-4
003	222	13/14	LATIN CAPITAL LETTER U WITH MACRON	Latin-4
003	224	14/00	LATIN SMALL LETTER a WITH MACRON	Latin-4
003	231	14/07	LATIN SMALL LETTER i WITH OGONEK	Latin-4
003	236	14/12	LATIN SMALL LETTER e WITH DOT ABOVE	Latin-4
003	239	14/15	LATIN SMALL LETTER i WITH MACRON	Latin-4
003	241	15/01	LATIN SMALL LETTER n WITH CEDILLA	Latin-4
003	242	15/02	LATIN SMALL LETTER o WITH MACRON	Latin-4
003	243	15/03	LATIN SMALL LETTER k WITH CEDILLA	Latin-4
003	249	15/09	LATIN SMALL LETTER u WITH OGONEK	Latin-4
003	253	15/13	LATIN SMALL LETTER u WITH TILDE	Latin-4
003	254	15/14	LATIN SMALL LETTER u WITH MACRON	Latin-4
004	126	07/14	OVERLINE	Kana
004	161	10/01	KANA FULL STOP	Kana
004	162	10/02	KANA OPENING BRACKET	Kana
004	163	10/03	KANA CLOSING BRACKET	Kana
004	164	10/04	KANA COMMA	Kana
004	165	10/05	KANA MIDDLE DOT	Kana
004	166	10/06	KANA LETTER WO	Kana
004	167	10/07	KANA LETTER SMALL A	Kana
004	168	10/08	KANA LETTER SMALL I	Kana

Byte 3	Byte 4	Code Pos	Name	Set
004	169	10/09	KANA LETTER SMALL U	Kana
004	170	10/10	KANA LETTER SMALL E	Kana
004	171	10/11	KANA LETTER SMALL O	Kana
004	172	10/12	KANA LETTER SMALL YA	Kana
004	173	10/13	KANA LETTER SMALL YU	Kana
004	174	10/14	KANA LETTER SMALL YO	Kana
004	175	10/15	KANA LETTER SMALL TU	Kana
004	176	11/00	PROLONGED SOUND SYMBOL	Kana
004	177	11/01	KANA LETTER A	Kana
004	178	11/02	KANA LETTER I	Kana
004	179	11/03	KANA LETTER U	Kana
004	180	11/04	KANA LETTER E	Kana
004	181	11/05	KANA LETTER O	Kana
004	182	11/06	KANA LETTER KA	Kana
004	183	11/07	KANA LETTER KI	Kana
004	184	11/08	KANA LETTER KU	Kana
004	185	11/09	KANA LETTER KE	Kana
004	186	11/10	KANA LETTER KO	Kana
004	187	11/11	KANA LETTER SA	Kana
004	188	11/12	KANA LETTER SHI	Kana
004	189	11/13	KANA LETTER SU	Kana
004	190	11/14	KANA LETTER SE	Kana
004	191	11/15	KANA LETTER SO	Kana
004	192	12/00	KANA LETTER TA	Kana
004	193	12/01	KANA LETTER TI	Kana
004	194	12/02	KANA LETTER TU	Kana
004	195	12/03	KANA LETTER TE	Kana
004	196	12/04	KANA LETTER TO	Kana
004	197	12/05	KANA LETTER NA	Kana
004	198	12/06	KANA LETTER NI	Kana
004	199	12/07	KANA LETTER NU	Kana
004	200	12/08	KANA LETTER NE	Kana
004	201	12/09	KANA LETTER NO	Kana
004	202	12/10	KANA LETTER HA	Kana
004	203	12/11	KANA LETTER HI	Kana
004	204	12/12	KANA LETTER HU	Kana
004	205	12/13	KANA LETTER HE	Kana
004	206	12/14	KANA LETTER HO	Kana
004	207	12/15	KANA LETTER MA	Kana
004	208	13/00	KANA LETTER MI	Kana
004	209	13/01	KANA LETTER MU	Kana
004	210	13/02	KANA LETTER ME	Kana
004	211	13/03	KANA LETTER MO	Kana
004	212	13/04	KANA LETTER YA	Kana
004	213	13/05	KANA LETTER YU	Kana
004	214	13/06	KANA LETTER YO	Kana
004	215	13/07	KANA LETTER RA	Kana
004	216	13/08	KANA LETTER RI	Kana
004	217	13/09	KANA LETTER RU	Kana
004	218	13/10	KANA LETTER RE	Kana
004	219	13/11	KANA LETTER RO	Kana
004	220	13/12	KANA LETTER WA	Kana
004	221	13/13	KANA LETTER N	Kana
004	222	13/14	VOICED SOUND SYMBOL	Kana
004	223	13/15	SEMIVOICED SOUND SYMBOL	Kana
005	172	10/12	ARABIC COMMA	Arabic
005	187	11/11	ARABIC SEMICOLON	Arabic
005	191	11/15	ARABIC QUESTION MARK	Arabic
005	193	12/01	ARABIC LETTER HAMZA	Arabic

Byte 3	Byte 4	Code Pos	Name	Set
005	194	12/02	ARABIC LETTER MADDA ON ALEF	Arabic
005	195	12/03	ARABIC LETTER HAMZA ON ALEF	Arabic
005	196	12/04	ARABIC LETTER HAMZA ON WAW	Arabic
005	197	12/05	ARABIC LETTER HAMZA UNDER ALEF	Arabic
005	198	12/06	ARABIC LETTER HAMZA ON YEH	Arabic
005	199	12/07	ARABIC LETTER ALEF	Arabic
005	200	12/08	ARABIC LETTER BEH	Arabic
005	201	12/09	ARABIC LETTER TEH MARBUTA	Arabic
005	202	12/10	ARABIC LETTER TEH	Arabic
005	203	12/11	ARABIC LETTER THEH	Arabic
005	204	12/12	ARABIC LETTER JEEM	Arabic
005	205	12/13	ARABIC LETTER HAH	Arabic
005	206	12/14	ARABIC LETTER KHAH	Arabic
005	207	12/15	ARABIC LETTER DAL	Arabic
005	208	13/00	ARABIC LETTER THAL	Arabic
005	209	13/01	ARABIC LETTER RA	Arabic
005	210	13/02	ARABIC LETTER ZAIN	Arabic
005	211	13/03	ARABIC LETTER SEEN	Arabic
005	212	13/04	ARABIC LETTER SHEEN	Arabic
005	213	13/05	ARABIC LETTER SAD	Arabic
005	214	13/06	ARABIC LETTER DAD	Arabic
005	215	13/07	ARABIC LETTER TAH	Arabic
005	216	13/08	ARABIC LETTER ZAH	Arabic
005	217	13/09	ARABIC LETTER AIN	Arabic
005	218	13/10	ARABIC LETTER GHAIN	Arabic
005	224	14/00	ARABIC LETTER TATWEEL	Arabic
005	225	14/01	ARABIC LETTER FEH	Arabic
005	226	14/02	ARABIC LETTER QAF	Arabic
005	227	14/03	ARABIC LETTER KAF	Arabic
005	228	14/04	ARABIC LETTER LAM	Arabic
005	229	14/05	ARABIC LETTER MEEM	Arabic
005	230	14/06	ARABIC LETTER NOON	Arabic
005	231	14/07	ARABIC LETTER HEH	Arabic
005	232	14/08	ARABIC LETTER WAW	Arabic
005	233	14/09	ARABIC LETTER ALEF MAKSURA	Arabic
005	234	14/10	ARABIC LETTER YEH	Arabic
005	235	14/11	ARABIC LETTER FATHATAN	Arabic
005	236	14/12	ARABIC LETTER DAMMATAN	Arabic
005	237	14/13	ARABIC LETTER KASRATAN	Arabic
005	238	14/14	ARABIC LETTER FATHA	Arabic
005	239	14/15	ARABIC LETTER DAMMA	Arabic
005	240	15/00	ARABIC LETTER KASRA	Arabic
005	241	15/01	ARABIC LETTER SHADDA	Arabic
005	242	15/02	ARABIC LETTER SUKUN	Arabic
006	161	10/01	SERBIAN SMALL LETTER DJE	Cyrillic
006	162	10/02	MACEDONIA SMALL LETTER GJE	Cyrillic
006	163	10/03	CYRILLIC SMALL LETTER IO	Cyrillic
006	164	10/04	UKRAINIAN SMALL LETTER JE	Cyrillic
006	165	10/05	MACEDONIA SMALL LETTER DSE	Cyrillic
006	166	10/06	UKRAINIAN SMALL LETTER I	Cyrillic
006	167	10/07	UKRAINIAN SMALL LETTER YI	Cyrillic
006	168	10/08	SERBIAN SMALL LETTER JE	Cyrillic
006	169	10/09	SERBIAN SMALL LETTER LJE	Cyrillic
006	170	10/10	SERBIAN SMALL LETTER NJE	Cyrillic
006	171	10/11	SERBIAN SMALL LETTER TSHE	Cyrillic
006	172	10/12	MACEDONIA SMALL LETTER KJE	Cyrillic
006	174	10/14	BYELORUSSIAN SMALL LETTER SHORT U	Cyrillic
006	175	10/15	SERBIAN SMALL LETTER DZE	Cyrillic
006	176	11/00	NUMERO SIGN	Cyrillic

Byte 3	Byte 4	Code Pos	Name	Set
006	177	11/01	SERBIAN CAPITAL LETTER DJE	Cyrillic
006	178	11/02	MACEDONIA CAPITAL LETTER GJE	Cyrillic
006	179	11/03	CYRILLIC CAPITAL LETTER IO	Cyrillic
006	180	11/04	UKRAINIAN CAPITAL LETTER JE	Cyrillic
006	181	11/05	MACEDONIA CAPITAL LETTER DSE	Cyrillic
006	182	11/06	UKRAINIAN CAPITAL LETTER I	Cyrillic
006	183	11/07	UKRAINIAN CAPITAL LETTER YI	Cyrillic
006	184	11/08	SERBIAN CAPITAL LETTER JE	Cyrillic
006	185	11/09	SERBIAN CAPITAL LETTER LJE	Cyrillic
006	186	11/10	SERBIAN CAPITAL LETTER NJE	Cyrillic
006	187	11/11	SERBIAN CAPITAL LETTER TSHE	Cyrillic
006	188	11/12	MACEDONIA CAPITAL LETTER KJE	Cyrillic
006	190	11/14	BYELORUSSIAN CAPITAL LETTER SHORT U	Cyrillic
006	191	11/15	SERBIAN CAPITAL LETTER DZE	Cyrillic
006	192	12/00	CYRILLIC SMALL LETTER YU	Cyrillic
006	193	12/01	CYRILLIC SMALL LETTER A	Cyrillic
006	194	12/02	CYRILLIC SMALL LETTER BE	Cyrillic
006	195	12/03	CYRILLIC SMALL LETTER TSE	Cyrillic
006	196	12/04	CYRILLIC SMALL LETTER DE	Cyrillic
006	197	12/05	CYRILLIC SMALL LETTER IE	Cyrillic
006	198	12/06	CYRILLIC SMALL LETTER EF	Cyrillic
006	199	12/07	CYRILLIC SMALL LETTER GHE	Cyrillic
006	200	12/08	CYRILLIC SMALL LETTER HA	Cyrillic
006	201	12/09	CYRILLIC SMALL LETTER I	Cyrillic
006	202	12/10	CYRILLIC SMALL LETTER SHORT I	Cyrillic
006	203	12/11	CYRILLIC SMALL LETTER KA	Cyrillic
006	204	12/12	CYRILLIC SMALL LETTER EL	Cyrillic
006	205	12/13	CYRILLIC SMALL LETTER EM	Cyrillic
006	206	12/14	CYRILLIC SMALL LETTER EN	Cyrillic
006	207	12/15	CYRILLIC SMALL LETTER O	Cyrillic
006	208	13/00	CYRILLIC SMALL LETTER PE	Cyrillic
006	209	13/01	CYRILLIC SMALL LETTER YA	Cyrillic
006	210	13/02	CYRILLIC SMALL LETTER ER	Cyrillic
006	211	13/03	CYRILLIC SMALL LETTER ES	Cyrillic
006	212	13/04	CYRILLIC SMALL LETTER TE	Cyrillic
006	213	13/05	CYRILLIC SMALL LETTER U	Cyrillic
006	214	13/06	CYRILLIC SMALL LETTER ZHE	Cyrillic
006	215	13/07	CYRILLIC SMALL LETTER VE	Cyrillic
006	216	13/08	CYRILLIC SMALL SOFT SIGN	Cyrillic
006	217	13/09	CYRILLIC SMALL LETTER YERU	Cyrillic
006	218	13/10	CYRILLIC SMALL LETTER ZE	Cyrillic
006	219	13/11	CYRILLIC SMALL LETTER SHA	Cyrillic
006	220	13/12	CYRILLIC SMALL LETTER E	Cyrillic
006	221	13/13	CYRILLIC SMALL LETTER SHCHA	Cyrillic
006	222	13/14	CYRILLIC SMALL LETTER CHE	Cyrillic
006	223	13/15	CYRILLIC SMALL HARD SIGN	Cyrillic
006	224	14/00	CYRILLIC CAPITAL LETTER YU	Cyrillic
006	225	14/01	CYRILLIC CAPITAL LETTER A	Cyrillic
006	226	14/02	CYRILLIC CAPITAL LETTER BE	Cyrillic
006	227	14/03	CYRILLIC CAPITAL LETTER TSE	Cyrillic
006	228	14/04	CYRILLIC CAPITAL LETTER DE	Cyrillic
006	229	14/05	CYRILLIC CAPITAL LETTER IE	Cyrillic
006	230	14/06	CYRILLIC CAPITAL LETTER EF	Cyrillic
006	231	14/07	CYRILLIC CAPITAL LETTER GHE	Cyrillic
006	232	14/08	CYRILLIC CAPITAL LETTER HA	Cyrillic
006	233	14/09	CYRILLIC CAPITAL LETTER I	Cyrillic
006	234	14/10	CYRILLIC CAPITAL LETTER SHORT I	Cyrillic
006	235	14/11	CYRILLIC CAPITAL LETTER KA	Cyrillic
006	236	14/12	CYRILLIC CAPITAL LETTER EL	Cyrillic
006	237	14/13	CYRILLIC CAPITAL LETTER EM	Cyrillic
006	238	14/14	CYRILLIC CAPITAL LETTER EN	Cyrillic

Byte 3	Byte 4	Code Pos	Name	Set
006	239	14/15	CYRILLIC CAPITAL LETTER O	Cyrillic
006	240	15/00	CYRILLIC CAPITAL LETTER PE	Cyrillic
006	241	15/01	CYRILLIC CAPITAL LETTER YA	Cyrillic
006	242	15/02	CYRILLIC CAPITAL LETTER ER	Cyrillic
006	243	15/03	CYRILLIC CAPITAL LETTER ES	Cyrillic
006	244	15/04	CYRILLIC CAPITAL LETTER TE	Cyrillic
006	245	15/05	CYRILLIC CAPITAL LETTER U	Cyrillic
006	246	15/06	CYRILLIC CAPITAL LETTER ZHE	Cyrillic
006	247	15/07	CYRILLIC CAPITAL LETTER VE	Cyrillic
006	248	15/08	CYRILLIC CAPITAL SOFT SIGN	Cyrillic
006	249	15/09	CYRILLIC CAPITAL LETTER YERU	Cyrillic
006	250	15/10	CYRILLIC CAPITAL LETTER ZE	Cyrillic
006	251	15/11	CYRILLIC CAPITAL LETTER SHA	Cyrillic
006	252	15/12	CYRILLIC CAPITAL LETTER E	Cyrillic
006	253	15/13	CYRILLIC CAPITAL LETTER SHCHA	Cyrillic
006	254	15/14	CYRILLIC CAPITAL LETTER CHE	Cyrillic
006	255	15/15	CYRILLIC CAPITAL HARD SIGN	Cyrillic
007	161	10/01	GREEK CAPITAL LETTER ALPHA WITH ACCENT	Greek
007	162	10/02	GREEK CAPITAL LETTER EPSILON WITH ACCENT	Greek
007	163	10/03	GREEK CAPITAL LETTER ETA WITH ACCENT	Greek
007	164	10/04	GREEK CAPITAL LETTER IOTA WITH ACCENT	Greek
007	165	10/05	GREEK CAPITAL LETTER IOTA WITH DIAERESIS	Greek
007	166	10/06	GREEK CAPITAL LETTER IOTA WITH ACCENT+DIAERESIS	Greek
007	167	10/07	GREEK CAPITAL LETTER OMICRON WITH ACCENT	Greek
007	168	10/08	GREEK CAPITAL LETTER UPSILON WITH ACCENT	Greek
007	169	10/09	GREEK CAPITAL LETTER UPSILON WITH DIAERESIS	Greek
007	170	10/10	GREEK CAPITAL LETTER UPSILON WITH ACCENT+DIAERESIS	Greek
007	171	10/11	GREEK CAPITAL LETTER OMEGA WITH ACCENT	Greek
007	177	11/01	GREEK SMALL LETTER ALPHA WITH ACCENT	Greek
007	178	11/02	GREEK SMALL LETTER EPSILON WITH ACCENT	Greek
007	179	11/03	GREEK SMALL LETTER ETA WITH ACCENT	Greek
007	180	11/04	GREEK SMALL LETTER IOTA WITH ACCENT	Greek
007	181	11/05	GREEK SMALL LETTER IOTA WITH DIAERESIS	Greek
007	182	11/06	GREEK SMALL LETTER IOTA WITH ACCENT+DIAERESIS	Greek
007	183	11/07	GREEK SMALL LETTER OMICRON WITH ACCENT	Greek
007	184	11/08	GREEK SMALL LETTER UPSILON WITH ACCENT	Greek
007	185	11/09	GREEK SMALL LETTER UPSILON WITH DIAERESIS	Greek
007	186	11/10	GREEK SMALL LETTER UPSILON WITH ACCENT+DIAERESIS	Greek
007	187	11/11	GREEK SMALL LETTER OMEGA WITH ACCENT	Greek
007	193	12/01	GREEK CAPITAL LETTER ALPHA	Greek
007	194	12/02	GREEK CAPITAL LETTER BETA	Greek
007	195	12/03	GREEK CAPITAL LETTER GAMMA	Greek
007	196	12/04	GREEK CAPITAL LETTER DELTA	Greek
007	197	12/05	GREEK CAPITAL LETTER EPSILON	Greek
007	198	12/06	GREEK CAPITAL LETTER ZETA	Greek
007	199	12/07	GREEK CAPITAL LETTER ETA	Greek
007	200	12/08	GREEK CAPITAL LETTER THETA	Greek
007	201	12/09	GREEK CAPITAL LETTER IOTA	Greek
007	202	12/10	GREEK CAPITAL LETTER KAPPA	Greek
007	203	12/11	GREEK CAPITAL LETTER LAMBDA	Greek
007	204	12/12	GREEK CAPITAL LETTER MU	Greek
007	205	12/13	GREEK CAPITAL LETTER NU	Greek
007	206	12/14	GREEK CAPITAL LETTER XI	Greek
007	207	12/15	GREEK CAPITAL LETTER OMICRON	Greek
007	208	13/00	GREEK CAPITAL LETTER PI	Greek
007	209	13/01	GREEK CAPITAL LETTER RHO	Greek
007	210	13/02	GREEK CAPITAL LETTER SIGMA	Greek
007	212	13/04	GREEK CAPITAL LETTER TAU	Greek
007	213	13/05	GREEK CAPITAL LETTER UPSILON	Greek

Byte 3	Byte 4	Code Pos	Name	Set
007	214	13/06	GREEK CAPITAL LETTER PHI	Greek
007	215	13/07	GREEK CAPITAL LETTER CHI	Greek
007	216	13/08	GREEK CAPITAL LETTER PSI	Greek
007	217	13/09	GREEK CAPITAL LETTER OMEGA	Greek
007	225	14/01	GREEK SMALL LETTER ALPHA	Greek
007	226	14/02	GREEK SMALL LETTER BETA	Greek
007	227	14/03	GREEK SMALL LETTER GAMMA	Greek
007	228	14/04	GREEK SMALL LETTER DELTA	Greek
007	229	14/05	GREEK SMALL LETTER EPSILON	Greek
007	230	14/06	GREEK SMALL LETTER ZETA	Greek
007	231	14/07	GREEK SMALL LETTER ETA	Greek
007	232	14/08	GREEK SMALL LETTER THETA	Greek
007	233	14/09	GREEK SMALL LETTER IOTA	Greek
007	234	14/10	GREEK SMALL LETTER KAPPA	Greek
007	235	14/11	GREEK SMALL LETTER LAMBDA	Greek
007	236	14/12	GREEK SMALL LETTER MU	Greek
007	237	14/13	GREEK SMALL LETTER NU	Greek
007	238	14/14	GREEK SMALL LETTER XI	Greek
007	239	14/15	GREEK SMALL LETTER OMICRON	Greek
007	240	15/00	GREEK SMALL LETTER PI	Greek
007	241	15/01	GREEK SMALL LETTER RHO	Greek
007	242	15/02	GREEK SMALL LETTER SIGMA	Greek
007	243	15/03	GREEK SMALL LETTER FINAL SMALL SIGMA	Greek
007	244	15/04	GREEK SMALL LETTER TAU	Greek
007	245	15/05	GREEK SMALL LETTER UPSILON	Greek
007	246	15/06	GREEK SMALL LETTER PHI	Greek
007	247	15/07	GREEK SMALL LETTER CHI	Greek
007	248	15/08	GREEK SMALL LETTER PSI	Greek
007	249	15/09	GREEK SMALL LETTER OMEGA	Greek
008	161	10/01	LEFT RADICAL	Technical
008	162	10/02	TOP LEFT RADICAL	Technical
008	163	10/03	HORIZONTAL CONNECTOR	Technical
008	164	10/04	TOP INTEGRAL	Technical
008	165	10/05	BOTTOM INTEGRAL	Technical
008	166	10/06	VERTICAL CONNECTOR	Technical
008	167	10/07	TOP LEFT SQUARE BRACKET	Technical
008	168	10/08	BOTTOM LEFT SQUARE BRACKET	Technical
008	169	10/09	TOP RIGHT SQUARE BRACKET	Technical
008	170	10/10	BOTTOM RIGHT SQUARE BRACKET	Technical
008	171	10/11	TOP LEFT PARENTHESIS	Technical
008	172	10/12	BOTTOM LEFT PARENTHESIS	Technical
008	173	10/13	TOP RIGHT PARENTHESIS	Technical
008	174	10/14	BOTTOM RIGHT PARENTHESIS	Technical
008	175	10/15	LEFT MIDDLE CURLY BRACE	Technical
008	176	11/00	RIGHT MIDDLE CURLY BRACE	Technical
008	177	11/01	TOP LEFT SUMMATION	Technical
008	178	11/02	BOTTOM LEFT SUMMATION	Technical
008	179	11/03	TOP VERTICAL SUMMATION CONNECTOR	Technical
008	180	11/04	BOTTOM VERTICAL SUMMATION CONNECTOR	Technical
008	181	11/05	TOP RIGHT SUMMATION	Technical
008	182	11/06	BOTTOM RIGHT SUMMATION	Technical
008	183	11/07	RIGHT MIDDLE SUMMATION	Technical
008	188	11/12	LESS THAN OR EQUAL SIGN	Technical
008	189	11/13	NOT EQUAL SIGN	Technical
008	190	11/14	GREATER THAN OR EQUAL SIGN	Technical
008	191	11/15	INTEGRAL	Technical
008	192	12/00	THEREFORE	Technical
008	193	12/01	VARIATION, PROPORTIONAL TO	Technical
008	194	12/02	INFINITY	Technical

Byte 3	Byte 4	Code Pos	Name	Set
008	197	12/05	NABLA, DEL	Technical
008	200	12/08	IS APPROXIMATE TO	Technical
008	201	12/09	SIMILAR OR EQUAL TO	Technical
008	205	12/13	IF AND ONLY IF	Technical
008	206	12/14	IMPLIES	Technical
008	207	12/15	IDENTICAL TO	Technical
008	214	13/06	RADICAL	Technical
008	218	13/10	IS INCLUDED IN	Technical
008	219	13/11	INCLUDES	Technical
008	220	13/12	INTERSECTION	Technical
008	221	13/13	UNION	Technical
008	222	13/14	LOGICAL AND	Technical
008	223	13/15	LOGICAL OR	Technical
008	239	14/15	PARTIAL DERIVATIVE	Technical
008	246	15/06	FUNCTION	Technical
008	251	15/11	LEFT ARROW	Technical
008	252	15/12	UPWARD ARROW	Technical
008	253	15/13	RIGHT ARROW	Technical
008	254	15/14	DOWNWARD ARROW	Technical
009	223	13/15	BLANK	Special
009	224	14/00	SOLID DIAMOND	Special
009	225	14/01	CHECKERBOARD	Special
009	226	14/02	"HT"	Special
009	227	14/03	"FF"	Special
009	228	14/04	"CR"	Special
009	229	14/05	"LF"	Special
009	232	14/08	"NL"	Special
009	233	14/09	"VT"	Special
009	234	14/10	LOWER-RIGHT CORNER	Special
009	235	14/11	UPPER-RIGHT CORNER	Special
009	236	14/12	UPPER-LEFT CORNER	Special
009	237	14/13	LOWER-LEFT CORNER	Special
009	238	14/14	CROSSING-LINES	Special
009	239	14/15	HORIZONTAL LINE, SCAN 1	Special
009	240	15/00	HORIZONTAL LINE, SCAN 3	Special
009	241	15/01	HORIZONTAL LINE, SCAN 5	Special
009	242	15/02	HORIZONTAL LINE, SCAN 7	Special
009	243	15/03	HORIZONTAL LINE, SCAN 9	Special
009	244	15/04	LEFT "T"	Special
009	245	15/05	RIGHT "T"	Special
009	246	15/06	BOTTOM "T"	Special
009	247	15/07	TOP "T"	Special
009	248	15/08	VERTICAL BAR	Special
010	161	10/01	EM SPACE	Publish
010	162	10/02	EN SPACE	Publish
010	163	10/03	3/EM SPACE	Publish
010	164	10/04	4/EM SPACE	Publish
010	165	10/05	DIGIT SPACE	Publish
010	166	10/06	PUNCTUATION SPACE	Publish
010	167	10/07	THIN SPACE	Publish
010	168	10/08	HAIR SPACE	Publish
010	169	10/09	EM DASH	Publish
010	170	10/10	EN DASH	Publish
010	172	10/12	SIGNIFICANT BLANK SYMBOL	Publish
010	174	10/14	ELLIPSIS	Publish
010	175	10/15	DOUBLE BASELINE DOT	Publish
010	176	11/00	VULGAR FRACTION ONE THIRD	Publish

Byte 3	Byte 4	Code Pos	Name	Set
010	177	11/01	VULGAR FRACTION TWO THIRDS	Publish
010	178	11/02	VULGAR FRACTION ONE FIFTH	Publish
010	179	11/03	VULGAR FRACTION TWO FIFTHS	Publish
010	180	11/04	VULGAR FRACTION THREE FIFTHS	Publish
010	181	11/05	VULGAR FRACTION FOUR FIFTHS	Publish
010	182	11/06	VULGAR FRACTION ONE SIXTH	Publish
010	183	11/07	VULGAR FRACTION FIVE SIXTHS	Publish
010	184	11/08	CARE OF	Publish
010	187	11/11	FIGURE DASH	Publish
010	188	11/12	LEFT ANGLE BRACKET	Publish
010	189	11/13	DECIMAL POINT	Publish
010	190	11/14	RIGHT ANGLE BRACKET	Publish
010	191	11/15	MARKER	Publish
010	195	12/03	VULGAR FRACTION ONE EIGHTH	Publish
010	196	12/04	VULGAR FRACTION THREE EIGHTHS	Publish
010	197	12/05	VULGAR FRACTION FIVE EIGHTHS	Publish
010	198	12/06	VULGAR FRACTION SEVEN EIGHTHS	Publish
010	201	12/09	TRADEMARK SIGN	Publish
010	202	12/10	SIGNATURE MARK	Publish
010	203	12/11	TRADEMARK SIGN IN CIRCLE	Publish
010	204	12/12	LEFT OPEN TRIANGLE	Publish
010	205	12/13	RIGHT OPEN TRIANGLE	Publish
010	206	12/14	EM OPEN CIRCLE	Publish
010	207	12/15	EM OPEN RECTANGLE	Publish
010	208	13/00	LEFT SINGLE QUOTATION MARK	Publish
010	209	13/01	RIGHT SINGLE QUOTATION MARK	Publish
010	210	13/02	LEFT DOUBLE QUOTATION MARK	Publish
010	211	13/03	RIGHT DOUBLE QUOTATION MARK	Publish
010	212	13/04	PRESCRIPTION, TAKE, RECIPE	Publish
010	214	13/06	MINUTES	Publish
010	215	13/07	SECONDS	Publish
010	217	13/09	LATIN CROSS	Publish
010	218	13/10	HEXAGRAM	Publish
010	219	13/11	FILLED RECTANGLE BULLET	Publish
010	220	13/12	FILLED LEFT TRIANGLE BULLET	Publish
010	221	13/13	FILLED RIGHT TRIANGLE BULLET	Publish
010	222	13/14	EM FILLED CIRCLE	Publish
010	223	13/15	EM FILLED RECTANGLE	Publish
010	224	14/00	EN OPEN CIRCLE BULLET	Publish
010	225	14/01	EN OPEN SQUARE BULLET	Publish
010	226	14/02	OPEN RECTANGULAR BULLET	Publish
010	227	14/03	OPEN TRIANGULAR BULLET UP	Publish
010	228	14/04	OPEN TRIANGULAR BULLET DOWN	Publish
010	229	14/05	OPEN STAR	Publish
010	230	14/06	EN FILLED CIRCLE BULLET	Publish
010	231	14/07	EN FILLED SQUARE BULLET	Publish
010	232	14/08	FILLED TRIANGULAR BULLET UP	Publish
010	233	14/09	FILLED TRIANGULAR BULLET DOWN	Publish
010	234	14/10	LEFT POINTER	Publish
010	235	14/11	RIGHT POINTER	Publish
010	236	14/12	CLUB	Publish
010	237	14/13	DIAMOND	Publish
010	238	14/14	HEART	Publish
010	240	15/00	MALTESE CROSS	Publish
010	241	15/01	DAGGER	Publish
010	242	15/02	DOUBLE DAGGER	Publish
010	243	15/03	CHECK MARK, TICK	Publish
010	244	15/04	BALLOT CROSS	Publish
010	245	15/05	MUSICAL SHARP	Publish
010	246	15/06	MUSICAL FLAT	Publish
010	247	15/07	MALE SYMBOL	Publish

Byte 3	Byte 4	Code Pos	Name	Set
010	248	15/08	FEMALE SYMBOL	Publish
010	249	15/09	TELEPHONE SYMBOL	Publish
010	250	15/10	TELEPHONE RECORDER SYMBOL	Publish
010	251	15/11	PHONOGRAPH COPYRIGHT SIGN	Publish
010	252	15/12	CARET	Publish
010	253	15/13	SINGLE LOW QUOTATION MARK	Publish
010	254	15/14	DOUBLE LOW QUOTATION MARK	Publish
010	255	15/15	CURSOR	Publish
011	163	10/03	LEFT CARET	APL
011	166	10/06	RIGHT CARET	APL
011	168	10/08	DOWN CARET	APL
011	169	10/09	UP CARET	APL
011	192	12/00	OVERBAR	APL
011	194	12/02	DOWN TACK	APL
011	195	12/03	UP SHOE (CAP)	APL
011	196	12/04	DOWN STILE	APL
011	198	12/06	UNDERBAR	APL
011	202	12/10	JOT	APL
011	204	12/12	QUAD	APL
011	206	12/14	UP TACK	APL
011	207	12/15	CIRCLE	APL
011	211	13/03	UP STILE	APL
011	214	13/06	DOWN SHOE (CUP)	APL
011	216	13/08	RIGHT SHOE	APL
011	218	13/10	LEFT SHOE	APL
011	220	13/12	LEFT TACK	APL
011	252	15/12	RIGHT TACK	APL
012	224	14/00	HEBREW LETTER ALEPH	Hebrew
012	225	14/01	HEBREW LETTER BETH	Hebrew
012	226	14/02	HEBREW LETTER GIMMEL	Hebrew
012	227	14/03	HEBREW LETTER DALETH	Hebrew
012	228	14/04	HEBREW LETTER HE	Hebrew
012	229	14/05	HEBREW LETTER WAW	Hebrew
012	230	14/06	HEBREW LETTER ZAYIN	Hebrew
012	231	14/07	HEBREW LETTER HET	Hebrew
012	232	14/08	HEBREW LETTER TETH	Hebrew
012	233	14/09	HEBREW LETTER YOD	Hebrew
012	234	14/10	HEBREW LETTER FINAL KAPH	Hebrew
012	235	14/11	HEBREW LETTER KAPH	Hebrew
012	236	14/12	HEBREW LETTER LAMED	Hebrew
012	237	14/13	HEBREW LETTER FINAL MEM	Hebrew
012	238	14/14	HEBREW LETTER MEM	Hebrew
012	239	14/15	HEBREW LETTER FINAL NUN	Hebrew
012	240	15/00	HEBREW LETTER NUN	Hebrew
012	241	15/01	HEBREW LETTER SAMEKH	Hebrew
012	242	15/02	HEBREW LETTER A'YIN	Hebrew
012	243	15/03	HEBREW LETTER FINAL PE	Hebrew
012	244	15/04	HEBREW LETTER PE	Hebrew
012	245	15/05	HEBREW LETTER FINAL ZADI	Hebrew
012	246	15/06	HEBREW LETTER ZADI	Hebrew
012	247	15/07	HEBREW KUF	Hebrew
012	248	15/08	HEBREW RESH	Hebrew
012	249	15/09	HEBREW SHIN	Hebrew
012	250	15/10	HEBREW TAF	Hebrew
255	008	00/08	BACKSPACE, BACK SPACE, BACK CHAR	Keyboard

Byte 3	Byte 4	Code Pos	Name	Set
255	009	00/09	TAB	Keyboard
255	010	00/10	LINEFEED, LF	Keyboard
255	011	00/11	CLEAR	Keyboard
255	013	00/13	RETURN, ENTER	Keyboard
255	019	01/03	PAUSE, HOLD, SCROLL LOCK	Keyboard
255	027	01/11	ESCAPE	Keyboard
255	032	02/00	MULTI-KEY CHARACTER PREFACE	Keyboard
255	033	02/01	KANJI, KANJI CONVERT	Keyboard
255	080	05/00	HOME	Keyboard
255	081	05/01	LEFT, MOVE LEFT, LEFT ARROW	Keyboard
255	082	05/02	UP, MOVE UP, UP ARROW	Keyboard
255	083	05/03	RIGHT, MOVE RIGHT, RIGHT ARROW	Keyboard
255	084	05/04	DOWN, MOVE DOWN, DOWN ARROW	Keyboard
255	085	05/05	PRIOR, PREVIOUS	Keyboard
255	086	05/06	NEXT	Keyboard
255	087	05/07	END, EOL	Keyboard
255	088	05/08	BEGIN, BOL	Keyboard
255	096	06/00	SELECT, MARK	Keyboard
255	097	06/01	PRINT	Keyboard
255	098	06/02	EXECUTE, RUN, DO	Keyboard
255	099	06/03	INSERT, INSERT HERE	Keyboard
255	101	06/05	UNDO, OOPS	Keyboard
255	102	06/06	REDO, AGAIN	Keyboard
255	103	06/07	MENU	Keyboard
255	104	06/08	FIND, SEARCH	Keyboard
255	105	06/09	CANCEL, STOP, ABORT, EXIT	Keyboard
255	106	06/10	HELP, QUESTION MARK	Keyboard
255	107	06/11	BREAK	Keyboard
255	126	07/14	MODE SWITCH, SCRIPT SWITCH, CHARACTER SET SWITCH	Keyboard
255	127	07/15	NUM LOCK	Keyboard
255	128	08/00	KEYPAD SPACE	Keyboard
255	137	08/09	KEYPAD TAB	Keyboard
255	141	08/13	KEYPAD ENTER	Keyboard
255	145	09/01	KEYPAD F1, PF1, A	Keyboard
255	146	09/02	KEYPAD F2, PF2, B	Keyboard
255	147	09/03	KEYPAD F3, PF3, C	Keyboard
255	148	09/04	KEYPAD F4, PF4, D	Keyboard
255	170	10/10	KEYPAD MULTIPLICATION SIGN, ASTERISK	Keyboard
255	171	10/11	KEYPAD PLUS SIGN	Keyboard
255	172	10/12	KEYPAD SEPARATOR, COMMA	Keyboard
255	173	10/13	KEYPAD MINUS SIGN, HYPHEN	Keyboard
255	174	10/14	KEYPAD DECIMAL POINT, FULL STOP	Keyboard
255	175	10/15	KEYPAD DIVISION SIGN, SOLIDUS	Keyboard
255	176	11/00	KEYPAD DIGIT ZERO	Keyboard
255	177	11/01	KEYPAD DIGIT ONE	Keyboard
255	178	11/02	KEYPAD DIGIT TWO	Keyboard
255	179	11/03	KEYPAD DIGIT THREE	Keyboard
255	180	11/04	KEYPAD DIGIT FOUR	Keyboard
255	181	11/05	KEYPAD DIGIT FIVE	Keyboard
255	182	11/06	KEYPAD DIGIT SIX	Keyboard
255	183	11/07	KEYPAD DIGIT SEVEN	Keyboard
255	184	11/08	KEYPAD DIGIT EIGHT	Keyboard
255	185	11/09	KEYPAD DIGIT NINE	Keyboard
255	189	11/13	KEYPAD EQUALS SIGN	Keyboard
255	190	11/14	F1	Keyboard
255	191	11/15	F2	Keyboard
255	192	12/00	F3	Keyboard
255	193	12/01	F4	Keyboard
255	194	12/02	F5	Keyboard
255	195	12/03	F6	Keyboard
255	196	12/04	F7	Keyboard

Byte 3	Byte 4	Code Pos	Name	Set
255	197	12/05	F8	Keyboard
255	198	12/06	F9	Keyboard
255	199	12/07	F10	Keyboard
255	200	12/08	F11, L1	Keyboard
255	201	12/09	F12, L2	Keyboard
255	202	12/10	F13, L3	Keyboard
255	203	12/11	F14, L4	Keyboard
255	204	12/12	F15, L5	Keyboard
255	205	12/13	F16, L6	Keyboard
255	206	12/14	F17, L7	Keyboard
255	207	12/15	F18, L8	Keyboard
255	208	13/00	F19, L9	Keyboard
255	209	13/01	F20, L10	Keyboard
255	210	13/02	F21, R1	Keyboard
255	211	13/03	F22, R2	Keyboard
255	212	13/04	F23, R3	Keyboard
255	213	13/05	F24, R4	Keyboard
255	214	13/06	F25, R5	Keyboard
255	215	13/07	F26, R6	Keyboard
255	216	13/08	F27, R7	Keyboard
255	217	13/09	F28, R8	Keyboard
255	218	13/10	F29, R9	Keyboard
255	219	13/11	F30, R10	Keyboard
255	220	13/12	F31, R11	Keyboard
255	221	13/13	F32, R12	Keyboard
255	222	13/14	F33, R13	Keyboard
255	223	13/15	F34, R14	Keyboard
255	224	14/00	F35, R15	Keyboard
255	225	14/01	LEFT SHIFT	Keyboard
255	226	14/02	RIGHT SHIFT	Keyboard
255	227	14/03	LEFT CONTROL	Keyboard
255	228	14/04	RIGHT CONTROL	Keyboard
255	229	14/05	CAPS LOCK	Keyboard
255	230	14/06	SHIFT LOCK	Keyboard
255	231	14/07	LEFT META	Keyboard
255	232	14/08	RIGHT META	Keyboard
255	233	14/09	LEFT ALT	Keyboard
255	234	14/10	RIGHT ALT	Keyboard
255	235	14/11	LEFT SUPER	Keyboard
255	236	14/12	RIGHT SUPER	Keyboard
255	237	14/13	LEFT HYPER	Keyboard
255	238	14/14	RIGHT HYPER	Keyboard
255	255	15/15	DELETE, RUBOUT	Keyboard

Appendix B
Protocol Encoding

Syntactic Conventions

All numbers are in decimal, unless prefixed with #x, in which case they are in hexadecimal (base 16).

The general syntax used to describe requests, replies, errors, events, and compound types is:

NameofThing
encode-form
...
encode-form

Each encode-form describes a single component.

For components described in the protocol as:

name: TYPE

the encode-form is:

N	TYPE	name

N is the number of bytes occupied in the data stream, and TYPE is the interpretation of those bytes. For example,

depth: CARD8

becomes:

1	CARD8	depth

For components with a static numeric value the encode-form is:

N	value	name

The value is always interpreted as an N-byte unsigned integer. For example, the first two bytes of a Window error are always zero (indicating an error in general) and three (indicating the Window error in particular):

1	0	Error
1	3	code

For components described in the protocol as:

name: {**Name1**,..., **NameI**}

the encode-form is:

N		name
	value1	Name1
	...	
	valueI	NameI

The value is always interpreted as an N-byte unsigned integer. Note that the size of N is sometimes larger than that strictly required to encode the values. For example:

class: {**InputOutput**, **InputOnly**, **CopyFromParent**}

becomes:

2		class
	0	CopyFromParent
	1	InputOutput
	2	InputOnly

For components described in the protocol as:

NAME: TYPE or **Alternative1** ...or **AlternativeI**

the encode-form is:

N	TYPE		NAME
	value1	Alternative1	
	...		
	valueI	AlternativeI	

The alternative values are guaranteed not to conflict with the encoding of TYPE. For example:

destination: WINDOW or **PointerWindow** or **InputFocus**

becomes:

4	WINDOW		destination
	0	PointerWindow	
	1	InputFocus	

For components described in the protocol as:

value-mask: BITMASK

the encode-form is:

N	BITMASK		value-mask
	mask1	mask-name1	
	...		
	maskI	mask-nameI	

The individual bits in the mask are specified and named, and N is 2 or 4. The most-significant bit in a BITMASK is reserved for use in defining chained (multiword) bitmasks, as extensions augment existing core requests. The precise interpretation of this bit is not yet defined here, although a probable mechanism is that a 1-bit indicates that another N bytes of bitmask follows, with bits within the overall mask still interpreted from least-significant to most-significant with an N-byte unit, with N-byte units interpreted in stream order, and with the overall mask being byte-swapped in individual N-byte units.

For LISTofVALUE encodings, the request is followed by a section of the form:

VALUEs
encode-form
...
encode-form

listing an encode-form for each VALUE. The NAME in each encode-form keys to the corresponding BITMASK bit. The encoding of a VALUE always occupies four bytes, but the number of bytes specified in the encoding-form indicates how many of the least-significant bytes are actually used; the remaining bytes are unused and their values do not matter.

In various cases, the number of bytes occupied by a component will be specified by a lowercase single-letter variable name instead of a specific numeric value, and often some other component will have its value specified as a simple numeric expression involving these variables. Components specified with such expressions are always interpreted as unsigned integers. The scope of such variables is always just the enclosing request, reply, error, event, or compound type structure. For example:

2	3+n	request length
4n	LISTofPOINT	points

For unused bytes (the values of the bytes are undefined and do no matter), the encode-form is:

N	unused

If the number of unused bytes is variable, the encode-form typically is:

p	unused, p=pad(E)

where E is some expression, and pad(E) is the number of bytes needed to round E up to a multiple of four.

pad(E) = (4 - (E mod 4)) mod 4

Common Types

LISTofFOO

In this document the LISTof notation strictly means some number of repetitions of the FOO encoding; the actual length of the list is encoded elsewhere.

SETofFOO

A set is always represented by a bitmask, with a 1-bit indicating presence in the set.

BITMASK: CARD32

WINDOW: CARD32

PIXMAP: CARD32

CURSOR: CARD32

FONT: CARD32

GCONTEXT: CARD32

COLORMAP: CARD32

DRAWABLE: CARD32

FONTABLE: CARD32

ATOM: CARD32

VISUALID: CARD32

BYTE: 8-bit value

INT8: 8-bit signed integer

INT16: 16-bit signed integer

INT32: 32-bit signed integer

CARD8: 8-bit unsigned integer

CARD16: 16-bit unsigned integer

CARD32: 32-bit unsigned integer

TIMESTAMP: CARD32

BITGRAVITY

0	Forget
1	NorthWest
2	North
3	NorthEast
4	West
5	Center
6	East
7	SouthWest
8	South
9	SouthEast
10	Static

WINGRAVITY

0	Unmap
1	NorthWest
2	North
3	NorthEast
4	West
5	Center
6	East
7	SouthWest
8	South
9	SouthEast
10	Static

BOOL

0	False
1	True

SETofEVENT

#x00000001	KeyPress

#x00000002	KeyRelease
#x00000004	ButtonPress
#x00000008	ButtonRelease
#x00000010	EnterWindow
#x00000020	LeaveWindow
#x00000040	PointerMotion
#x00000080	PointerMotionHint
#x00000100	Button1Motion
#x00000200	Button2Motion
#x00000400	Button3Motion
#x00000800	Button4Motion
#x00001000	Button5Motion
#x00002000	ButtonMotion
#x00004000	KeymapState
#x00008000	Exposure
#x00010000	VisibilityChange
#x00020000	StructureNotify
#x00040000	ResizeRedirect
#x00080000	SubstructureNotify
#x00100000	SubstructureRedirect
#x00200000	FocusChange
#x00400000	PropertyChange
#x00800000	ColormapChange
#x01000000	OwnerGrabButton
#xfe000000	unused but must be zero

SETofPOINTEREVENT
encodings are the same as for SETofEVENT, except with
#xffff8003 unused but must be zero

SETofDEVICEEVENT
encodings are the same as for SETofEVENT, except with
#xffffc0b0 unused but must be zero

KEYSYM: CARD32

KEYCODE: CARD8

BUTTON: CARD8

SETofKEYBUTMASK

#x0001	Shift
#x0002	Lock
#x0004	Control
#x0008	Mod1
#x0010	Mod2
#x0020	Mod3
#x0040	Mod4
#x0080	Mod5
#x0100	Button1
#x0200	Button2
#x0400	Button3
#x0800	Button4
#x1000	Button5
#xe000	unused but must be zero

SETofKEYMASK
encodings are the same as for SETofKEYBUTMASK, except with
#xff00 unused but must be zero

STRING8: LISTofCARD8

STRING16: LISTofCHAR2B

CHAR2B

1	CARD8	byte1
1	CARD8	byte2

POINT

2	INT16	x	
2	INT16	y	

RECTANGLE

2	INT16	x	
2	INT16	y	
2	CARD16	width	
2	CARD16	height	

ARC

2	INT16	x	
2	INT16	y	
2	CARD16	width	
2	CARD16	height	
2	INT16	angle1	
2	INT16	angle2	

HOST

1			family
	0	Internet	
	1	DECnet	
	2	Chaos	
1			unused
2	n		length of address
n	LISTofBYTE		address
p			unused, p=pad(n)

STR

1	n		length of name in bytes
n	STRING8		name

Errors

Request

1	0		Error
1	1		code
2	CARD16		sequence number
4			unused
2	CARD16		minor opcode
1	CARD8		major opcode
21			unused

Value

1	0		Error
1	2		code
2	CARD16		sequence number
4	<32-bits>		bad value
2	CARD16		minor opcode
1	CARD8		major opcode
21			unused

Window

1	0		Error
1	3		code
2	CARD16		sequence number
4	CARD32		bad resource id
2	CARD16		minor opcode
1	CARD8		major opcode
21			unused

Pixmap

1	0		Error
1	4		code
2	CARD16		sequence number
4	CARD32		bad resource id

2	CARD16	minor opcode
1	CARD8	major opcode
21		unused

Atom

1	0	Error
1	5	code
2	CARD16	sequence number
4	CARD32	bad atom id
2	CARD16	minor opcode
1	CARD8	major opcode
21		unused

Cursor

1	0	Error
1	6	code
2	CARD16	sequence number
4	CARD32	bad resource id
2	CARD16	minor opcode
1	CARD8	major opcode
21		unused

Font

1	0	Error
1	7	code
2	CARD16	sequence number
4	CARD32	bad resource id
2	CARD16	minor opcode
1	CARD8	major opcode
21		unused

Match

1	0	Error
1	8	code
2	CARD16	sequence number
4		unused
2	CARD16	minor opcode
1	CARD8	major opcode
21		unused

Drawable

1	0	Error
1	9	code
2	CARD16	sequence number
4	CARD32	bad resource id
2	CARD16	minor opcode
1	CARD8	major opcode
21		unused

Access

1	0	Error
1	10	code
2	CARD16	sequence number
4		unused
2	CARD16	minor opcode
1	CARD8	major opcode
21		unused

Alloc

1	0	Error
1	11	code
2	CARD16	sequence number
4		unused
2	CARD16	minor opcode
1	CARD8	major opcode
21		unused

Colormap

1	0	Error
1	12	code
2	CARD16	sequence number
4	CARD32	bad resource id
2	CARD16	minor opcode
1	CARD8	major opcode
21		unused

GContext

1	0	Error
1	13	code
2	CARD16	sequence number
4	CARD32	bad resource id
2	CARD16	minor opcode
1	CARD8	major opcode
21		unused

IDChoice

1	0	Error
1	14	code
2	CARD16	sequence number
4	CARD32	bad resource id
2	CARD16	minor opcode
1	CARD8	major opcode
21		unused

Name

1	0	Error
1	15	code
2	CARD16	sequence number
4		unused
2	CARD16	minor opcode
1	CARD8	major opcode
21		unused

Length

1	0	Error
1	16	code
2	CARD16	sequence number
4		unused
2	CARD16	minor opcode
1	CARD8	major opcode
21		unused

Implementation

1	0	Error
1	17	code
2	CARD16	sequence number
4		unused
2	CARD16	minor opcode
1	CARD8	major opcode
21		unused

Keyboards

KEYCODE values are always greater than 7 (and less than 256).

KEYSYM values with the bit #x10000000 set are reserved as vendor-specific.

The names and encodings of the standard KEYSYM values are contained in appendix F.

Pointers

BUTTON values are numbered starting with one.

Predefined Atoms

PRIMARY	1	WM_NORMAL_HINTS	40
SECONDARY	2	WM_SIZE_HINTS	41
ARC	3	WM_ZOOM_HINTS	42
ATOM	4	MIN_SPACE	43
BITMAP	5	NORM_SPACE	44
CARDINAL	6	MAX_SPACE	45
COLORMAP	7	END_SPACE	46
CURSOR	8	SUPERSCRIPT_X	47
CUT_BUFFER0	9	SUPERSCRIPT_Y	48
CUT_BUFFER1	10	SUBSCRIPT_X	49
CUT_BUFFER2	11	SUBSCRIPT_Y	50
CUT_BUFFER3	12	UNDERLINE_POSITION	51
CUT_BUFFER4	13	UNDERLINE_THICKNESS	52
CUT_BUFFER5	14	STRIKEOUT_ASCENT	53
CUT_BUFFER6	15	STRIKEOUT_DESCENT	54
CUT_BUFFER7	16	ITALIC_ANGLE	55
DRAWABLE	17	X_HEIGHT	56
FONT	18	QUAD_WIDTH	57
INTEGER	19	WEIGHT	58
PIXMAP	20	POINT_SIZE	59
POINT	21	RESOLUTION	60
RECTANGLE	22	COPYRIGHT	61
RESOURCE_MANGER	23	NOTICE	62
RGB_COLOR_MAP	24	FONT_NAME	63
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Connection Setup

For TCP connections, displays on a given host are numbered starting from 0, and the server for display N listens and accepts connections on port 6000 + N. For DECnet connections, displays on a given host are numbered starting from 0, and the server for display N listens and accepts connections on the object name obtained by concatenating "X$X" with the decimal representation of N, for example, X$X0 and X$X1.

Information sent by the client at connection setup:

1			byte-order
	#x42	MSB first	
	#x6C	LSB first	
1			unused
2	CARD16		protocol-major-version
2	CARD16		protocol-minor-version
2	n		length of authorization-protocol-name
2	d		length of authorization-protocol-data
2			unused
n	STRING8		authorization-protocol-name
p			unused, p=pad(n)
d	STRING8		authorization-protocol-data
q			unused, q=pad(d)

Except where explicitly noted in the protocol, all 16-bit and 32-bit quantities sent by the client must be transmitted with the specified byte order, and all 16-bit and 32-bit quantities returned by the server will be transmitted with this byte order.

Information received by the client if authorization fails:

1	0		failed
1	n		length of reason in bytes
2	CARD16		protocol-major-version
2	CARD16		protocol-minor-version
2	(n+p)/4		length in 4-byte units of "additional data"
n	STRING8		reason
p			unused, p=pad(n)

Information received by the client if authorization is accepted:

1	1		success
1			unused
2	CARD16		protocol-major-version
2	CARD16		protocol-minor-version
2	8+2n+(v+p+m)/4		length in 4-byte units of "additional data"
4	CARD32		release-number
4	CARD32		resource-id-base
4	CARD32		resource-id-mask
4	CARD32		motion-buffer-size
2	v		length of vendor
2	CARD16		maximum-request-length
1	CARD8		number of SCREENs in roots
1	n		number for FORMATs in pixmap-formats
1			image-byte-order
	0	LSBFirst	
	1	MSBFirst	
1			bitmap-format-bit-order
	0	LeastSignificant	
	1	MostSignificant	
1	CARD8		bitmap-format-scanline-unit
1	CARD8		bitmap-format-scanline-pad
1	KEYCODE		min-keycode
1	KEYCODE		max-keycode
4			unused
v	STRING8		vendor
p			unused, p=pad(v)
8n	LISTofFORMAT		pixmap-formats
m	LISTofSCREEN		roots (m is always a multiple of 4)

FORMAT

1	CARD8		depth
1	CARD8		bits-per-pixel
1	CARD8		scanline-pad
5			unused

SCREEN

4	WINDOW		root
4	COLORMAP		default-colormap
4	CARD32		white-pixel
4	CARD32		black-pixel
4	SETofEVENT		current-input-masks
2	CARD16		width-in-pixels
2	CARD16		height-in-pixels
2	CARD16		width-in-millimeters
2	CARD16		height-in-millimeters
2	CARD16		min-installed-maps
2	CARD16		max-installed-maps
4	VISUALID		root-visual
1			backing-stores
	0	Never	
	1	WhenMapped	
	2	Always	
1	BOOL		save-unders
1	CARD8		root-depth
1	CARD8		number of DEPTHs in allowed-depths

n	LISTofDEPTH		allowed-depths (n is always a multiple of 4)

DEPTH

1	CARD8		depth
1			unused
2	n		number of VISUALTYPES in visuals
4			unused
24n	LISTofVISUALTYPE		visuals

VISUALTYPE

4	VISUALID		visual-id
1			class
	0	StaticGray	
	1	GrayScale	
	2	StaticColor	
	3	PseudoColor	
	4	TrueColor	
	5	DirectColor	
1	CARD8		bits-per-rgb-value
2	CARD16		colormap-entries
4	CARD32		red-mask
4	CARD32		green-mask
4	CARD32		blue-mask
4			unused

Requests

CreateWindow

1	1		opcode
1	CARD8		depth
2	8+n		request length
4	WINDOW		wid
4	WINDOW		parent
2	INT16		x
2	INT16		y
2	CARD16		width
2	CARD16		height
2	CARD16		border-width
2			class
	0	CopyFromParent	
	1	InputOutput	
	2	InputOnly	
4	VISUALID		visual
	0	CopyFromParent	
4	BITMASK		value-mask (has n bits set to 1)
	#x00000001	background-pixmap	
	#x00000002	background-pixel	
	#x00000004	border-pixmap	
	#x00000008	border-pixel	
	#x00000010	bit-gravity	
	#x00000020	win-gravity	
	#x00000040	backing-store	
	#x00000080	backing-planes	
	#x00000100	backing-pixel	
	#x00000200	override-redirect	
	#x00000400	save-under	
	#x00000800	event-mask	
	#x00001000	do-not-propagate-mask	
	#x00002000	colormap	
	#x00004000	cursor	
4n	LISTofVALUE		value-list

VALUEs

4	PIXMAP		background-pixmap
	0	None	
	1	ParentRelative	

4	CARD32		background-pixel
4	PIXMAP		border-pixmap
	0	CopyFromParent	
4	CARD32		border-pixel
1	BITGRAVITY		bit-gravity
1	WINGRAVITY		win-gravity
1			backing-store
	0	NotUseful	
	1	WhenMapped	
	2	Always	
4	CARD32		backing-planes
4	CARD32		backing-pixel
1	BOOL		override-redirect
1	BOOL		save-under
4	SETofEVENT		event-mask
4	SETofDEVICEEVENT		do-not-propagate-mask
4	COLORMAP		colormap
	0	CopyFromParent	
4	CURSOR		cursor
	0	None	

ChangeWindowAttributes

1	2		opcode
1			unused
2	3+n		request length
4	WINDOW		window
4	BITMASK		value-mask (has n bits set to 1)
	encodings are the same as for CreateWindow		
4n	LISTofVALUE		value-list
	encodings are the same as for CreateWindow		

GetWindowAttributes

1	3		opcode
1			unused
2	2		request length
4	WINDOW		window

=>

1	1		Reply
1			backing-store
	0	NotUseful	
	1	WhenMapped	
	2	Always	
2	CARD16		sequence number
4	3		reply length
4	VISUALID		visual
2			class
	1	InputOutput	
	2	InputOnly	
1	BITGRAVITY		bit-gravity
1	WINGRAVITY		win-gravity
4	CARD32		backing-planes
4	CARD32		backing-pixel
1	BOOL		save-under
1	BOOL		map-is-installed
1			map-state
	0	Unmapped	
	1	Unviewable	
	2	Viewable	
1	BOOL		override-redirect
4	COLORMAP		colormap
	0	None	
4	SETofEVENT		all-event-masks
4	SETofEVENT		your-event-mask
2	SETofDEVICEEVENT		do-not-propagate-mask
2			unused

DestroyWindow

1	4		opcode
1			unused
2	2		request length
4	WINDOW		window

DestroySubwindows

1	5		opcode
1			unused
2	2		request length
4	WINDOW		window

ChangeSaveSet

1	6		opcode
1			mode
	0	Insert	
	1	Delete	
2	2		request length
4	WINDOW		window

ReparentWindow

1	7		opcode
1			unused
2	4		request length
4	WINDOW		window
4	WINDOW		parent
2	INT16		x
2	INT16		y

MapWindow

1	8		opcode
1			unused
2	2		request length
4	WINDOW		window

MapSubwindows

1	9		opcode
1			unused
2	2		request length
4	WINDOW		window

UnmapWindow

1	10		opcode
1			unused
2	2		request length
4	WINDOW		window

UnmapSubwindows

1	11		opcode
1			unused
2	2		request length
4	WINDOW		window

ConfigureWindow

1	12		opcode
1			unused
2	3+n		request length
4	WINDOW		window
2	BITMASK		value-mask (has n bits set to 1)
	#x0001	x	
	#x0002	y	
	#x0004	width	
	#x0008	height	
	#x0010	border-width	
	#x0020	sibling	
	#x0040	stack-mode	

2			unused
4n	LISTofVALUE		value-list

VALUEs

2	INT16		x
2	INT16		y
2	CARD16		width
2	CARD16		height
2	CARD16		border-width
4	WINDOW		sibling
1			stack-mode
	0	Above	
	1	Below	
	2	TopIf	
	3	BottomIf	
	4	Opposite	

CirculateWindow

1	13		opcode
1			direction
	0	RaiseLowest	
	1	LowerHighest	
2	2		request length
4	WINDOW		window

GetGeometry

1	14		opcode
1			unused
2	2		request length
4	DRAWABLE		drawable

=>

1	1		Reply
1	CARD8		depth
2	CARD16		sequence number
4	0		reply length
4	WINDOW		root
2	INT16		x
2	INT16		y
2	CARD16		width
2	CARD16		height
2	CARD16		border-width
10			unused

QueryTree

1	15		opcode
1			unused
2	2		request length
4	WINDOW		window

=>

1	1		Reply
1			unused
2	CARD16		sequence number
4	n		reply length
4	WINDOW		root
4	WINDOW		parent
	0	None	
2	n		number of WINDOWs in children
14			unused
4n	LISTofWINDOW		children

InternAtom

1	16		opcode
1	BOOL		only-if-exists
2	2+(n+p)/4		request length
2	n		length of name

2			unused
n	STRING8		name
p			unused, p=pad(n)

=>

1	1		Reply
1			unused
2	CARD16		sequence number
4	0		reply length
4	ATOM		atom
	0	None	
20			unused

GetAtomName

1	17		opcode
1			unused
2	2		request length
4	ATOM		atom

=>

1	1		Reply
1			unused
2	CARD16		sequence number
4	(n+p)/4		reply length
2	n		length of name
22			unused
n	STRING8		name
p			unused, p=pad(n)

ChangeProperty

1	18		opcode
1			mode
	0	Replace	
	1	Prepend	
	2	Append	
2	6+(n+p)/4		request length
4	WINDOW		window
4	ATOM		property
4	ATOM		type
1	CARD8		format
3			unused
4	CARD32		length of data in format units (= n for format = 8) (= n/2 for format = 16) (= n/4 for format = 32)
n	LISTofBYTE		data (n is a multiple of 2 for format = 16) (n is a multiple of 4 for format = 32)
p			unused, p=pad(n)

DeleteProperty

1	19		opcode
1			unused
2	3		request length
4	WINDOW		window
4	ATOM		property

GetProperty

1	20		opcode
1	BOOL		delete
2	6		request length
4	WINDOW		window
4	ATOM		property
4	ATOM		type
	0	AnyPropertyType	
4	CARD32		long-offset

4	CARD32		long-length

=>

1	1		Reply
1	CARD8		format
2	CARD16		sequence number
4	(n+p)/4		reply length
4	ATOM		type
	0	None	
4	CARD32		bytes-after
4	CARD32		length of value in format units (= 0 for format = 0) (= n for format = 8) (= n/2 for format = 16) (= n/4 for format = 32)
12			unused
n	LISTofBYTE		value (n is zero for format = 0) (n is a multiple of 2 for format = 16) (n is a multiple of 4 for format = 32)
p			unused, p=pad(n)

ListProperties

1	21		opcode
1			unused
2	2		request length
4	WINDOW		window

=>

1	1		Reply
1			unused
2	CARD16		sequence number
4	n		reply length
2	n		number of ATOMs in atoms
22			unused
4n	LISTofATOM		atoms

SetSelectionOwner

1	22		opcode
1			unused
2	4		request length
4	WINDOW		owner
	0	None	
4	ATOM		selection
4	TIMESTAMP		time
	0	CurrentTime	

GetSelectionOwner

1	23		opcode
1			unused
2	2		request length
4	ATOM		selection

=>

1	1		Reply
1			unused
2	CARD16		sequence number
4	0		reply length
4	WINDOW		owner
	0	None	
20			unused

ConvertSelection

1	24		opcode
1			unused
2	6		request length
4	WINDOW		requestor

4	ATOM		selection
4	ATOM		target
4	ATOM		property
	0	None	
4	TIMESTAMP		time
	0	CurrentTime	

SendEvent

1	25		opcode
1	BOOL		propagate
2	11		request length
4	WINDOW		destination
	0	PointerWindow	
	1	InputFocus	
4	SETofEVENT		event-mask
32			event
	standard event format (see the Events section)		

GrabPointer

1	26		opcode
1	BOOL		owner-events
2	6		request length
4	WINDOW		grab-window
2	SETofPOINTEREVENT		event-mask
1			pointer-mode
	0	Synchronous	
	1	Asynchronous	
1			keyboard-mode
	0	Synchronous	
	1	Asynchronous	
4	WINDOW		confine-to
	0	None	
4	CURSOR		cursor
	0	None	
4	TIMESTAMP		time
	0	CurrentTime	

=>

1	1		Reply
1			status
	0	Success	
	1	AlreadyGrabbed	
	2	InvalidTime	
	3	NotViewable	
	4	Frozen	
2	CARD16		sequence number
4	0		reply length
24			unused

UngrabPointer

1	27		opcode
1			unused
2	2		request length
4	TIMESTAMP		time
	0	CurrentTime	

GrabButton

1	28		opcode
1	BOOL		owner-events
2	6		request length
4	WINDOW		grab-window
2	SETofPOINTEREVENT		event-mask
1			pointer-mode
	0	Synchronous	
	1	Asynchronous	
1			keyboard-mode

	0	Synchronous	
	1	Asynchronous	
4	WINDOW		confine-to
	0	None	
4	CURSOR		cursor
	0	None	
1	BUTTON		button
	0	AnyButton	
1			unused
2	SETofKEYMASK		modifiers
	#x8000	AnyModifier	

UngrabButton

1	29		opcode
1	BUTTON		button
	0	AnyButton	
2	3		request length
4	WINDOW		grab-window
2	SETofKEYMASK		modifiers
	#x8000	AnyModifier	
2			unused

ChangeActivePointerGrab

1	30		opcode
1			unused
2	4		request length
4	CURSOR		cursor
	0	None	
4	TIMESTAMP		time
	0	CurrentTime	
2	SETofPOINTEREVENT		event-mask
2			unused

GrabKeyboard

1	31		opcode
1	BOOL		owner-events
2	4		request length
4	WINDOW		grab-window
4	TIMESTAMP		time
	0	CurrentTime	
1			pointer-mode
	0	Synchronous	
	1	Asynchronous	
1			keyboard-mode
	0	Synchronous	
	1	Asynchronous	
2			unused

=>

1	1		Reply
1			status
	0	Success	
	1	AlreadyGrabbed	
	2	InvalidTime	
	3	NotViewable	
	4	Frozen	
2	CARD16		sequence number
4	0		reply length
24			unused

UngrabKeyboard

1	32		opcode
1			unused
2	2		request length
4	TIMESTAMP		time
	0	CurrentTime	

GrabKey

1	33		opcode
1	BOOL		owner-events
2	4		request length
4	WINDOW		grab-window
2	SETofKEYMASK		modifiers
	#x8000	AnyModifier	
1	KEYCODE		key
	0	AnyKey	
1			pointer-mode
	0	Synchronous	
	1	Asynchronous	
1			keyboard-mode
	0	Synchronous	
	1	Asynchronous	
3			unused

UngrabKey

1	34		opcode
1	KEYCODE		key
	0	AnyKey	
2	3		request length
4	WINDOW		grab-window
2	SETofKEYMASK		modifiers
	#x8000	AnyModifier	
2			unused

AllowEvents

1	35		opcode
1			mode
	0	AsyncPointer	
	1	SyncPointer	
	2	ReplayPointer	
	3	AsyncKeyboard	
	4	SyncKeyboard	
	5	ReplayKeyboard	
	6	AsyncBoth	
	7	SyncBoth	
2	2		request length
4	TIMESTAMP		time
	0	CurrentTime	

GrabServer

1	36		opcode
1			unused
2	1		request length

UngrabServer

1	37		opcode
1			unused
2	1		request length

QueryPointer

1	38		opcode
1			unused
2	2		request length
4	WINDOW		window

=>

1	1		Reply
1	BOOL		same-screen
2	CARD16		sequence number
4	0		reply length
4	WINDOW		root
4	WINDOW		child
	0	None	

2	INT16		root-x
2	INT16		root-y
2	INT16		win-x
2	INT16		win-y
2	SETofKEYBUTMASK		mask
6			unused

GetMotionEvents

1	39		opcode
1			unused
2	4		request length
4	WINDOW		window
4	TIMESTAMP		start
	0	CurrentTime	
4	TIMESTAMP		stop
	0	CurrentTime	

=>

1	1		Reply
1			unused
2	CARD16		sequence number
4	2n		reply length
4	n		number of TIMECOORDs in events
20			unused
8n	LISTofTIMECOORD		events

TIMECOORD

4	TIMESTAMP		time
2	CARD16		x
2	CARD16		y

TranslateCoordinates

1	40		opcode
1			unused
2	4		request length
4	WINDOW		src-window
4	WINDOW		dst-window
2	INT16		src-x
2	INT16		src-y

=>

1	1		Reply
1	BOOL		same-screen
2	CARD16		sequence number
4	0		reply length
4	WINDOW		child
	0	None	
2	INT16		dst-x
2	INT16		dst-y
16			unused

WarpPointer

1	41		opcode
1			unused
2	6		request length
4	WINDOW		src-window
	0	None	
4	WINDOW		dst-window
	0	None	
2	INT16		src-x
2	INT16		src-y
2	CARD16		src-width
2	CARD16		src-height
2	INT16		dst-x
2	INT16		dst-y

SetInputFocus

1	42		opcode
1			revert-to
	0	None	
	1	PointerRoot	
	2	Parent	
2	3		request length
4	WINDOW		focus
	0	None	
	1	PointerRoot	
4	TIMESTAMP		time
	0	CurrentTime	

GetInputFocus

1	43		opcode
1			unused
2	1		request length
=>			
1	1		Reply
1			revert-to
	0	None	
	1	PointerRoot	
	2	Parent	
2	CARD16		sequence number
4	0		reply length
4	WINDOW		focus
	0	None	
	1	PointerRoot	
20			unused

QueryKeymap

1	44		opcode
1			unused
2	1		request length
=>			
1	1		Reply
1			unused
2	CARD16		sequence number
4	2		reply length
32	LISTofCARD8		keys

OpenFont

1	45		opcode
1			unused
2	3+(n+p)/4		request length
4	FONT		fid
2	n		length of name
2			unused
n	STRING8		name
p			unused, p=pad(n)

CloseFont

1	46		opcode
1			unused
2	2		request length
4	FONT		font

QueryFont

1	47		opcode
1			unused
2	2		request length
4	FONTABLE		font
=>			
1	1		Reply

1			unused
2	CARD16		sequence number
4	7+2n+3m		reply length
12	CHARINFO		min-bounds
4			unused
12	CHARINFO		max-bounds
4			unused
2	CARD16		min-char-or-byte2
2	CARD16		max-char-or-byte2
2	CARD16		default-char
2	n		number of FONTPROPs in properties
1			draw-direction
	0	LeftToRight	
	1	RightToLeft	
1	CARD8		min-byte1
1	CARD8		max-byte1
1	BOOL		all-chars-exist
2	INT16		font-ascent
2	INT16		font-descent
4	m		number of CHARINFOs in char-infos
8n	LISTofFONTPROP		properties
12m	LISTofCHARINFO		char-infos

FONTPROP

4	ATOM	name
4	<32-bits>	value

CHARINFO

2	INT16	left-side-bearing
2	INT16	right-side-bearing
2	INT16	character-width
2	INT16	ascent
2	INT16	descent
2	CARD16	attributes

QueryTextExtents

1	48	opcode
1	BOOL	odd length, True if p = 2
2	2+(2n+p)/4	request length
4	FONTABLE	font
2n	STRING16	string
p		unused, p=pad(2n)

=>

1	1		Reply
1			draw-direction
	0	LeftToRight	
	1	RightToLeft	
2	CARD16		sequence number
4	0		reply length
2	INT16		font-ascent
2	INT16		font-descent
2	INT16		overall-ascent
2	INT16		overall-descent
4	INT32		overall-width
4	INT32		overall-left
4	INT32		overall-right
4			unused

ListFonts

1	49	opcode
1		unused
2	2+(n+p)/4	request length
2	CARD16	max-names
2	n	length of pattern
n	STRING8	pattern

```
     p                                      unused, p=pad(n)

  =>
     1     1                                Reply
     1                                      unused
     2     CARD16                           sequence number
     4     (n+p)/4                          reply length
     2     CARD16                           number of STRs in names
     22                                     unused
     n     LISTofSTR                        names
     p                                      unused, p=pad(n)
```

ListFontsWithInfo

```
     1     50                               opcode
     1                                      unused
     2     2+(n+p)/4                        request length
     2     CARD16                           max-names
     2     n                                length of pattern
     n     STRING8                          pattern
     p                                      unused, p=pad(n)

  => (except for last in series)
     1     1                                Reply
     1     n                                length of name in bytes
     2     CARD16                           sequence number
     4     7+2m+(n+p)/4                     reply length
     12    CHARINFO                         min-bounds
     4                                      unused
     12    CHARINFO                         max-bounds
     4                                      unused
     2     CARD16                           min-char-or-byte2
     2     CARD16                           max-char-or-byte2
     2     CARD16                           default-char
     2     m                                number of FONTPROPs in properties
     1                                      draw-direction
           0               LeftToRight
           1               RightToLeft
     1     CARD8                            min-byte1
     1     CARD8                            max-byte1
     1     BOOL                             all-chars-exist
     2     INT16                            font-ascent
     2     INT16                            font-descent
     4     CARD32                           replies-hint
     8m    LISTofFONTPROP                   properties
     n     STRING8                          name
     p                                      unused, p=pad(n)

   FONTPROP
     encodings are the same as for QueryFont

   CHARINFO
     encodings are the same as for QueryFont

  => (last in series)
     1     1                                Reply
     1     0                                last-reply indicator
     2     CARD16                           sequence number
     4     7                                reply length
     52                                     unused
```

SetFontPath

```
     1     51                               opcode
     1                                      unused
     2     2+(n+p)/4                        request length
     2     CARD16                           number of STRs in path
     2                                      unused
     n     LISTofSTR                        path
```

p			unused, p=pad(n)

GetFontPath

1	52		opcode
1			unused
2	1		request list

=>

1	1		Reply
1			unused
2	CARD16		sequence number
4	(n+p)/4		reply length
2	CARD16		number of STRs in path
22			unused
n	LISTofSTR		path
p			unused, p=pad(n)

CreatePixmap

1	53		opcode
1	CARD8		depth
2	4		request length
4	PIXMAP		pid
4	DRAWABLE		drawable
2	CARD16		width
2	CARD16		height

FreePixmap

1	54		opcode
1			unused
2	2		request length
4	PIXMAP		pixmap

CreateGC

1	55		opcode
1			unused
2	4+n		request length
4	GCONTEXT		cid
4	DRAWABLE		drawable
4	BITMASK		value-mask (has n bits set to 1)
	#x00000001	function	
	#x00000002	plane-mask	
	#x00000004	foreground	
	#x00000008	background	
	#x00000010	line-width	
	#x00000020	line-style	
	#x00000040	cap-style	
	#x00000080	join-style	
	#x00000100	fill-style	
	#x00000200	fill-rule	
	#x00000400	tile	
	#x00000800	stipple	
	#x00001000	tile-stipple-x-origin	
	#x00002000	tile-stipple-y-origin	
	#x00004000	font	
	#x00008000	subwindow-mode	
	#x00010000	graphics-exposures	
	#x00020000	clip-x-origin	
	#x00040000	clip-y-origin	
	#x00080000	clip-mask	
	#x00100000	dash-offset	
	#x00200000	dashes	
	#x00400000	arc-mode	
4n	LISTofVALUE		value-list

VALUEs

1			function

	0	Clear	
	1	And	
	2	AndReverse	
	3	Copy	
	4	AndInverted	
	5	NoOp	
	6	Xor	
	7	Or	
	8	Nor	
	9	Equiv	
	10	Invert	
	11	OrReverse	
	12	CopyInverted	
	13	OrInverted	
	14	Nand	
	15	Set	
4	CARD32		plane-mask
4	CARD32		foreground
4	CARD32		background
2	CARD16		line-width
1			line-style
	0	Solid	
	1	OnOffDash	
	2	DoubleDash	
1			cap-style
	0	NotLast	
	1	Butt	
	2	Round	
	3	Projecting	
1			join-style
	0	Miter	
	1	Round	
	2	Bevel	
1			fill-style
	0	Solid	
	1	Tiled	
	2	Stippled	
	3	OpaqueStippled	
1			fill-rule
	0	EvenOdd	
	1	Winding	
4	PIXMAP		tile
4	PIXMAP		stipple
2	INT16		tile-stipple-x-origin
2	INT16		tile-stipple-y-origin
4	FONT		font
1			subwindow-mode
	0	ClipByChildren	
	1	IncludeInferiors	
1	BOOL		graphics-exposures
2	INT16		clip-x-origin
2	INT16		clip-y-origin
4	PIXMAP		clip-mask
	0	None	
2	CARD16		dash-offset
1	CARD8		dashes
1			arc-mode
	0	Chord	
	1	PieSlice	

ChangeGC

1	56		opcode
1			unused
2	3+n		request length
4	GCONTEXT		gc

4	BITMASK	value-mask (has n bits set to 1)
	encodings are the same as for CreateGC	
4n	LISTofVALUE	value-list
	encodings are the same as for CreateGC	

CopyGC

1	57	opcode
1		unused
2	4	request length
4	GCONTEXT	src-gc
4	GCONTEXT	dst-gc
4	BITMASK	value-mask
	encodings are the same as for CreateGC	

SetDashes

1	58	opcode
1		unused
2	3+(n+p)/4	request length
4	GCONTEXT	gc
2	CARD16	dash-offset
2	n	length of dashes
n	LISTofCARD8	dashes
p		unused, p=pad(n)

SetClipRectangles

1	59		opcode
1			ordering
	0	UnSorted	
	1	YSorted	
	2	YXSorted	
	3	YXBanded	
2	3+2n		request length
4	GCONTEXT		gc
2	INT16		clip-x-origin
2	INT16		clip-y-origin
8n	LISTofRECTANGLE		rectangles

FreeGC

1	60	opcode
1		unused
2	2	request length
4	GCONTEXT	gc

ClearArea

1	61	opcode
1	BOOL	exposures
2	4	request length
4	WINDOW	window
2	INT16	x
2	INT16	y
2	CARD16	width
2	CARD16	height

CopyArea

1	62	opcode
1		unused
2	7	request length
4	DRAWABLE	src-drawable
4	DRAWABLE	dst-drawable
4	GCONTEXT	gc
2	INT16	src-x
2	INT16	src-y
2	INT16	dst-x
2	INT16	dst-y
2	CARD16	width
2	CARD16	height

CopyPlane

1	63		opcode
1			unused
2	8		request length
4	DRAWABLE		src-drawable
4	DRAWABLE		dst-drawable
4	GCONTEXT		gc
2	INT16		src-x
2	INT16		src-y
2	INT16		dst-x
2	INT16		dst-y
2	CARD16		width
2	CARD16		height
4	CARD32		bit-plane

PolyPoint

1	64		opcode
1			coordinate-mode
	0	Origin	
	1	Previous	
2	3+n		request length
4	DRAWABLE		drawable
4	GCONTEXT		gc
4n	LISTofPOINT		points

PolyLine

1	65		opcode
1			coordinate-mode
	0	Origin	
	1	Previous	
2	3+n		request length
4	DRAWABLE		drawable
4	GCONTEXT		gc
4n	LISTofPOINT		points

PolySegment

1	66		opcode
1			unused
2	3+2n		request length
4	DRAWABLE		drawable
4	GCONTEXT		gc
8n	LISTofSEGMENT		segments

SEGMENT

2	INT16		x1
2	INT16		y1
2	INT16		x2
2	INT16		y2

PolyRectangle

1	67		opcode
1			unused
2	3+2n		request length
4	DRAWABLE		drawable
4	GCONTEXT		gc
8n	LISTofRECTANGLE		rectangles

PolyArc

1	68		opcode
1			unused
2	3+3n		request length
4	DRAWABLE		drawable
4	GCONTEXT		gc
12n	LISTofARC		arcs

FillPoly

1	69		opcode
1			unused
2	4+n		request length
4	DRAWABLE		drawable
4	GCONTEXT		gc
1			shape
	0	Complex	
	1	Nonconvex	
	2	Convex	
1			coordinate-mode
	0	Origin	
	1	Previous	
2			unused
4n	LISTofPOINT		points

PolyFillRectangle

1	70	opcode
1		unused
2	3+2n	request length
4	DRAWABLE	drawable
4	GCONTEXT	gc
8n	LISTofRECTANGLE	rectangles

PolyFillArc

1	71	opcode
1		unused
2	3+3n	request length
4	DRAWABLE	drawable
4	GCONTEXT	gc
12n	LISTofARC	arcs

PutImage

1	72		opcode
1			format
	0	Bitmap	
	1	XYPixmap	
	2	ZPixmap	
2	6+(n+p)/4		request length
4	DRAWABLE		drawable
4	GCONTEXT		gc
2	CARD16		width
2	CARD16		height
2	INT16		dst-x
2	INT16		dst-y
1	CARD8		left-pad
1	CARD8		depth
2			unused
n	LISTofBYTE		data
p			unused, p=pad(n)

GetImage

1	73		opcode
1			format
	1	XYPixmap	
	2	ZPixmap	
2	5		request length
4	DRAWABLE		drawable
2	INT16		x
2	INT16		y
2	CARD16		width
2	CARD16		height
4	CARD32		plane-mask

=>

1	1	Reply

1	CARD8	depth
2	CARD16	sequence number
4	(n+p)/4	reply length
4	VISUALID	visual
	0 None	
20		unused
n	LISTofBYTE	data
p		unused, p=pad(n)

PolyText8

1	74	opcode
1		unused
2	4+(n+p)/4	request length
4	DRAWABLE	drawable
4	GCONTEXT	gc
2	INT16	x
2	INT16	y
n	LISTofTEXTITEM8	items
p		unused, p=pad(n) (p is always 0 or 1)

TEXTITEM8

1	n	length of string (cannot be 255)
1	INT8	delta
n	STRING8	string
or		
1	255	font-shift indicator
1		font byte 3 (most-significant)
1		font byte 2
1		font byte 1
1		font byte 0 (least-significant)

PolyText16

1	75	opcode
1		unused
2	4+(n+p)/4	request length
4	DRAWABLE	drawable
4	GCONTEXT	gc
2	INT16	x
2	INT16	y
n	LISTofTEXTITEM16	items
p		unused, p=pad(n) (p is always 0 or 1)

TEXTITEM16

1	n	number of CHAR2Bs in string (cannot be 255)
1	INT8	delta
n	STRING16	string
or		
1	255	font-shift indicator
1		font byte 3 (most-significant)
1		font byte 2
1		font byte 1
1		font byte 0 (least-significant)

ImageText8

1	76	opcode
1	n	length of string
2	4+(n+p)/4	request length
4	DRAWABLE	drawable
4	GCONTEXT	gc
2	INT16	x
2	INT16	y
n	STRING8	string
p		unused, p=pad(n)

ImageText16

1	77	opcode

1	n		number of CHAR2Bs in string
2	4+(2n+p)/4		request length
4	DRAWABLE		drawable
4	GCONTEXT		gc
2	INT16		x
2	INT16		y
2n	STRING16		string
p			unused, p=pad(2n)

CreateColormap

1	78		opcode
1			alloc
	0	None	
	1	All	
2	4		request length
4	COLORMAP		mid
4	WINDOW		window
4	VISUALID		visual

FreeColormap

1	79	opcode
1		unused
2	2	request length
4	COLORMAP	cmap

CopyColormapAndFree

1	80	opcode
1		unused
2	3	request length
4	COLORMAP	mid
4	COLORMAP	src-cmap

InstallColormap

1	81	opcode
1		unused
2	2	request length
4	COLORMAP	cmap

UninstallColormap

1	82	opcode
1		unused
2	2	request length
4	COLORMAP	cmap

ListInstalledColormaps

1	83	opcode
1		unused
2	2	request length
4	WINDOW	window

=>

1	1	Reply
1		unused
2	CARD16	sequence number
4	n	reply length
2	n	number of COLORMAPs in cmaps
22		unused
4n	LISTofCOLORMAP	cmaps

AllocColor

1	84	opcode
1		unused
2	4	request length
4	COLORMAP	cmap
2	CARD16	red
2	CARD16	green

2	CARD16	blue
2		unused

=>

1	1	Reply
1		unused
2	CARD16	sequence number
4	0	reply length
2	CARD16	red
2	CARD16	green
2	CARD16	blue
2		unused
4	CARD32	pixel
12		unused

AllocNamedColor

1	85	opcode
1		unused
2	3+(n+p)/4	request length
4	COLORMAP	cmap
2	n	length of name
2		unused
n	STRING8	name
p		unused, p=pad(n)

=>

1	1	Reply
1		unused
2	CARD16	sequence number
4	0	reply length
4	CARD32	pixel
2	CARD16	exact-red
2	CARD16	exact-green
2	CARD16	exact-blue
2	CARD16	visual-red
2	CARD16	visual-green
2	CARD16	visual-blue
8		unused

AllocColorCells

1	86	opcode
1	BOOL	contiguous
2	3	request length
4	COLORMAP	cmap
2	CARD16	colors
2	CARD16	planes

=>

1	1	Reply
1		unused
2	CARD16	sequence number
4	n+m	reply length
2	n	number of CARD32s in pixels
2	m	number of CARD32s in masks
20		unused
4n	LISTofCARD32	pixels
4m	LISTofCARD32	masks

AllocColorPlanes

1	87	opcode
1	BOOL	contiguous
2	4	request length
4	COLORMAP	cmap
2	CARD16	colors
2	CARD16	reds
2	CARD16	greens
2	CARD16	blues

=>

1	1	Reply
1		unused
2	CARD16	sequence number
4	n	reply length
2	n	number of CARD32s in pixels
2		unused
4	CARD32	red-mask
4	CARD32	green-mask
4	CARD32	blue-mask
8		unused
4n	LISTofCARD32	pixels

FreeColors

1	88	opcode
1		unused
2	3+n	request length
4	COLORMAP	cmap
4	CARD32	plane-mask
4n	LISTofCARD32	pixels

StoreColors

1	89	opcode
1		unused
2	2+3n	request length
4	COLORMAP	cmap
12n	LISTofCOLORITEM	items

COLORITEM

4	CARD32		pixel
2	CARD16		red
2	CARD16		green
2	CARD16		blue
1			do-red, do-green, do-blue
	#x01	do-red (1 is True, 0 is False)	
	#x02	do-green (1 is True, 0 is False)	
	#x04	do-blue (1 is True, 0 is False)	
	#xf8	unused	
1			unused

StoreNamedColor

1	90		opcode
1			do-red, do-green, do-blue
	#x01	do-red (1 is True, 0 is False)	
	#x02	do-green (1 is True, 0 is False)	
	#x04	do-blue (1 is True, 0 is False)	
	#xf8	unused	
2	4+(n+p)/4		request length
4	COLORMAP		cmap
4	CARD32		pixel
2	n		length of name
2			unused
n	STRING8		name
p			unused, p=pad(n)

QueryColors

1	91	opcode
1		unused
2	2+n	request length
4	COLORMAP	cmap
4n	LISTofCARD32	pixels

=>

1	1	Reply
1		unused
2	CARD16	sequence number

4	2n		reply length
2	n		number of RGBs in colors
22			unused
8n	LISTofRGB		colors

RGB

2	CARD16		red
2	CARD16		green
2	CARD16		blue
2			unused

LookupColor

1	92		opcode
1			unused
2	3+(n+p)/4		request length
4	COLORMAP		cmap
2	n		length of name
2			unused
n	STRING8		name
p			unused, p=pad(n)

=>

1	1		Reply
1			unused
2	CARD16		sequence number
4	0		reply length
2	CARD16		exact-red
2	CARD16		exact-green
2	CARD16		exact-blue
2	CARD16		visual-red
2	CARD16		visual-green
2	CARD16		visual-blue
12			unused

CreateCursor

1	93		opcode
1			unused
2	8		request length
4	CURSOR		cid
4	PIXMAP		source
4	PIXMAP		mask
	0	None	
2	CARD16		fore-red
2	CARD16		fore-green
2	CARD16		fore-blue
2	CARD16		back-red
2	CARD16		back-green
2	CARD16		back-blue
2	CARD16		x
2	CARD16		y

CreateGlyphCursor

1	94		CreateGlyphCursor
1			unused
2	8		request length
4	CURSOR		cid
4	FONT		source-font
4	FONT		mask-font
	0	None	
2	CARD16		source-char
2	CARD16		mask-char
2	CARD16		fore-red
2	CARD16		fore-green
2	CARD16		fore-blue
2	CARD16		back-red
2	CARD16		back-green

2	CARD16		back-blue

FreeCursor

1	95		opcode
1			unused
2	2		request length
4	CURSOR		cursor

RecolorCursor

1	96		opcode
1			unused
2	5		request length
4	CURSOR		cursor
2	CARD16		fore-red
2	CARD16		fore-green
2	CARD16		fore-blue
2	CARD16		back-red
2	CARD16		back-green
2	CARD16		back-blue

QueryBestSize

1	97		opcode
1			class
	0	Cursor	
	1	Tile	
	2	Stipple	
2	3		request length
4	DRAWABLE		drawable
2	CARD16		width
2	CARD16		height

=>

1	1		Reply
1			unused
2	CARD16		sequence number
4	0		reply length
2	CARD16		width
2	CARD16		height
20			unused

QueryExtension

1	98		opcode
1			unused
2	2+(n+p)/4		request length
2	n		length of name
2			unused
n	STRING8		name
p			unused, p=pad(n)

=>

1	1		Reply
1			unused
2	CARD16		sequence number
4	0		reply length
1	BOOL		present
1	CARD8		major-opcode
1	CARD8		first-event
1	CARD8		first-error
20			unused

ListExtensions

1	99		opcode
1			unused
2	1		request length

=>

1	1		Reply

1	CARD8		number of STRs in names
2	CARD16		sequence number
4	(n+p)/4		reply length
24			unused
n	LISTofSTR		names
p			unused, p=pad(n)

ChangeKeyboardMapping

1	100		opcode
1	n		keycode-count
2	2+nm		request length
1	KEYCODE		first-keycode
1	m		keysyms-per-keycode
2			unused
4nm	LISTofKEYSYM		keysyms

GetKeyboardMapping

1	101		opcode
1			unused
2	2		request length
1	KEYCODE		first-keycode
1	CARD8		count
2			unused

=>

1	1		Reply
1	n		keysyms-per-keycode
2	CARD16		sequence number
4	nm		reply length (m = count field from the request)
24			unused
4nm	LISTofKEYSYM		keysyms

ChangeKeyboardControl

1	102		opcode
1			unused
2	2+n		request length
4	BITMASK		value-mask (has n bits set to 1)
	#x0001	key-click-percent	
	#x0002	bell-percent	
	#x0004	bell-pitch	
	#x0008	bell-duration	
	#x0010	led	
	#x0020	led-mode	
	#x0040	key	
	#x0080	auto-repeat-mode	
4n	LISTofVALUE		value-list

VALUEs

1	INT8		key-click-percent
1	INT8		bell-percent
2	INT16		bell-pitch
2	INT16		bell-duration
1	CARD8		led
1			led-mode
	0	Off	
	1	On	
1	KEYCODE		key
1			auto-repeat-mode
	0	Off	
	1	On	
	2	Default	

GetKeyboardControl

1	103		opcode
1			unused
2	1		request length

=>

1	1		Reply
1			global-auto-repeat
	0	Off	
	1	On	
2	CARD16		sequence number
4	5		reply length
4	CARD32		led-mask
1	CARD8		key-click-percent
1	CARD8		bell-percent
2	CARD16		bell-pitch
2	CARD16		bell-duration
2			unused
32	LISTofCARD8		auto-repeats

Bell

1	104	opcode
1	INT8	percent
2	1	request length

ChangePointerControl

1	105	opcode
1		unused
2	3	request length
2	INT16	acceleration-numerator
2	INT16	acceleration-denominator
2	INT16	threshold
1	BOOL	do-acceleration
1	BOOL	do-threshold

GetPointerControl

1	106	opcode
1		unused
2	1	request length

=>

1	1	Reply
1		unused
2	CARD16	sequence number
4	0	reply length
2	CARD16	acceleration-numerator
2	CARD16	acceleration-denominator
2	CARD16	threshold
18		unused

SetScreenSaver

1	107		opcode
1			unused
2	3		request length
2	INT16		timeout
2	INT16		interval
1			prefer-blanking
	0	No	
	1	Yes	
	2	Default	
1			allow-exposures
	0	No	
	1	Yes	
	2	Default	
2			unused

GetScreenSaver

1	108	opcode
1		unused
2	1	request length

=>

1	1		Reply
1			unused
2	CARD16		sequence number
4	0		reply length
2	CARD16		timeout
2	CARD16		interval
1			prefer-blanking
	0	No	
	1	Yes	
1			allow-exposures
	0	No	
	1	Yes	
18			unused

ChangeHosts

1	109		opcode
1			mode
	0	Insert	
	1	Delete	
2	2+(n+p)/4		request length
1			family
	0	Internet	
	1	DECnet	
	2	Chaos	
1			unused
2	CARD16		length of address
n	LISTofCARD8		address
p			unused, p=pad(n)

ListHosts

1	110		opcode
1			unused
2	1		request length

=>

1	1		Reply
1			mode
	0	Disabled	
	1	Enabled	
2	CARD16		sequence number
4	n/4		reply length
2	CARD16		number of HOSTs in hosts
22			unused
n	LISTofHOST		hosts (n always a multiple of 4)

SetAccessControl

1	111		opcode
1			mode
	0	Disable	
	1	Enable	
2	1		request length

SetCloseDownMode

1	112		opcode
1			mode
	0	Destroy	
	1	RetainPermanent	
	2	RetainTemporary	
2	1		request length

KillClient

1	113		opcode
1			unused
2	2		request length
4	CARD32		resource

	0	AllTemporary	

RotateProperties

1	114		opcode
1			unused
2	3+n		request length
4	WINDOW		window
2	n		number of properties
2	INT16		delta
4n	LISTofATOM		properties

ForceScreenSaver

1	115		opcode
1			mode
	0	Reset	
	1	Activate	
2	1		request length

SetPointerMapping

1	116		opcode
1	n		length of map
2	1+(n+p)/4		request length
n	LISTofCARD8		map
p			unused, p=pad(n)

=>

1	1		Reply
1			status
	0	Success	
	1	Busy	
2	CARD16		sequence number
4	0		reply length
24			unused

GetPointerMapping

1	117		opcode
1			unused
2	1		request length

=>

1	1		Reply
1	n		length of map
2	CARD16		sequence number
4	(n+p)/4		reply length
24			unused
n	LISTofCARD8		map
p			unused, p=pad(n)

SetModifierMapping

1	118		opcode
1	n		keycodes-per-modifier
2	1+2n		request length
8n	LISTofKEYCODE		keycodes

=>

1	1		Reply
1			status
	0	Success	
	1	Busy	
	2	Failed	
2	CARD16		sequence number
4	0		reply length
24			unused

GetModifierMapping

1	119		opcode
1			unused

2	1		request length

=>

1	1		Reply
1	n		keycodes-per-modifier
2	CARD16		sequence number
4	2n		reply length
24			unused
8n	LISTofKEYCODE		keycodes

NoOperation

1	127		opcode
1			unused
2	1		request length

Events

KeyPress

1	2		code
1	KEYCODE		detail
2	CARD16		sequence number
4	TIMESTAMP		time
4	WINDOW		root
4	WINDOW		event
4	WINDOW		child
	0	None	
2	INT16		root-x
2	INT16		root-y
2	INT16		event-x
2	INT16		event-y
2	SETofKEYBUTMASK		state
1	BOOL		same-screen
1			unused

KeyRelease

1	3		code
1	KEYCODE		detail
2	CARD16		sequence number
4	TIMESTAMP		time
4	WINDOW		root
4	WINDOW		event
4	WINDOW		child
	0	None	
2	INT16		root-x
2	INT16		root-y
2	INT16		event-x
2	INT16		event-y
2	SETofKEYBUTMASK		state
1	BOOL		same-screen
1			unused

ButtonPress

1	4		code
1	BUTTON		detail
2	CARD16		sequence number
4	TIMESTAMP		time
4	WINDOW		root
4	WINDOW		event
4	WINDOW		child
	0	None	
2	INT16		root-x
2	INT16		root-y
2	INT16		event-x
2	INT16		event-y
2	SETofKEYBUTMASK		state
1	BOOL		same-screen

1			unused

ButtonRelease

1	5		code
1	BUTTON		detail
2	CARD16		sequence number
4	TIMESTAMP		time
4	WINDOW		root
4	WINDOW		event
4	WINDOW		child
	0	None	
2	INT16		root-x
2	INT16		root-y
2	INT16		event-x
2	INT16		event-y
2	SETofKEYBUTMASK		state
1	BOOL		same-screen
1			unused

MotionNotify

1	6		code
1			detail
	0	Normal	
	1	Hint	
2	CARD16		sequence number
4	TIMESTAMP		time
4	WINDOW		root
4	WINDOW		event
4	WINDOW		child
	0	None	
2	INT16		root-x
2	INT16		root-y
2	INT16		event-x
2	INT16		event-y
2	SETofKEYBUTMASK		state
1	BOOL		same-screen
1			unused

EnterNotify

1	7		code
1			detail
	0	Ancestor	
	1	Virtual	
	2	Inferior	
	3	Nonlinear	
	4	NonlinearVirtual	
2	CARD16		sequence number
4	TIMESTAMP		time
4	WINDOW		root
4	WINDOW		event
4	WINDOW		child
	0	None	
2	INT16		root-x
2	INT16		root-y
2	INT16		event-x
2	INT16		event-y
2	SETofKEYBUTMASK		state
1			mode
	0	Normal	
	1	Grab	
	2	Ungrab	
1			same-screen, focus
	#x01	focus (1 is True, 0 is False)	
	#x02	same-screen (1 is True, 0 is False)	
	#xfc	unused	

LeaveNotify

1	8		code
1			detail
	0	Ancestor	
	1	Virtual	
	2	Inferior	
	3	Nonlinear	
	4	NonlinearVirtual	
2	CARD16		sequence number
4	TIMESTAMP		time
4	WINDOW		root
4	WINDOW		event
4	WINDOW		child
	0	None	
2	INT16		root-x
2	INT16		root-y
2	INT16		event-x
2	INT16		event-y
2	SETofKEYBUTMASK		state
1			mode
	0	Normal	
	1	Grab	
	2	Ungrab	
1			same-screen, focus
	#x01	focus (1 is True, 0 is False)	
	#x02	same-screen (1 is True, 0 is False)	
	#xfc	unused	

FocusIn

1	9		code
1			detail
	0	Ancestor	
	1	Virtual	
	2	Inferior	
	3	Nonlinear	
	4	NonlinearVirtual	
	5	Pointer	
	6	PointerRoot	
	7	None	
2	CARD16		sequence number
4	WINDOW		event
1			mode
	0	Normal	
	1	Grab	
	2	Ungrab	
	3	WhileGrabbed	
23			unused

FocusOut

1	10		code
1			detail
	0	Ancestor	
	1	Virtual	
	2	Inferior	
	3	Nonlinear	
	4	NonlinearVirtual	
	5	Pointer	
	6	PointerRoot	
	7	None	
2	CARD16		sequence number
4	WINDOW		event
1			mode
	0	Normal	
	1	Grab	
	2	Ungrab	

	3	WhileGrabbed	
23			unused

KeymapNotify

1	11	code
31	LISTofCARD8	keys (byte for keycodes 0–7 is omitted)

Expose

1	12	code
1		unused
2	CARD16	sequence number
4	WINDOW	window
2	CARD16	x
2	CARD16	y
2	CARD16	width
2	CARD16	height
2	CARD16	count
14		unused

GraphicsExposure

1	13	code
1		unused
2	CARD16	sequence number
4	DRAWABLE	drawable
2	CARD16	x
2	CARD16	y
2	CARD16	width
2	CARD16	height
2	CARD16	minor-opcode
2	CARD16	count
1	CARD8	major-opcode
11		unused

NoExposure

1	14	code
1		unused
2	CARD16	sequence number
4	DRAWABLE	drawable
2	CARD16	minor-opcode
1	CARD8	major-opcode
21		unused

VisibilityNotify

1	15		code
1			unused
2	CARD16		sequence number
4	WINDOW		window
1			state
	0	Unobscured	
	1	PartiallyObscured	
	2	FullyObscured	
23			unused

CreateNotify

1	16	code
1		unused
2	CARD16	sequence number
4	WINDOW	parent
4	WINDOW	window
2	INT16	x
2	INT16	y
2	CARD16	width
2	CARD16	height
2	CARD16	border-width
1	BOOL	override-redirect
9		unused

DestroyNotify

1	17		code
1			unused
2	CARD16		sequence number
4	WINDOW		event
4	WINDOW		window
20			unused

UnmapNotify

1	18		code
1			unused
2	CARD16		sequence number
4	WINDOW		event
4	WINDOW		window
1	BOOL		from-configure
19			unused

MapNotify

1	19		code
1			unused
2	CARD16		sequence number
4	WINDOW		event
4	WINDOW		window
1	BOOL		override-redirect
19			unused

MapRequest

1	20		code
1			unused
2	CARD16		sequence number
4	WINDOW		parent
4	WINDOW		window
20			unused

ReparentNotify

1	21		code
1			unused
2	CARD16		sequence number
4	WINDOW		event
4	WINDOW		window
4	WINDOW		parent
2	INT16		x
2	INT16		y
1	BOOL		override-redirect
11			unused

ConfigureNotify

1	22		code
1			unused
2	CARD16		sequence number
4	WINDOW		event
4	WINDOW		window
4	WINDOW		above-sibling
	0	None	
2	INT16		x
2	INT16		y
2	CARD16		width
2	CARD16		height
2	CARD16		border-width
1	BOOL		override-redirect
5			unused

ConfigureRequest

1	23		code
1			stack-mode
	0	Above	

	1	Below	
	2	TopIf	
	3	BottomIf	
	4	Opposite	
2	CARD16		sequence number
4	WINDOW		parent
4	WINDOW		window
4	WINDOW		sibling
	0	None	
2	INT16		x
2	INT16		y
2	CARD16		width
2	CARD16		height
2	CARD16		border-width
2	BITMASK		value-mask
	#x0001	x	
	#x0002	y	
	#x0004	width	
	#x0008	height	
	#x0010	border-width	
	#x0020	sibling	
	#x0040	stack-mode	
4			unused

GravityNotify

1	24		code
1			unused
2	CARD16		sequence number
4	WINDOW		event
4	WINDOW		window
2	INT16		x
2	INT16		y
16			unused

ResizeRequest

1	25		code
1			unused
2	CARD16		sequence number
4	WINDOW		window
2	CARD16		width
2	CARD16		height
20			unused

CirculateNotify

1	26		code
1			unused
2	CARD16		sequence number
4	WINDOW		event
4	WINDOW		window
4	WINDOW		unused
1			place
	0	Top	
	1	Bottom	
15			unused

CirculateRequest

1	27		code
1			unused
2	CARD16		sequence number
4	WINDOW		parent
4	WINDOW		window
4			unused
1			place
	0	Top	
	1	Bottom	

15			unused

PropertyNotify

1	28		code
1			unused
2	CARD16		sequence number
4	WINDOW		window
4	ATOM		atom
4	TIMESTAMP		time
1			state
	0	NewValue	
	1	Deleted	
15			unused

SelectionClear

1	29		code
1			unused
2	CARD16		sequence number
4	TIMESTAMP		time
4	WINDOW		owner
4	ATOM		selection
16			unused

SelectionRequest

1	30		code
1			unused
2	CARD16		sequence number
4	TIMESTAMP		time
	0	CurrentTime	
4	WINDOW		owner
4	WINDOW		requestor
4	ATOM		selection
4	ATOM		target
4	ATOM		property
	0	None	
4			unused

SelectionNotify

1	31		code
1			unused
2	CARD16		sequence number
4	TIMESTAMP		time
	0	CurrentTime	
4	WINDOW		requestor
4	ATOM		selection
4	ATOM		target
4	ATOM		property
	0	None	
8			unused

ColormapNotify

1	32		code
1			unused
2	CARD16		sequence number
4	WINDOW		window
4	COLORMAP		colormap
	0	None	
1	BOOL		new
1			state
	0	Uninstalled	
	1	Installed	
18			unused

ClientMessage

1	33		code
1	CARD8		format

2	CARD16		sequence number
4	WINDOW		window
4	ATOM		type
20			data

MappingNotify

1	34		code
1			unused
2	CARD16		sequence number
1			request
	0	Modifier	
	1	Keyboard	
	2	Pointer	
1	KEYCODE		first-keycode
1	CARD8		count
25			unused

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Xlib – C Language X Interface

X Window System

X Version 11, Release 3

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Table of Contents

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Chapter 1

Introduction to Xlib

The X Window System is a network-transparent window system that was designed at MIT. It runs under 4.3BSD UNIX, ULTRIX-32, many other UNIX variants, VAX/VMS, MS/DOS, as well as several other operating systems.

X display servers run on computers with either monochrome or color bitmap display hardware. The server distributes user input to and accepts output requests from various client programs located either on the same machine or elsewhere in the network. Xlib is a C subroutine library that application programs (clients) use to interface with the window system by means of a stream connection. Although a client usually runs on the same machine as the X server it is talking to, this need not be the case.

Xlib – C Language X Interface is a reference guide to the low-level C language interface to the X Window System protocol. It is neither a tutorial nor a user's guide to programming the X Window System. Rather, it provides a detailed description of each function in the library as well as a discussion of the related background information. *Xlib – C Language X Interface* assumes a basic understanding of a graphics window system and of the C programming language. Other higher-level abstractions (for example, those provided by the toolkits for X) are built on top of the Xlib library. For further information about these higher-level libraries, see the appropriate toolkit documentation. The *X Window System Protocol* provides the definitive word on the behavior of X. Although additional information appears here, the protocol document is the ruling document.

To provide an introduction to X programming, this chapter discusses:

- Overview of the X Window System
- Errors
- Naming and argument conventions
- Programming considerations
- Conventions used in this document

1.1. Overview of the X Window System

Some of the terms used in this book are unique to X, and other terms that are common to other window systems have different meanings in X. You may find it helpful to refer to the glossary, which is located at the end of the book.

The X Window System supports one or more screens containing overlapping windows or subwindows. A screen is a physical monitor and hardware, which can be either color or black and white. There can be multiple screens for each display or workstation. A single X server can provide display services for any number of screens. A set of screens for a single user with one keyboard and one pointer (usually a mouse) is called a display.

All the windows in an X server are arranged in strict hierarchies. At the top of each hierarchy is a root window, which covers each of the display screens. Each root window is partially or completely covered by child windows. All windows, except for root windows, have parents. There is usually at least one window for each application program. Child windows may in turn have their own children. In this way, an application program can create an arbitrarily deep tree on each screen. X provides graphics, text, and raster operations for windows.

A child window can be larger than its parent. That is, part or all of the child window can extend beyond the boundaries of the parent, but all output to a window is clipped by its parent. If several children of a window have overlapping locations, one of the children is considered to be on top of or raised over the others thus obscuring them. Output to areas covered by other windows is suppressed by the window system unless the window has backing store. If a window is obscured by a second window, the second window obscures only those ancestors of the second window, which are also ancestors of the first window.

A window has a border zero or more pixels in width, which can be any pattern (pixmap) or solid color you like. A window usually but not always has a background pattern, which will be repainted by the window system when uncovered. Each window has its own coordinate system. Child windows obscure their parents unless the child windows (of the same depth) have no background, and graphic operations in the parent window usually are clipped by the children.

X does not guarantee to preserve the contents of windows. When part or all of a window is hidden and then brought back onto the screen, its contents may be lost. The server then sends the client program an **Expose** event to notify it that part or all of the window needs to be repainted. Programs must be prepared to regenerate the contents of windows on demand.

X also provides off-screen storage of graphics objects, called pixmaps. Single plane (depth 1) pixmaps are sometimes referred to as bitmaps. Pixmaps can be used in most graphics functions interchangeably with windows and are used in various graphics operations to define patterns or tiles. Windows and pixmaps together are referred to as drawables.

Most of the functions in Xlib just add requests to an output buffer. These requests later execute asynchronously on the X server. Functions that return values of information stored in the server do not return (that is, they block) until an explicit reply is received or an error occurs. You can provide an error handler, which will be called when the error is reported.

If a client does not want a request to execute asynchronously, it can follow the request with a call to **XSync**, which blocks until all previously buffered asynchronous events have been sent and acted on. As an important side effect, the output buffer in Xlib is always flushed by a call to any function that returns a value from the server or waits for input.

Many Xlib functions will return an integer resource ID, which allows you to refer to objects stored on the X server. These can be of type **Window**, **Font**, **Pixmap**, **Colormap**, **Cursor**, and **GContext**, as defined in the file <**X11/X.h**>.± These resources are created by requests and are destroyed (or freed) by requests or when connections are closed. Most of these resources are potentially sharable between applications, and in fact, windows are manipulated explicitly by window manager programs. Fonts and cursors are shared automatically across multiple screens. Fonts are loaded and unloaded as needed and are shared by multiple clients. Fonts are often cached in the server. Xlib provides no support for sharing graphics contexts between applications.

Client programs are informed of events. Events may either be side effects of a request (for example, restacking windows generates **Expose** events) or completely asynchronous (for example, from the keyboard). A client program asks to be informed of events. Because other applications can send events to your application, programs must be prepared to handle (or ignore) events of all types.

Input events (for example, a key pressed or the pointer moved) arrive asynchronously from the server and are queued until they are requested by an explicit call (for example, **XNextEvent** or **XWindowEvent**). In addition, some library functions (for example,

± The < > has the meaning defined by the # include statement of the C compiler and is a file relative to a well-known directory. On UNIX-based systems, this is /usr/include.

XRaiseWindow) generate **Expose** and **ConfigureRequest** events. These events also arrive asynchronously, but the client may wish to explicitly wait for them by calling **XSync** after calling a function that can cause the server to generate events.

1.2. Errors

Some functions return **Status**, an integer error indication. If the function fails, it returns a zero. If the function returns a status of zero, it has not updated the return arguments. Because C does not provide multiple return values, many functions must return their results by writing into client-passed storage. By default, errors are handled either by a standard library function or by one that you provide. Functions that return pointers to strings return NULL pointers if the string does not exist.

The X server reports protocol errors at the time that it detects them. If more than one error could be generated for a given request, the server can report any of them.

Because Xlib usually does not transmit requests to the server immediately (that is, it buffers them), errors can be reported much later than they actually occur. For debugging purposes, however, Xlib provides a mechanism for forcing synchronous behavior (see section 8.12.1). When synchronization is enabled, errors are reported as they are generated.

When Xlib detects an error, it calls an error handler, which your program can provide. If you do not provide an error handler, the error is printed, and your program terminates.

1.3. Naming and Argument Conventions within Xlib

Xlib follows a number of conventions for the naming and syntax of the functions. Given that you remember what information the function requires, these conventions are intended to make the syntax of the functions more predictable.

The major naming conventions are:

- To differentiate the X symbols from the other symbols, the library uses mixed case for external symbols. It leaves lowercase for variables and all uppercase for user macros, as per existing convention.
- All Xlib functions begin with a capital X.
- The beginnings of all function names and symbols are capitalized.
- All user-visible data structures begin with a capital X. More generally, anything that a user might dereference begins with a capital X.
- Macros and other symbols do not begin with a capital X. To distinguish them from all user symbols, each word in the macro is capitalized.
- All elements of or variables in a data structure are in lowercase. Compound words, where needed, are constructed with underscores (_).
- The display argument, where used, is always first in the argument list.
- All resource objects, where used, occur at the beginning of the argument list immediately after the display argument.
- When a graphics context is present together with another type of resource (most commonly, a drawable), the graphics context occurs in the argument list after the other resource. Drawables outrank all other resources.
- Source arguments always precede the destination arguments in the argument list.
- The x argument always precedes the y argument in the argument list.
- The width argument always precedes the height argument in the argument list.
- Where the x, y, width, and height arguments are used together, the x and y arguments always precede the width and height arguments.

- Where a mask is accompanied with a structure, the mask always precedes the pointer to the structure in the argument list.

1.4. Programming Considerations

The major programming considerations are:

- Keyboards are the greatest variable between different manufacturer's workstations. If you want your program to be portable, you should be particularly conservative here.
- Many display systems have limited amounts of off-screen memory. If you can, you should minimize use of pixmaps and backing store.
- The user should have control of his screen real estate. Therefore, you should write your applications to react to window management rather than presume control of the entire screen. What you do inside of your top-level window, however, is up to your application. For further information, see chapter 9.
- Coordinates and sizes in X are actually 16-bit quantities. They usually are declared as an "int" in the interface (int is 16 bits on some machines). Values larger than 16 bits are truncated silently. Sizes (width and height) are unsigned quantities. This decision was taken to minimize the bandwidth required for a given level of performance.

1.5. Conventions Used in *Xlib – C Language X Interface*

This document uses the following conventions:

- Global symbols in *Xlib – C Language X Interface* are printed in **this special font**. These can be either function names, symbols defined in include files, or structure names. Arguments are printed in *italics*.
- Each function is introduced by a general discussion that distinguishes it from other functions. The function declaration itself follows, and each argument is specifically explained. General discussion of the function, if any is required, follows the arguments. Where applicable, the last paragraph of the explanation lists the possible Xlib error codes that the function can generate. For a complete discussion of the Xlib error codes, see section 8.12.2.
- To eliminate any ambiguity between those arguments that you pass and those that a function returns to you, the explanations for all arguments that you pass start with the word *specifies* or, in the case of multiple arguments, the word *specify*. The explanations for all arguments that are returned to you start with the word *returns* or, in the case of multiple arguments, the word *return*. The explanations for all arguments that you can pass and are returned start with the words *specifies and returns*.
- Any pointer to a structure that is used to return a value is designated as such by the *_return* suffix as part of its name. All other pointers passed to these functions are used for reading only. A few arguments use pointers to structures that are used for both input and output and are indicated by using the *_in_out* suffix.
- Xlib defines the Boolean values of **True** and **False**.

Chapter 2

Display Functions

Before your program can use a display, you must establish a connection to the X server. Once you have established a connection, you then can use the Xlib macros and functions discussed in this chapter to return information about the display. This chapter discusses how to:

- Open (connect to) the display
- Obtain information about the display, image format, and screen
- Free client-created data
- Close (disconnect from) a display

The chapter concludes with a general discussion of what occurs when the connection to the X server is closed.

2.1. Opening the Display

To open a connection to the X server that controls a display, use **XOpenDisplay**.

Display *XOpenDisplay(*display_name*)
    char **display_name*;

display_name Specifies the hardware display name, which determines the display and communications domain to be used. On a UNIX-based system, if the display_name is NULL, it defaults to the value of the DISPLAY environment variable.

On UNIX-based systems, the display name or DISPLAY environment variable is a string in the format:

hostname: *number* . *screen_number*

hostname Specifies the name of the host machine on which the display is physically attached. You follow the hostname with either a single colon (:) or a double colon (::).

number Specifies the number of the display server on that host machine. You may optionally follow this display number with a period (.). A single CPU can have more than one display. Multiple displays are usually numbered starting with zero.

screen_number Specifies the screen to be used on that server. Multiple screens can be controlled by a single X server. The screen_number sets an internal variable that can be accessed by using the **DefaultScreen** macro or the **XDefaultScreen** function if you are using languages other than C (see section 2.2.1).

For example, the following would specify screen 2 of display 0 on the machine named mit-athena:

mit-athena:0.2

The **XOpenDisplay** function returns a **Display** structure that serves as the connection to the X server and that contains all the information about that X server. **XOpenDisplay** connects your application to the X server through TCP, UNIX domain, or DECnet communications protocols. If the hostname is a host machine name and a single colon (:) separates the hostname and display number, **XOpenDisplay** connects using TCP streams. If the hostname is *unix* and a single colon (:) separates it from the display number, **XOpenDisplay** connects using UNIX domain IPC streams. If the hostname is not specified, Xlib uses whatever it believes is the fastest transport. If the hostname is a host machine name and a double colon (::) separates the hostname and display number, **XOpenDisplay** connects using DECnet. A single X server can support any or all of these transport mechanisms simultaneously. A particular Xlib implementation can support many more of these transport mechanisms.

If successful, **XOpenDisplay** returns a pointer to a **Display** structure, which is defined in **<X11/Xlib.h>**. If **XOpenDisplay** does not succeed, it returns NULL. After a successful call to **XOpenDisplay**, all of the screens in the display can be used by the client. The screen number specified in the display_name argument is returned by the **DefaultScreen** macro (or the **XDefaultScreen** function). You can access elements of the **Display** and **Screen** structures only by using the information macros or functions. For information about using macros and functions to obtain information from the **Display** structure, see section 2.2.1.

X servers may implement various types of access control mechanisms (see section 7.11).

2.2. Obtaining Information about the Display, Image Formats, or Screens

The Xlib library provides a number of useful macros and corresponding functions that return data from the **Display** structure. The macros are used for C programming, and their corresponding function equivalents are for other language bindings. This section discusses the:

- Display macros
- Image format macros
- Screen macros

All other members of the **Display** structure (that is, those for which no macros are defined) are private to Xlib and must not be used. Applications must never directly modify or inspect these private members of the **Display** structure.

Note

> The **XDisplayWidth**, **XDisplayHeight**, **XDisplayCells**, **XDisplayPlanes**, **XDisplayWidthMM**, and **XDisplayHeightMM** functions in the next sections are misnamed. These functions really should be named Screen*whatever* and XScreen*whatever*, not Display*whatever* or XDisplay*whatever*. Our apologies for the resulting confusion.

2.2.1. Display Macros

Applications should not directly modify any part of the **Display** and **Screen** structures. The members should be considered read-only, although they may change as the result of other operations on the display.

The following lists the C language macros, their corresponding function equivalents that are for other language bindings, and what data they both can return.

AllPlanes( )

unsigned long XAllPlanes( )

Both return a value with all bits set to 1 suitable for use in a plane argument to a procedure.

Both **BlackPixel** and **WhitePixel** can be used in implementing a monochrome application. These pixel values are for permanently allocated entries in the default colormap. The actual RGB (red, green, and blue) values are settable on some screens and, in any case, may not actually be black or white. The names are intended to convey the expected relative intensity of the colors.

BlackPixel(*display*, *screen_number*)

unsigned long XBlackPixel(*display*, *screen_number*)
    Display **display*;
    int *screen_number*;

Both return the black pixel value for the specified screen.

WhitePixel(*display*, *screen_number*)

unsigned long XWhitePixel(*display*, *screen_number*)
    Display **display*;
    int *screen_number*;

Both return the white pixel value for the specified screen.

ConnectionNumber(*display*)

int XConnectionNumber(*display*)
    Display **display*;

Both return a connection number for the specified display. On a UNIX-based system, this is the file descriptor of the connection.

DefaultColormap(*display*, *screen_number*)

Colormap XDefaultColormap(*display*, *screen_number*)
    Display **display*;
    int *screen_number*;

Both return the default colormap ID for allocation on the specified screen. Most routine allocations of color should be made out of this colormap.

DefaultDepth(*display*, *screen_number*)

int XDefaultDepth(*display*, *screen_number*)
    Display **display*;
    int *screen_number*;

Both return the depth (number of planes) of the default root window for the specified screen. Other depths may also be supported on this screen (see **XMatchVisualInfo**).

DefaultGC(*display*, *screen_number*)

GC XDefaultGC(*display*, *screen_number*)
    Display **display*;
    int *screen_number*;

Both return the default graphics context for the root window of the specified screen. This GC is created for the convenience of simple applications and contains the default GC components with the foreground and background pixel values initialized to the black and white pixels for the screen, respectively. You can modify its contents freely because it is not used in any Xlib function. This GC should never be freed.

DefaultRootWindow(*display*)

Window XDefaultRootWindow(*display*)
    Display **display*;

Both return the root window for the default screen.

DefaultScreenOfDisplay(*display*)

Screen *XDefaultScreenOfDisplay(*display*)
    Display **display*;

Both return a pointer to the default screen.

ScreenOfDisplay(*display, screen_number*)

Screen *XScreenOfDisplay(*display, screen_number*)
    Display **display*;
    int *screen_number*;

Both return a pointer to the indicated screen.

DefaultScreen(*display*)

int XDefaultScreen(*display*)
    Display **display*;

Both return the default screen number referenced by the **XOpenDisplay** function. This macro or function should be used to retrieve the screen number in applications that will use only a single screen.

DefaultVisual(*display*, *screen_number*)

Visual *XDefaultVisual(*display*, *screen_number*)
    Display **display*;
    int *screen_number*;

Both return the default visual type for the specified screen. For further information about visual types, see section 3.1.

DisplayCells(*display*, *screen_number*)

int XDisplayCells(*display*, *screen_number*)
    Display **display*;
    int *screen_number*;

Both return the number of entries in the default colormap.

DisplayPlanes(*display*, *screen_number*)

```
int XDisplayPlanes(display, screen_number)
      Display *display;
      int screen_number;
```

Both return the depth of the root window of the specified screen. For an explanation of depth, see the glossary.

DisplayString(*display*)

```
char *XDisplayString(display)
      Display *display;
```

Both return the string that was passed to **XOpenDisplay** when the current display was opened. On UNIX-based systems, if the passed string was NULL, these return the value of the DISPLAY environment variable when the current display was opened. These are useful to applications that invoke the **fork** system call and want to open a new connection to the same display from the child process as well as for printing error messages.

LastKnownRequestProcessed (*display*)

```
unsigned long XLastKnownRequestProcessed(display)
     Display *display;
```

Both extract the full serial number of the last request known by Xlib to have been processed by the X server. Xlib automatically sets this number when replies, events, and errors are received.

NextRequest (*display*)

```
unsigned long XNextRequest(display)
     Display *display;
```

Both extract the full serial number that is to be used for the next request. Serial numbers are maintained separately for each display connection.

ProtocolVersion (*display*)

```
int XProtocolVersion(display)
      Display *display;
```

Both return the major version number (11) of the X protocol associated with the connected display.

ProtocolRevision (*display*)

```
int XProtocolRevision(display)
      Display *display;
```

Both return the minor protocol revision number of the X server.

QLength(*display*)

int XQLength(*display*)
    Display **display*;

Both return the length of the event queue for the connected display. Note that there may be more events that have not been read into the queue yet (see **XEventsQueued**).

RootWindow(*display*, *screen_number*)

Window XRootWindow(*display*, *screen_number*)
    Display **display*;
    int *screen_number*;

Both return the root window. These are useful with functions that need a drawable of a particular screen and for creating top-level windows.

ScreenCount(*display*)

int XScreenCount(*display*)
    Display **display*;

Both return the number of available screens.

ServerVendor(*display*)

char *XServerVendor(*display*)
    Display **display*;

Both return a pointer to a null-terminated string that provides some identification of the owner of the X server implementation.

VendorRelease(*display*)

int XVendorRelease(*display*)
    Display **display*;

Both return a number related to a vendor's release of the X server.

2.2.2. Image Format Macros

Applications are required to present data to the X server in a format that the server demands. To help simplify applications, most of the work required to convert the data is provided by Xlib (see sections 6.7 and 10.9).

The following lists the C language macros, their corresponding function equivalents that are for other language bindings, and what data they both return for the specified server and screen. These are often used by toolkits as well as by simple applications.

ImageByteOrder(*display*)

int XImageByteOrder(*display*)
    Display **display*;

Both specify the required byte order for images for each scanline unit in XY format (bitmap) or for each pixel value in Z format. The macro or function can return either **LSBFirst** or **MSBFirst**.

BitmapUnit(*display*)

int XBitmapUnit(*display*)
    Display **display*;

Both return the size of a bitmap's scanline unit in bits. The scanline is calculated in multiples of this value.

BitmapBitOrder(*display*)

int XBitmapBitOrder(*display*)
    Display **display*;

Within each bitmap unit, the left-most bit in the bitmap as displayed on the screen is either the least-significant or most-significant bit in the unit. This macro or function can return **LSBFirst** or **MSBFirst**.

BitmapPad(*display*)

int XBitmapPad(*display*)
    Display **display*;

Each scanline must be padded to a multiple of bits returned by this macro or function.

DisplayHeight(*display*, *screen_number*)

int XDisplayHeight(*display*, *screen_number*)
    Display **display*;
    int *screen_number*;

Both return an integer that describes the height of the screen in pixels.

DisplayHeightMM(*display*, *screen_number*)

int XDisplayHeightMM(*display*, *screen_number*)
    Display **display*;
    int *screen_number*;

Both return the height of the specified screen in millimeters.

DisplayWidth (*display*, *screen_number*)

int XDisplayWidth (*display*, *screen_number*)
    Display **display*;
    int *screen_number*;

Both return the width of the screen in pixels.

DisplayWidthMM (*display*, *screen_number*)

int XDisplayWidthMM (*display*, *screen_number*)
    Display **display*;
    int *screen_number*;

Both return the width of the specified screen in millimeters.

2.2.3. Screen Information Macros

The following lists the C language macros, their corresponding function equivalents that are for other language bindings, and what data they both can return. These macros or functions all take a pointer to the appropriate screen structure.

BlackPixelOfScreen (*screen*)

unsigned long XBlackPixelOfScreen (*screen*)
    Screen **screen*;

Both return the black pixel value of the specified screen.

WhitePixelOfScreen (*screen*)

unsigned long XWhitePixelOfScreen (*screen*)
    Screen **screen*;

Both return the white pixel value of the specified screen.

CellsOfScreen (*screen*)

int XCellsOfScreen (*screen*)
    Screen **screen*;

Both return the number of colormap cells in the default colormap of the specified screen.

DefaultColormapOfScreen (*screen*)

Colormap XDefaultColormapOfScreen (*screen*)
    Screen **screen*;

Both return the default colormap of the specified screen.

DefaultDepthOfScreen (*screen*)

int XDefaultDepthOfScreen (*screen*)
    Screen **screen*;

Both return the depth of the root window.

DefaultGCOfScreen(*screen*)

GC XDefaultGCOfScreen(*screen*)
    Screen **screen*;

Both return a default graphics context (GC) of the specified screen, which has the same depth as the root window of the screen. The GC must never be freed.

DefaultVisualOfScreen(*screen*)

Visual *XDefaultVisualOfScreen(*screen*)
    Screen **screen*;

Both return the default visual of the specified screen. For information on visual types, see section 3.1.

DoesBackingStore(*screen*)

int XDoesBackingStore(*screen*)
    Screen **screen*;

Both return a value indicating whether the screen supports backing stores. The value returned can be one of **WhenMapped**, **NotUseful**, or **Always** (see section 3.2.4).

DoesSaveUnders(*screen*)

Bool XDoesSaveUnders(*screen*)
    Screen **screen*;

Both return a Boolean value indicating whether the screen supports save unders. If **True**, the screen supports save unders. If **False**, the screen does not support save unders (see section 3.2.5).

DisplayOfScreen(*screen*)

Display *XDisplayOfScreen(*screen*)
    Screen **screen*;

Both return the display of the specified screen.

EventMaskOfScreen(*screen*)

long XEventMaskOfScreen(*screen*)
    Screen **screen*;

Both return the event mask of the root window for the specified screen at connection setup time.

WidthOfScreen(*screen*)

```
int XWidthOfScreen(screen)
      Screen *screen;
```

Both return the width of the specified screen in pixels.

HeightOfScreen(*screen*)

```
int XHeightOfScreen(screen)
      Screen *screen;
```

Both return the height of the specified screen in pixels.

WidthMMOfScreen(*screen*)

```
int XWidthMMOfScreen(screen)
      Screen *screen;
```

Both return the width of the specified screen in millimeters.

HeightMMOfScreen(*screen*)

```
int XHeightMMOfScreen(screen)
      Screen *screen;
```

Both return the height of the specified screen in millimeters.

MaxCmapsOfScreen(*screen*)

```
int XMaxCmapsOfScreen(screen)
      Screen *screen;
```

Both return the maximum number of installed colormaps supported by the specified screen (see section 7.3).

MinCmapsOfScreen(*screen*)

```
int XMinCmapsOfScreen(screen)
      Screen *screen;
```

Both return the minimum number of installed colormaps supported by the specified screen (see section 7.3).

PlanesOfScreen(*screen*)

```
int XPlanesOfScreen(screen)
      Screen *screen;
```

Both return the depth of the root window.

RootWindowOfScreen (*screen*)

Window XRootWindowOfScreen (*screen*)
    Screen **screen*;

Both return the root window of the specified screen.

2.3. Generating a NoOperation Protocol Request

To execute a **NoOperation** protocol request, use **XNoOp**.

XNoOp (*display*)
    Display **display*;

display Specifies the connection to the X server.

The **XNoOp** function sends a **NoOperation** protocol request to the X server, thereby exercising the connection.

2.4. Freeing Client-Created Data

To free any in-memory data that was created by an Xlib function, use **XFree**.

XFree (*data*)
    char **data*;

data Specifies a pointer to the data that is to be freed.

The **XFree** function is a general-purpose Xlib routine that frees the specified data. You must use it to free any objects that were allocated by Xlib.

2.5. Closing the Display

To close a display or disconnect from the X server, use **XCloseDisplay**.

XCloseDisplay (*display*)
    Display **display*;

display Specifies the connection to the X server.

The **XCloseDisplay** function closes the connection to the X server for the display specified in the **Display** structure and destroys all windows, resource IDs (**Window**, **Font**, **Pixmap**, **Colormap**, **Cursor**, and **GContext**), or other resources that the client has created on this display, unless the close-down mode of the resource has been changed (see **XSetCloseDownMode**). Therefore, these windows, resource IDs, and other resources should never be referenced again or an error will be generated. Before exiting, you should call **XCloseDisplay** explicitly so that any pending errors are reported as **XCloseDisplay** performs a final **XSync** operation.

XCloseDisplay can generate a **BadGC** error.

2.6. X Server Connection Close Operations

When the X server's connection to a client is closed either by an explicit call to **XCloseDisplay** or by a process that exits, the X server performs the following automatic operations:

- It disowns all selections owned by the client (see **XSetSelectionOwner**).
- It performs an **XUngrabPointer** and **XUngrabKeyboard** if the client has actively grabbed the pointer or the keyboard.
- It performs an **XUngrabServer** if the client has grabbed the server.
- It releases all passive grabs made by the client.

- It marks all resources (including colormap entries) allocated by the client either as permanent or temporary, depending on whether the close-down mode is **RetainPermanent** or **RetainTemporary**. However, this does not prevent other client applications from explicitly destroying the resources (see **XSetCloseDownMode**).

When the close-down mode is **DestroyAll**, the X server destroys all of a client's resources as follows:

- It examines each window in the client's save-set to determine if it is an inferior (subwindow) of a window created by the client. (The save-set is a list of other clients' windows, which are referred to as save-set windows.) If so, the X server reparents the save-set window to the closest ancestor so that the save-set window is not an inferior of a window created by the client. The reparenting leaves unchanged the absolute coordinates (with respect to the root window) of the upper-left outer corner of the save-set window.
- It performs a **MapWindow** request on the save-set window if the save-set window is unmapped. The X server does this even if the save-set window was not an inferior of a window created by the client.
- It destroys all windows created by the client.
- It performs the appropriate free request on each nonwindow resource created by the client in the server (for example, **Font**, **Pixmap**, **Cursor**, **Colormap**, and **GContext**).
- It frees all colors and colormap entries allocated by a client application.

Additional processing occurs when the last connection to the X server closes. An X server goes through a cycle of having no connections and having some connections. When the last connection to the X server closes as a result of a connection closing with the close_mode of **DestroyAll**, the X server does the following:

- It resets its state as if it had just been started. The X server begins by destroying all lingering resources from clients that have terminated in **RetainPermanent** or **RetainTemporary** mode.
- It deletes all but the predefined atom identifiers.
- It deletes all properties on all root windows (see chapter 4).
- It resets all device maps and attributes (for example, key click, bell volume, and acceleration) as well as the access control list.
- It restores the standard root tiles and cursors.
- It restores the default font path.
- It restores the input focus to state **PointerRoot**.

However, the X server does not reset if you close a connection with a close-down mode set to **RetainPermanent** or **RetainTemporary**.

Chapter 3

Window Functions

In the X Window System, a window is a rectangular area on the screen that lets you view graphic output. Client applications can display overlapping and nested windows on one or more screens that are driven by X servers on one or more machines. Clients who want to create windows must first connect their program to the X server by calling **XOpenDisplay**. This chapter begins with a discussion of visual types and window attributes. The chapter continues with a discussion of the Xlib functions you can use to:

- Create windows
- Destroy windows
- Map windows
- Unmap windows
- Configure windows
- Change the stacking order
- Change window attributes
- Translate window coordinates

This chapter also identifies the window actions that may generate events.

Note that it is vital that your application conform to the established conventions for communicating with window managers for it to work well with the various window managers in use (see section 9.1). Toolkits generally adhere to these conventions for you, relieving you of the burden. Toolkits also often supersede many functions in this chapter with versions of their own. Refer to the documentation for the toolkit you are using for more information.

3.1. Visual Types

On some display hardware, it may be possible to deal with color resources in more than one way. For example, you may be able to deal with a screen of either 12-bit depth with arbitrary mapping of pixel to color (pseudo-color) or 24-bit depth with 8 bits of the pixel dedicated to each of red, green, and blue. These different ways of dealing with the visual aspects of the screen are called visuals. For each screen of the display, there may be a list of valid visual types supported at different depths of the screen. Because default windows and visual types are defined for each screen, most simple applications need not deal with this complexity. Xlib provides macros and functions that return the default root window, the default depth of the default root window, and the default visual type (see section 2.2.1 and **XMatchVisualInfo**).

Xlib uses a **Visual** structure that contains information about the possible color mapping. The members of this structure pertinent to this discussion are class, red_mask, green_mask, blue_mask, bits_per_rgb, and map_entries. The class member specifies one of the possible visual classes of the screen and can be **StaticGray**, **StaticColor**, **TrueColor**, **GrayScale**, **PseudoColor**, or **DirectColor**.

The following concepts may serve to make the explanation of visual types clearer. The screen can be color or grayscale, can have a colormap that is writable or read-only, and can also have a colormap whose indices are decomposed into separate RGB pieces, provided one is not on a grayscale screen. This leads to the following diagram:

```
                    Color          GrayScale
               R/O      R/W      R/O     R/W
+-----------------+-------------------------------------+
| Undecomposed        | Static  | Pseudo         | Static| Gray|
|  Colormap       | Color | Color   | Gray  | Scale |
+-----------------+-------------------------------------+
| Decomposed      | True  | Direct  |
|  Colormap       | Color | Color   |
+-----------------+-------------------+
```

Conceptually, as each pixel is read out of video memory for display on the screen, it goes through a look-up stage by indexing into a colormap. Colormaps can be manipulated arbitrarily on some hardware, in limited ways on other hardware, and not at all on other hardware. The visual types affect the colormap and the RGB values in the following ways:

- For **PseudoColor**, a pixel value indexes a colormap to produce independent RGB values, and the RGB values can be changed dynamically.
- **GrayScale** is treated the same way as **PseudoColor** except that the primary that drives the screen is undefined. Thus, the client should always store the same value for red, green, and blue in the colormaps.
- For **DirectColor**, a pixel value is decomposed into separate RGB subfields, and each subfield separately indexes the colormap for the corresponding value. The RGB values can be changed dynamically.
- **TrueColor** is treated the same way as **DirectColor** except that the colormap has predefined, read-only RGB values. These RGB values are server-dependent but provide linear or near-linear ramps in each primary.
- **StaticColor** is treated the same way as **PseudoColor** except that the colormap has predefined, read-only, server-dependent RGB values.
- **StaticGray** is treated the same way as **StaticColor** except that the RGB values are equal for any single pixel value, thus resulting in shades of gray. **StaticGray** with a two-entry colormap can be thought of as monochrome.

The red_mask, green_mask, and blue_mask members are only defined for **DirectColor** and **TrueColor**. Each has one contiguous set of bits with no intersections. The bits_per_rgb member specifies the log base 2 of the number of distinct color values (individually) of red, green, and blue. Actual RGB values are unsigned 16-bit numbers. The map_entries member defines the number of available colormap entries in a newly created colormap. For **DirectColor** and **TrueColor**, this is the size of an individual pixel subfield.

To obtain the visual ID from a **Visual**, use **XVisualIDFromVisual**.

VisualID XVisualIDFromVisual(*visual*)
      Visual **visual*;

visual   Specifies the visual type.

The **XVisualIDFromVisual** function returns the visual ID for the specified visual type.

3.2. Window Attributes

All **InputOutput** windows have a border width of zero or more pixels, an optional background, an event suppression mask (which suppresses propagation of events from children), and a property list (see section 4.2). The window border and background can be a solid color or a pattern, called a tile. All windows except the root have a parent and are clipped by their parent. If a window is stacked on top of another window, it obscures that other window for the purpose of input. If a window has a background (almost all do), it obscures the other window for purposes of output. Attempts to output to the obscured area do nothing, and no input events (for example, pointer motion) are generated for the obscured area.

Windows also have associated property lists (see section 4.2).

Both **InputOutput** and **InputOnly** windows have the following common attributes, which are the only attributes of an **InputOnly** window:

- win-gravity
- event-mask
- do-not-propagate-mask
- override-redirect
- cursor

If you specify any other attributes for an **InputOnly** window, a **BadMatch** error results.

InputOnly windows are used for controlling input events in situations where **InputOutput** windows are unnecessary. **InputOnly** windows are invisible; can only be used to control such things as cursors, input event generation, and grabbing; and cannot be used in any graphics requests. Note that **InputOnly** windows cannot have **InputOutput** windows as inferiors.

Windows have borders of a programmable width and pattern as well as a background pattern or tile. Pixel values can be used for solid colors. The background and border pixmaps can be destroyed immediately after creating the window if no further explicit references to them are to be made. The pattern can either be relative to the parent or absolute. If **ParentRelative**, the parent's background is used.

When windows are first created, they are not visible (not mapped) on the screen. Any output to a window that is not visible on the screen and that does not have backing store will be discarded. An application may wish to create a window long before it is mapped to the screen. When a window is eventually mapped to the screen (using **XMapWindow**), the X server generates an **Expose** event for the window if backing store has not been maintained.

A window manager can override your choice of size, border width, and position for a top-level window. Your program must be prepared to use the actual size and position of the top window. It is not acceptable for a client application to resize itself unless in direct response to a human command to do so. Instead, either your program should use the space given to it, or if the space is too small for any useful work, your program might ask the user to resize the window. The border of your top-level window is considered fair game for window managers.

To set an attribute of a window, set the appropriate member of the **XSetWindowAttributes** structure and OR in the corresponding value bitmask in your subsequent calls to **XCreateWindow** and **XChangeWindowAttributes**, or use one of the other convenience functions that set the appropriate attribute. The symbols for the value mask bits and the **XSetWindowAttributes** structure are:

```
/* Window attribute value mask bits */

#define    CWBackPixmap        (1L<<0)
#define    CWBackPixel         (1L<<1)
#define    CWBorderPixmap      (1L<<2)
#define    CWBorderPixel       (1L<<3)
#define    CWBitGravity        (1L<<4)
```

```
#define   CWWinGravity              (1L<<5)
#define   CWBackingStore            (1L<<6)
#define   CWBackingPlanes           (1L<<7)
#define   CWBackingPixel            (1L<<8)
#define   CWOverrideRedirect        (1L<<9)
#define   CWSaveUnder               (1L<<10)
#define   CWEventMask               (1L<<11)
#define   CWDontPropagate           (1L<<12)
#define   CWColormap                (1L<<13)
#define   CWCursor                  (1L<<14)

/* Values */

typedef struct {
    Pixmap background_pixmap;          /* background, None, or ParentRelative */
    unsigned long background_pixel;    /* background pixel */
    Pixmap border_pixmap;              /* border of the window or CopyFromParent */
    unsigned long border_pixel;        /* border pixel value */
    int bit_gravity;                   /* one of bit gravity values */
    int win_gravity;                   /* one of the window gravity values */
    int backing_store;                 /* NotUseful, WhenMapped, Always */
    unsigned long backing_planes;      /* planes to be preserved if possible */
    unsigned long backing_pixel;       /* value to use in restoring planes */
    Bool save_under;                   /* should bits under be saved? (popups) */
    long event_mask;                   /* set of events that should be saved */
    long do_not_propagate_mask;        /* set of events that should not propagate */
    Bool override_redirect;            /* boolean value for override_redirect */
    Colormap colormap;                 /* color map to be associated with window */
    Cursor cursor;                     /* cursor to be displayed (or None) */
} XSetWindowAttributes;
```

The following lists the defaults for each window attribute and indicates whether the attribute is applicable to **InputOutput** and **InputOnly** windows:

Attribute	Default	**InputOutput**	**InputOnly**
background-pixmap	**None**	Yes	No
background-pixel	Undefined	Yes	No
border-pixmap	**CopyFromParent**	Yes	No
border-pixel	Undefined	Yes	No
bit-gravity	**ForgetGravity**	Yes	No
win-gravity	**NorthWestGravity**	Yes	Yes
backing-store	**NotUseful**	Yes	No
backing-planes	All ones	Yes	No
backing-pixel	zero	Yes	No
save-under	**False**	Yes	No
event-mask	empty set	Yes	Yes
do-not-propagate-mask	empty set	Yes	Yes
override-redirect	**False**	Yes	Yes
colormap	**CopyFromParent**	Yes	No

Attribute	Default	InputOutput	InputOnly
cursor	**None**	Yes	Yes

3.2.1. Background Attribute

Only **InputOutput** windows can have a background. You can set the background of an **InputOutput** window by using a pixel or a pixmap.

The background-pixmap attribute of a window specifies the pixmap to be used for a window's background. This pixmap can be of any size, although some sizes may be faster than others. The background-pixel attribute of a window specifies a pixel value used to paint a window's background in a single color.

You can set the background-pixmap to a pixmap, **None** (default), or **ParentRelative**. You can set the background-pixel of a window to any pixel value (no default). If you specify a background-pixel, it overrides either the default background-pixmap or any value you may have set in the background-pixmap. A pixmap of an undefined size that is filled with the background-pixel is used for the background. Range checking is not performed on the background pixel; it simply is truncated to the appropriate number of bits.

If you set the background-pixmap, it overrides the default. The background-pixmap and the window must have the same depth, or a **BadMatch** error results. If you set background-pixmap to **None**, the window has no defined background. If you set the background-pixmap to **ParentRelative**:

- The parent window's background-pixmap is used. The child window, however, must have the same depth as its parent, or a **BadMatch** error results.
- If the parent window has a background-pixmap of **None**, the window also has a background-pixmap of **None**.
- A copy of the parent window's background-pixmap is not made. The parent's background-pixmap is examined each time the child window's background-pixmap is required.
- The background tile origin always aligns with the parent window's background tile origin. If the background-pixmap is not **ParentRelative**, the background tile origin is the child window's origin.

Setting a new background, whether by setting background-pixmap or background-pixel, overrides any previous background. The background-pixmap can be freed immediately if no further explicit reference is made to it (the X server will keep a copy to use when needed). If you later draw into the pixmap used for the background, what happens is undefined because the X implementation is free to make a copy of the pixmap or to use the same pixmap.

When no valid contents are available for regions of a window and either the regions are visible or the server is maintaining backing store, the server automatically tiles the regions with the window's background unless the window has a background of **None**. If the background is **None**, the previous screen contents from other windows of the same depth as the window are simply left in place as long as the contents come from the parent of the window or an inferior of the parent. Otherwise, the initial contents of the exposed regions are undefined. **Expose** events are then generated for the regions, even if the background-pixmap is **None** (see chapter 8).

3.2.2. Border Attribute

Only **InputOutput** windows can have a border. You can set the border of an **InputOutput** window by using a pixel or a pixmap.

The border-pixmap attribute of a window specifies the pixmap to be used for a window's border. The border-pixel attribute of a window specifies a pixmap of undefined size filled with that pixel be used for a window's border. Range checking is not performed on the background pixel; it simply is truncated to the appropriate number of bits. The border tile origin is always the same as the background tile origin.

You can also set the border-pixmap to a pixmap of any size (some may be faster than others) or to **CopyFromParent** (default). You can set the border-pixel to any pixel value (no default).

If you set a border-pixmap, it overrides the default. The border-pixmap and the window must have the same depth, or a **BadMatch** error results. If you set the border-pixmap to **CopyFromParent**, the parent window's border-pixmap is copied. Subsequent changes to the parent window's border attribute do not affect the child window. However, the child window must have the same depth as the parent window, or a **BadMatch** error results.

The border-pixmap can be freed immediately if no further explicit reference is made to it. If you later draw into the pixmap used for the border, what happens is undefined because the X implementation is free either to make a copy of the pixmap or to use the same pixmap. If you specify a border-pixel, it overrides either the default border-pixmap or any value you may have set in the border-pixmap. All pixels in the window's border will be set to the border-pixel. Setting a new border, whether by setting border-pixel or by setting border-pixmap, overrides any previous border.

Output to a window is always clipped to the inside of the window. Therefore, graphics operations never affect the window border.

3.2.3. Gravity Attributes

The bit gravity of a window defines which region of the window should be retained when an **InputOutput** window is resized. The default value for the bit-gravity attribute is **ForgetGravity**. The window gravity of a window allows you to define how the **InputOutput** or **InputOnly** window should be repositioned if its parent is resized. The default value for the win-gravity attribute is **NorthWestGravity**.

If the inside width or height of a window is not changed and if the window is moved or its border is changed, then the contents of the window are not lost but move with the window. Changing the inside width or height of the window causes its contents to be moved or lost (depending on the bit-gravity of the window) and causes children to be reconfigured (depending on their win-gravity). For a change of width and height, the (x, y) pairs are defined:

Gravity Direction	Coordinates
NorthWestGravity	(0, 0)
NorthGravity	(Width/2, 0)
NorthEastGravity	(Width, 0)
WestGravity	(0, Height/2)
CenterGravity	(Width/2, Height/2)
EastGravity	(Width, Height/2)
SouthWestGravity	(0, Height)
SouthGravity	(Width/2, Height)
SouthEastGravity	(Width, Height)

When a window with one of these bit-gravity values is resized, the corresponding pair defines the change in position of each pixel in the window. When a window with one of these win-gravities has its parent window resized, the corresponding pair defines the change in position of the window within the parent. When a window is so repositioned, a **GravityNotify** event is generated (see chapter 8).

A bit-gravity of **StaticGravity** indicates that the contents or origin should not move relative to the origin of the root window. If the change in size of the window is coupled with a change in position (x, y), then for bit-gravity the change in position of each pixel is (–x, –y), and for win-gravity the change in position of a child when its parent is so resized is (–x, –y). Note that **StaticGravity** still only takes effect when the width or height of the window is changed, not when the window is moved.

A bit-gravity of **ForgetGravity** indicates that the window's contents are always discarded after a size change, even if a backing store or save under has been requested. The window is tiled with its background and zero or more **Expose** events are generated. If no background is defined, the existing screen contents are not altered. Some X servers may also ignore the specified bit-gravity and always generate **Expose** events.

A win-gravity of **UnmapGravity** is like **NorthWestGravity** (the window is not moved), except the child is also unmapped when the parent is resized, and an **UnmapNotify** event is generated.

3.2.4. Backing Store Attribute

Some implementations of the X server may choose to maintain the contents of **InputOutput** windows. If the X server maintains the contents of a window, the off-screen saved pixels are known as backing store. The backing store advises the X server on what to do with the contents of a window. The backing-store attribute can be set to **NotUseful** (default), **WhenMapped**, or **Always**.

A backing-store attribute of **NotUseful** advises the X server that maintaining contents is unnecessary, although some X implementations may still choose to maintain contents and, therefore, not generate **Expose** events. A backing-store attribute of **WhenMapped** advises the X server that maintaining contents of obscured regions when the window is mapped would be beneficial. In this case, the server may generate an **Expose** event when the window is created. A backing-store attribute of **Always** advises the X server that maintaining contents even when the window is unmapped would be beneficial. Even if the window is larger than its parent, this is a request to the X server to maintain complete contents, not just the region within the parent window boundaries. While the X server maintains the window's contents, **Expose** events normally are not generated, but the X server may stop maintaining contents at any time.

When the contents of obscured regions of a window are being maintained, regions obscured by noninferior windows are included in the destination of graphics requests (and source, when the window is the source). However, regions obscured by inferior windows are not included.

3.2.5. Save Under Flag

Some server implementations may preserve contents of **InputOutput** windows under other **InputOutput** windows. This is not the same as preserving the contents of a window for you. You may get better visual appeal if transient windows (for example, pop-up menus) request that the system preserve the screen contents under them, so the temporarily obscured applications do not have to repaint.

You can set the save-under flag to **True** or **False** (default). If save-under is **True**, the X server is advised that, when this window is mapped, saving the contents of windows it obscures would be beneficial.

3.2.6. Backing Planes and Backing Pixel Attributes

You can set backing planes to indicate (with bits set to 1) which bit planes of an **InputOutput** window hold dynamic data that must be preserved in backing store and during save unders. The default value for the backing-planes attribute is all bits set to 1. You can set backing pixel to specify what bits to use in planes not covered by backing planes. The default value for the backing-pixel attribute is all bits set to 0. The X server is free to save only the specified bit planes in the backing store or the save under and is free to regenerate the remaining planes with the specified pixel value. Any extraneous bits in these values (that is, those bits beyond the specified depth of the window) may be simply ignored. If you request backing store or save unders, you should use these members to minimize the amount of off-screen memory required to store your window.

3.2.7. Event Mask and Do Not Propagate Mask Attributes

The event mask defines which events the client is interested in for this **InputOutput** or **InputOnly** window (or, for some event types, inferiors of that window). The do-not-propagate-mask attribute defines which events should not be propagated to ancestor windows when no client has the event type selected in this **InputOutput** or **InputOnly** window. Both masks are the bitwise inclusive OR of one or more of the valid event mask bits. You can specify that no maskable events are reported by setting **NoEventMask** (default).

3.2.8. Override Redirect Flag

To control window placement or to add decoration, a window manager often needs to intercept (redirect) any map or configure request. Pop-up windows, however, often need to be mapped without a window manager getting in the way. To control whether an **InputOutput** or **InputOnly** window is to ignore these structure control facilities, use the override-redirect flag.

The override-redirect flag specifies whether map and configure requests on this window should override a **SubstructureRedirectMask** on the parent. You can set the override-redirect flag to **True** or **False** (default). Window managers use this information to avoid tampering with pop-up windows (see also chapter 9).

3.2.9. Colormap Attribute

The colormap attribute specifies which colormap best reflects the true colors of the **InputOutput** window. The colormap must have the same visual type as the window, or a **BadMatch** error results. X servers capable of supporting multiple hardware colormaps can use this information, and window managers can use it for calls to **XInstallColormap**. You can set the colormap attibute to a colormap or to **CopyFromParent** (default).

If you set the colormap to **CopyFromParent**, the parent window's colormap is copied and used by its child. However, the child window must have the same visual type as the parent, or a **BadMatch** error results. The parent window must not have a colormap of **None**, or a **BadMatch** error results. The colormap is copied by sharing the colormap object between the child and parent, not by making a complete copy of the colormap contents. Subsequent changes to the parent window's colormap attribute do not affect the child window.

3.2.10. Cursor Attribute

The cursor attribute specifies which cursor is to be used when the pointer is in the **InputOutput** or **InputOnly** window. You can set the cursor to a cursor or **None** (default).

If you set the cursor to **None**, the parent's cursor is used when the pointer is in the **InputOutput** or **InputOnly** window, and any change in the parent's cursor will cause an immediate change in the displayed cursor. By calling **XFreeCursor**, the cursor can be freed immediately as long as no further explicit reference to it is made.

3.3. Creating Windows

Xlib provides basic ways for creating windows, and toolkits often supply higher-level functions specifically for creating and placing top-level windows, which are discussed in the appropriate toolkit documentation. If you do not use a toolkit, however, you must provide some standard information or hints for the window manager by using the Xlib predefined property functions (see chapter 9).

If you use Xlib to create your own top-level windows (direct children of the root window), you must observe the following rules so that all applications interact reasonably across the different styles of window management:

- You must never fight with the window manager for the size or placement of your top-level window.
- You must be able to deal with whatever size window you get, even if this means that your application just prints a message like "Please make me bigger" in its window.
- You should only attempt to resize or move top-level windows in direct response to a user request. If a request to change the size of a top-level window fails, you must be prepared to live with what you get. You are free to resize or move the children of top-level windows as necessary. (Toolkits often have facilities for automatic relayout.)
- If you do not use a toolkit that automatically sets standard window properties, you should set these properties for top-level windows before mapping them.

XCreateWindow is the more general function that allows you to set specific window attributes when you create a window. **XCreateSimpleWindow** creates a window that inherits its attributes from its parent window.

The X server acts as if **InputOnly** windows do not exist for the purposes of graphics requests, exposure processing, and **VisibilityNotify** events. An **InputOnly** window cannot be used as a drawable (that is, as a source or destination for graphics requests). **InputOnly** and **InputOutput** windows act identically in other respects (properties, grabs, input control, and so on). Extension packages can define other classes of windows.

To create an unmapped window and set its window attributes, use **XCreateWindow**.

```
Window XCreateWindow(display, parent, x, y, width, height, border_width, depth,
                     class, visual, valuemask, attributes)
    Display *display;
    Window parent;
    int x, y;
    unsigned int width, height;
    unsigned int border_width;
    int depth;
    unsigned int class;
    Visual *visual
    unsigned long valuemask;
    XSetWindowAttributes *attributes;
```

display Specifies the connection to the X server.

parent Specifies the parent window.

x
y Specify the x and y coordinates, which are the top-left outside corner of the created window's borders and are relative to the inside of the parent window's borders.

width
height Specify the width and height, which are the created window's inside dimensions and do not include the created window's borders. The dimensions must be nonzero, or a **BadValue** error results.

border_width Specifies the width of the created window's border in pixels.

depth Specifies the window's depth. A depth of **CopyFromParent** means the depth is taken from the parent.

class Specifies the created window's class. You can pass **InputOutput**, **InputOnly**, or **CopyFromParent**. A class of **CopyFromParent** means the class is taken from the parent.

visual Specifies the visual type. A visual of **CopyFromParent** means the visual type is taken from the parent.

valuemask Specifies which window attributes are defined in the attributes argument. This mask is the bitwise inclusive OR of the valid attribute mask bits. If valuemask is zero, the attributes are ignored and are not referenced.

attributes Specifies the structure from which the values (as specified by the value mask) are to be taken. The value mask should have the appropriate bits set to indicate which attributes have been set in the structure.

The **XCreateWindow** function creates an unmapped subwindow for a specified parent window, returns the window ID of the created window, and causes the X server to generate a **CreateNotify** event. The created window is placed on top in the stacking order with respect to siblings.

The border_width for an **InputOnly** window must be zero, or a **BadMatch** error results. For class **InputOutput**, the visual type and depth must be a combination supported for the screen, or a **BadMatch** error results. The depth need not be the same as the parent, but the parent must not be a window of class **InputOnly**, or a **BadMatch** error results. For an **InputOnly** window, the depth must be zero, and the visual must be one supported by the screen. If either condition is not met, a **BadMatch** error results. The parent window, however, may have any depth and class. If you specify any invalid window attribute for a window, a **BadMatch** error results.

The created window is not yet displayed (mapped) on the user's display. To display the window, call **XMapWindow**. The new window initially uses the same cursor as its parent. A new cursor can be defined for the new window by calling **XDefineCursor**. The window will not be visible on the screen unless it and all of its ancestors are mapped and it is not obscured by any of its ancestors.

XCreateWindow can generate **BadAlloc**, **BadColor**, **BadCursor**, **BadMatch**, **BadPixmap**, **BadValue**, and **BadWindow** errors.

To create an unmapped **InputOutput** subwindow of a given parent window, use **XCreateSimpleWindow**.

```
Window XCreateSimpleWindow(display, parent, x, y, width, height, border_width,
                        border, background)
      Display *display;
      Window parent;
      int x, y;
      unsigned int width, height;
      unsigned int border_width;
      unsigned long border;
      unsigned long background;
```

display Specifies the connection to the X server.

parent Specifies the parent window.

x
y Specify the x and y coordinates, which are the top-left outside corner of the new window's borders and are relative to the inside of the parent window's borders.

width
height Specify the width and height, which are the created window's inside dimensions and do not include the created window's borders. The dimensions must be nonzero, or a **BadValue** error results.

border_width Specifies the width of the created window's border in pixels.

border Specifies the border pixel value of the window.

background Specifies the background pixel value of the window.

The **XCreateSimpleWindow** function creates an unmapped **InputOutput** subwindow for a specified parent window, returns the window ID of the created window, and causes the X server to generate a **CreateNotify** event. The created window is placed on top in the stacking order with respect to siblings. Any part of the window that extends outside its parent window is clipped. The border_width for an **InputOnly** window must be zero, or a **BadMatch** error results. **XCreateSimpleWindow** inherits its depth, class, and visual from its parent. All other window attributes, except background and border, have their default values.

XCreateSimpleWindow can generate **BadAlloc**, **BadMatch**, **BadValue**, and **BadWindow** errors.

3.4. Destroying Windows

Xlib provides functions that you can use to destroy a window or destroy all subwindows of a window.

To destroy a window and all of its subwindows, use **XDestroyWindow**.

```
XDestroyWindow(display, w)
      Display *display;
      Window w;
```

display Specifies the connection to the X server.

w Specifies the window.

The **XDestroyWindow** function destroys the specified window as well as all of its subwindows and causes the X server to generate a **DestroyNotify** event for each window. The window should never be referenced again. If the window specified by the w argument is mapped, it is unmapped automatically. The ordering of the **DestroyNotify** events is such that for any given window being destroyed, **DestroyNotify** is generated on any inferiors of the window before being generated on the window itself. The ordering among siblings and across subhierarchies is not otherwise constrained. If the window you specified is a root window, no windows are destroyed. Destroying a mapped window will generate **Expose** events on other windows that were obscured by the window being destroyed.

XDestroyWindow can generate a **BadWindow** error.

To destroy all subwindows of a specified window, use **XDestroySubwindows**.

XDestroySubwindows(*display*, *w*)
    Display **display*;
    Window *w*;

display Specifies the connection to the X server.

w Specifies the window.

The **XDestroySubwindows** function destroys all inferior windows of the specified window, in bottom-to-top stacking order. It causes the X server to generate a **DestroyNotify** event for each window. If any mapped subwindows were actually destroyed, **XDestroySubwindows** causes the X server to generate **Expose** events on the specified window. This is much more efficient than deleting many windows one at a time because much of the work need be performed only once for all of the windows, rather than for each window. The subwindows should never be referenced again.

XDestroySubwindows can generate a **BadWindow** error.

3.5. Mapping Windows

A window is considered mapped if an **XMapWindow** call has been made on it. It may not be visible on the screen for one of the following reasons:

- It is obscured by another opaque window.
- One of its ancestors is not mapped.
- It is entirely clipped by an ancestor.

Expose events are generated for the window when part or all of it becomes visible on the screen. A client receives the **Expose** events only if it has asked for them. Windows retain their position in the stacking order when they are unmapped.

A window manager may want to control the placement of subwindows. If **SubstructureRedirectMask** has been selected by a window manager on a parent window (usually a root window), a map request initiated by other clients on a child window is not performed, and the window manager is sent a **MapRequest** event. However, if the override-redirect flag on the child had been set to **True** (usually only on pop-up menus), the map request is performed.

A tiling window manager might decide to reposition and resize other client's windows and then decide to map the window to its final location. A window manager that wants to provide decoration might reparent the child into a frame first. For further information, see section 3.2.8 and chapter 8. Only a single client at a time can select for **SubstructureRedirectMask**.

Similarly, a single client can select for **ResizeRedirectMask** on a parent window. Then, any attempt to resize the window by another client is suppressed, and the client receives a **ResizeRequest** event.

To map a given window, use **XMapWindow**.

XMapWindow (*display*, *w*)
    Display **display*;
    Window *w*;

display Specifies the connection to the X server.

w Specifies the window.

The **XMapWindow** function maps the window and all of its subwindows that have had map requests. Mapping a window that has an unmapped ancestor does not display the window but marks it as eligible for display when the ancestor becomes mapped. Such a window is called unviewable. When all its ancestors are mapped, the window becomes viewable and will be visible on the screen if it is not obscured by another window. This function has no effect if the window is already mapped.

If the override-redirect of the window is **False** and if some other client has selected **SubstructureRedirectMask** on the parent window, then the X server generates a **MapRequest** event, and the **XMapWindow** function does not map the window. Otherwise, the window is mapped, and the X server generates a **MapNotify** event.

If the window becomes viewable and no earlier contents for it are remembered, the X server tiles the window with its background. If the window's background is undefined, the existing screen contents are not altered, and the X server generates zero or more **Expose** events. If backing-store was maintained while the window was unmapped, no **Expose** events are generated. If backing-store will now be maintained, a full-window exposure is always generated. Otherwise, only visible regions may be reported. Similar tiling and exposure take place for any newly viewable inferiors.

If the window is an **InputOutput** window, **XMapWindow** generates **Expose** events on each **InputOutput** window that it causes to be displayed. If the client maps and paints the window and if the client begins processing events, the window is painted twice. To avoid this, first ask for **Expose** events and then map the window, so the client processes input events as usual. The event list will include **Expose** for each window that has appeared on the screen. The client's normal response to an **Expose** event should be to repaint the window. This method usually leads to simpler programs and to proper interaction with window managers.

XMapWindow can generate a **BadWindow** error.

To map and raise a window, use **XMapRaised**.

XMapRaised (*display*, *w*)
    Display **display*;
    Window *w*;

display Specifies the connection to the X server.

w Specifies the window.

The **XMapRaised** function essentially is similar to **XMapWindow** in that it maps the window and all of its subwindows that have had map requests. However, it also raises the specified window to the top of the stack. For additional information, see **XMapWindow**.

XMapRaised can generate multiple **BadWindow** errors.

To map all subwindows for a specified window, use **XMapSubwindows**.

XMapSubwindows (*display*, *w*)
    Display **display*;
    Window *w*;

display Specifies the connection to the X server.

w Specifies the window.

The **XMapSubwindows** function maps all subwindows for a specified window in top-to-bottom stacking order. The X server generates **Expose** events on each newly displayed window. This may be much more efficient than mapping many windows one at a time because the server needs to perform much of the work only once, for all of the windows, rather than for each window.

XMapSubwindows can generate a **BadWindow** error.

3.6. Unmapping Windows

Xlib provides functions that you can use to unmap a window or all subwindows.

To unmap a window, use **XUnmapWindow**.

```
XUnmapWindow(display, w)
      Display *display;
      Window w;
```

display Specifies the connection to the X server.

w Specifies the window.

The **XUnmapWindow** function unmaps the specified window and causes the X server to generate an **UnmapNotify** event. If the specified window is already unmapped, **XUnmapWindow** has no effect. Normal exposure processing on formerly obscured windows is performed. Any child window will no longer be visible until another map call is made on the parent. In other words, the subwindows are still mapped but are not visible until the parent is mapped. Unmapping a window will generate **Expose** events on windows that were formerly obscured by it.

XUnmapWindow can generate a **BadWindow** error.

To unmap all subwindows for a specified window, use **XUnmapSubwindows**.

```
XUnmapSubwindows(display, w)
      Display *display;
      Window w;
```

display Specifies the connection to the X server.

w Specifies the window.

The **XUnmapSubwindows** function unmaps all subwindows for the specified window in bottom-to-top stacking order. It causes the X server to generate an **UnmapNotify** event on each subwindow and **Expose** events on formerly obscured windows. Using this function is much more efficient than unmapping multiple windows one at a time because the server needs to perform much of the work only once, for all of the windows, rather than for each window.

XUnmapSubwindows can generate a **BadWindow** error.

3.7. Configuring Windows

Xlib provides functions that you can use to move a window, resize a window, move and resize a window, or change a window's border width. To change one of these parameters, set the appropriate member of the **XWindowChanges** structure and OR in the corresponding value mask in subsequent calls to **XConfigureWindow**. The symbols for the value mask bits and the **XWindowChanges** structure are:

```
/* Configure window value mask bits */
#define   CWX             (1<<0)
#define   CWY             (1<<1)
#define   CWWidth         (1<<2)
#define   CWHeight        (1<<3)
#define   CWBorderWidth   (1<<4)
#define   CWSibling       (1<<5)
#define   CWStackMode     (1<<6)

/* Values */

typedef struct {
        int x, y;
        int width, height;
        int border_width;
        Window sibling;
        int stack_mode;
} XWindowChanges;
```

The x and y members are used to set the window's x and y coordinates, which are relative to the parent's origin and indicate the position of the upper-left outer corner of the window. The width and height members are used to set the inside size of the window, not including the border, and must be nonzero, or a **BadValue** error results. Attempts to configure a root window have no effect.

The border_width member is used to set the width of the border in pixels. Note that setting just the border width leaves the outer-left corner of the window in a fixed position but moves the absolute position of the window's origin. If you attempt to set the border-width attribute of an **InputOnly** window nonzero, a **BadMatch** error results.

The sibling member is used to set the sibling window for stacking operations. The stack_mode member is used to set how the window is to be restacked and can be set to **Above**, **Below**, **TopIf**, **BottomIf**, or **Opposite**.

If the override-redirect flag of the window is **False** and if some other client has selected **SubstructureRedirectMask** on the parent, the X server generates a **ConfigureRequest** event, and no further processing is performed. Otherwise, if some other client has selected **ResizeRedirectMask** on the window and the inside width or height of the window is being changed, a **ResizeRequest** event is generated, and the current inside width and height are used instead. Note that the override-redirect flag of the window has no effect on **ResizeRedirectMask** and that **SubstructureRedirectMask** on the parent has precedence over **ResizeRedirectMask** on the window.

When the geometry of the window is changed as specified, the window is restacked among siblings, and a **ConfigureNotify** event is generated. if the state of the window actually changes. **GravityNotify** events are generated after **ConfigureNotify** events. If the inside width or height of the window has actually changed, children of the window are affected as specified.

If a window's size actually changes, the window's subwindows move according to their window gravity. Depending on the window's bit gravity, the contents of the window also may be moved (see section 3.2.3).

If regions of the window were obscured but now are not, exposure processing is performed on these formerly obscured windows, including the window itself and its inferiors. As a result of increasing the width or height, exposure processing is also performed on any new regions of the window and any regions where window contents are lost.

The restack check (specifically, the computation for **BottomIf**, **TopIf**, and **Opposite**) is performed with respect to the window's final size and position (as controlled by the other arguments of the request), not its initial position. If a sibling is specified without a stack_mode, a **BadMatch** error results.

If a sibling and a stack_mode are specified, the window is restacked as follows:

Above The window is placed just above the sibling.

Below The window is placed just below the sibling.

TopIf If the sibling occludes the window, the window is placed at the top of the stack.

BottomIf If the window occludes the sibling, the window is placed at the bottom of the stack.

Opposite If the sibling occludes the window, the window is placed at the top of the stack. If the window occludes the sibling, the window is placed at the bottom of the stack.

If a stack_mode is specified but no sibling is specified, the window is restacked as follows:

Above The window is placed at the top of the stack.

Below The window is placed at the bottom of the stack.

TopIf If any sibling occludes the window, the window is placed at the top of the stack.

BottomIf If the window occludes any sibling, the window is placed at the bottom of the stack.

Opposite If any sibling occludes the window, the window is placed at the top of the stack. If the window occludes any sibling, the window is placed at the bottom of the stack.

Attempts to configure a root window have no effect.

To configure a window's size, location, stacking, or border, use **XConfigureWindow**.

XConfigureWindow(*display*, *w*, *value_mask*, *values*)
    Display **display*;
    Window *w*;
    unsigned int *value_mask*;
    XWindowChanges **values*;

display Specifies the connection to the X server.

w Specifies the window to be reconfigured.

value_mask Specifies which values are to be set using information in the values structure. This mask is the bitwise inclusive OR of the valid configure window values bits.

values Specifies a pointer to the **XWindowChanges** structure.

The **XConfigureWindow** function uses the values specified in the **XWindowChanges** structure to reconfigure a window's size, position, border, and stacking order. Values not specified are taken from the existing geometry of the window.

If a sibling is specified without a stack_mode or if the window is not actually a sibling, a **BadMatch** error results. Note that the computations for **BottomIf**, **TopIf**, and **Opposite** are performed with respect to the window's final geometry (as controlled by the other arguments passed to **XConfigureWindow**), not its initial geometry. Any backing store contents of the window, its inferiors, and other newly visible windows are either discarded or changed to reflect the current screen contents (depending on the implementation).

XConfigureWindow can generate **BadMatch**, **BadValue**, and **BadWindow** errors.

To move a window without changing its size, use **XMoveWindow**.

```
XMoveWindow(display, w, x, y)
      Display *display;
      Window w;
      int x, y;
```

display Specifies the connection to the X server.

w Specifies the window to be moved.

x
y Specify the x and y coordinates, which define the new location of the top-left pixel of the window's border or the window itself if it has no border.

The **XMoveWindow** function moves the specified window to the specified x and y coordinates, but it does not change the window's size, raise the window, or change the mapping state of the window. Moving a mapped window may or may not lose the window's contents depending on if the window is obscured by nonchildren and if no backing store exists. If the contents of the window are lost, the X server generates **Expose** events. Moving a mapped window generates **Expose** events on any formerly obscured windows.

If the override-redirect flag of the window is **False** and some other client has selected **SubstructureRedirectMask** on the parent, the X server generates a **ConfigureRequest** event, and no further processing is performed. Otherwise, the window is moved.

XMoveWindow can generate a **BadWindow** error.

To change a window's size without changing the upper-left coordinate, use **XResizeWindow**.

```
XResizeWindow(display, w, width, height)
      Display *display;
      Window w;
      unsigned int width, height;
```

display Specifies the connection to the X server.

w Specifies the window.

width
height Specify the width and height, which are the interior dimensions of the window after the call completes.

The **XResizeWindow** function changes the inside dimensions of the specified window, not including its borders. This function does not change the window's upper-left coordinate or the origin and does not restack the window. Changing the size of a mapped window may lose its contents and generate **Expose** events. If a mapped window is made smaller, changing its size generates **Expose** events on windows that the mapped window formerly obscured.

If the override-redirect flag of the window is **False** and some other client has selected **SubstructureRedirectMask** on the parent, the X server generates a **ConfigureRequest** event, and no further processing is performed. If either width or height is zero, a **BadValue** error results.

XResizeWindow can generate **BadValue** and **BadWindow** errors.

To change the size and location of a window, use **XMoveResizeWindow**.

XMoveResizeWindow(*display*, *w*, *x*, *y*, *width*, *height*)
    Display **display*;
    Window *w*;
    int *x*, *y*;
    unsigned int *width*, *height*;

display Specifies the connection to the X server.

w Specifies the window to be reconfigured.

x
y Specify the x and y coordinates, which define the new position of the window relative to its parent.

width
height Specify the width and height, which define the interior size of the window.

The **XMoveResizeWindow** function changes the size and location of the specified window without raising it. Moving and resizing a mapped window may generate an **Expose** event on the window. Depending on the new size and location parameters, moving and resizing a window may generate **Expose** events on windows that the window formerly obscured.

If the override-redirect flag of the window is **False** and some other client has selected **SubstructureRedirectMask** on the parent, the X server generates a **ConfigureRequest** event, and no further processing is performed. Otherwise, the window size and location are changed.

XMoveResizeWindow can generate **BadValue** and **BadWindow** errors.

To change the border width of a given window, use **XSetWindowBorderWidth**.

XSetWindowBorderWidth(*display*, *w*, *width*)
    Display **display*;
    Window *w*;
    unsigned int *width*;

display Specifies the connection to the X server.

w Specifies the window.

width Specifies the width of the window border.

The **XSetWindowBorderWidth** function sets the specified window's border width to the specified width.

XSetWindowBorderWidth can generate a **BadWindow** error.

3.8. Changing Window Stacking Order

Xlib provides functions that you can use to raise, lower, circulate, or restack windows.

To raise a window so that no sibling window obscures it, use **XRaiseWindow**.

XRaiseWindow(*display*, *w*)
    Display **display*;
    Window *w*;

display Specifies the connection to the X server.

w Specifies the window.

The **XRaiseWindow** function raises the specified window to the top of the stack so that no sibling window obscures it. If the windows are regarded as overlapping sheets of paper stacked on a desk, then raising a window is analogous to moving the sheet to the top of the stack but leaving its x and y location on the desk constant. Raising a mapped window may generate **Expose** events for the window and any mapped subwindows that were formerly obscured.

If the override-redirect attribute of the window is **False** and some other client has selected **SubstructureRedirectMask** on the parent, the X server generates a **ConfigureRequest** event, and no processing is performed. Otherwise, the window is raised.

XRaiseWindow can generate a **BadWindow** error.

To lower a window so that it does not obscure any sibling windows, use **XLowerWindow**.

XLowerWindow(*display*, *w*)
    Display **display*;
    Window *w*;

display Specifies the connection to the X server.

w Specifies the window.

The **XLowerWindow** function lowers the specified window to the bottom of the stack so that it does not obscure any sibling windows. If the windows are regarded as overlapping sheets of paper stacked on a desk, then lowering a window is analogous to moving the sheet to the bottom of the stack but leaving its x and y location on the desk constant. Lowering a mapped window will generate **Expose** events on any windows it formerly obscured.

If the override-redirect attribute of the window is **False** and some other client has selected **SubstructureRedirectMask** on the parent, the X server generates a **ConfigureRequest** event, and no processing is performed. Otherwise, the window is lowered to the bottom of the stack.

XLowerWindow can generate a **BadWindow** error.

To circulate a subwindow up or down, use **XCirculateSubwindows**.

XCirculateSubwindows(*display*, *w*, *direction*)
    Display **display*;
    Window *w*;
    int *direction*;

display Specifies the connection to the X server.

w Specifies the window.

direction Specifies the direction (up or down) that you want to circulate the window. You can pass **RaiseLowest** or **LowerHighest**.

The **XCirculateSubwindows** function circulates children of the specified window in the specified direction. If you specify **RaiseLowest**, **XCirculateSubwindows** raises the lowest mapped child (if any) that is occluded by another child to the top of the stack. If you specify **LowerHighest**, **XCirculateSubwindows** lowers the highest mapped child (if any) that occludes another child to the bottom of the stack. Exposure processing is then performed on formerly obscured windows. If some other client has selected **SubstructureRedirectMask** on the window, the X server generates a **CirculateRequest** event, and no further processing is performed. If a child is actually restacked, the X server generates a **CirculateNotify** event.

XCirculateSubwindows can generate **BadValue** and **BadWindow** errors.

To raise the lowest mapped child of a window that is partially or completely occluded by another child, use **XCirculateSubwindowsUp**.

```
XCirculateSubwindowsUp(display, w)
      Display *display;
      Window w;
```

display Specifies the connection to the X server.

w Specifies the window.

The **XCirculateSubwindowsUp** function raises the lowest mapped child of the specified window that is partially or completely occluded by another child. Completely unobscured children are not affected. This is a convenience function equivalent to **XCirculateSubwindows** with **RaiseLowest** specified.

XCirculateSubwindowsUp can generate a **BadWindow** error.

To lower the highest mapped child of a window that partially or completely occludes another child, use **XCirculateSubwindowsDown**.

```
XCirculateSubwindowsDown(display, w)
      Display *display;
      Window w;
```

display Specifies the connection to the X server.

w Specifies the window.

The **XCirculateSubwindowsDown** function lowers the highest mapped child of the specified window that partially or completely occludes another child. Completely unobscured children are not affected. This is a convenience function equivalent to **XCirculateSubwindows** with **LowerHighest** specified.

XCirculateSubwindowsDown can generate a **BadWindow** error.

To restack a set of windows from top to bottom, use **XRestackWindows**.

```
XRestackWindows(display, windows, nwindows);
      Display *display;
      Window windows[];
      int nwindows;
```

display Specifies the connection to the X server.

windows Specifies an array containing the windows to be restacked.

nwindows Specifies the number of windows to be restacked.

The **XRestackWindows** function restacks the windows in the order specified, from top to bottom. The stacking order of the first window in the windows array is unaffected, but the other windows in the array are stacked underneath the first window, in the order of the array. The stacking order of the other windows is not affected. For each window in the window array that is not a child of the specified window, a **BadMatch** error results.

If the override-redirect attribute of a window is **False** and some other client has selected **SubstructureRedirectMask** on the parent, the X server generates **ConfigureRequest** events for each window whose override-redirect flag is not set, and no further processing is performed. Otherwise, the windows will be restacked in top to bottom order.

XRestackWindows can generate a **BadWindow** error.

3.9. Changing Window Attributes

Xlib provides functions that you can use to set window attributes. **XChangeWindowAttributes** is the more general function that allows you to set one or more window attributes provided by the **XSetWindowAttributes** structure. The other functions described in this section allow you to set one specific window attribute, such as a window's background.

To change one or more attributes for a given window, use **XChangeWindowAttributes**.

XChangeWindowAttributes(*display, w, valuemask, attributes*)
    Display **display*;
    Window *w*;
    unsigned long *valuemask*;
    XSetWindowAttributes **attributes*;

display Specifies the connection to the X server.

w Specifies the window.

valuemask Specifies which window attributes are defined in the attributes argument. This mask is the bitwise inclusive OR of the valid attribute mask bits. If valuemask is zero, the attributes are ignored and are not referenced. The values and restrictions are the same as for **XCreateWindow**.

attributes Specifies the structure from which the values (as specified by the value mask) are to be taken. The value mask should have the appropriate bits set to indicate which attributes have been set in the structure (see section 3.2).

Depending on the valuemask, the **XChangeWindowAttributes** function uses the window attributes in the **XSetWindowAttributes** structure to change the specified window attributes. Changing the background does not cause the window contents to be changed. To repaint the window and its background, use **XClearWindow**. Setting the border or changing the background such that the border tile origin changes causes the border to be repainted. Changing the background of a root window to **None** or **ParentRelative** restores the default background pixmap. Changing the border of a root window to **CopyFromParent** restores the default border pixmap. Changing the win-gravity does not affect the current position of the window. Changing the backing-store of an obscured window to **WhenMapped** or **Always**, or changing the backing-planes, backing-pixel, or save-under of a mapped window may have no immediate effect. Changing the colormap of a window (that is, defining a new map, not changing the contents of the existing map) generates a **ColormapNotify** event. Changing the colormap of a visible window may have no immediate effect on the screen because the map may not be installed (see **XInstallColormap**). Changing the cursor of a root window to **None** restores the default cursor. Whenever possible, you are encouraged to share colormaps.

Multiple clients can select input on the same window. Their event masks are maintained separately. When an event is generated, it is reported to all interested clients. However, only one client at a time can select for **SubstructureRedirectMask**,

ResizeRedirectMask, and **ButtonPressMask**. If a client attempts to select any of these event masks and some other client has already selected one, a **BadAccess** error results. There is only one do-not-propagate-mask for a window, not one per client.

XChangeWindowAttributes can generate **BadAccess**, **BadColor**, **BadCursor**, **BadMatch**, **BadPixmap**, **BadValue**, and **BadWindow** errors.

To set the background of a window to a given pixel, use **XSetWindowBackground**.

```
XSetWindowBackground(display, w, background_pixel)
      Display *display;
      Window w;
      unsigned long background_pixel;
```

display Specifies the connection to the X server.

w Specifies the window.

background_pixel
Specifies the pixel that is to be used for the background.

The **XSetWindowBackground** function sets the background of the window to the specified pixel value. Changing the background does not cause the window contents to be changed. **XSetWindowBackground** uses a pixmap of undefined size filled with the pixel value you passed. If you try to change the background of an **InputOnly** window, a **BadMatch** error results.

XSetWindowBackground can generate **BadMatch** and **BadWindow** errors.

To set the background of a window to a given pixmap, use **XSetWindowBackgroundPixmap**.

```
XSetWindowBackgroundPixmap(display, w, background_pixmap)
      Display *display;
      Window w;
      Pixmap background_pixmap;
```

display Specifies the connection to the X server.

w Specifies the window.

background_pixmap
Specifies the background pixmap, **ParentRelative**, or **None**.

The **XSetWindowBackgroundPixmap** function sets the background pixmap of the window to the specified pixmap. The background pixmap can immediately be freed if no further explicit references to it are to be made. If **ParentRelative** is specified, the background pixmap of the window's parent is used, or on the root window, the default background is restored. If you try to change the background of an **InputOnly** window, a **BadMatch** error results. If the background is set to **None**, the window has no defined background.

XSetWindowBackgroundPixmap can generate **BadMatch**, **BadPixmap**, and **BadWindow** errors.

Note

> **XSetWindowBackground** and **XSetWindowBackgroundPixmap** do not change the current contents of the window.

To change and repaint a window's border to a given pixel, use **XSetWindowBorder**.

```
XSetWindowBorder(display, w, border_pixel)
      Display *display;
      Window w;
      unsigned long border_pixel;
```

display Specifies the connection to the X server.

w Specifies the window.

border_pixel Specifies the entry in the colormap.

The **XSetWindowBorder** function sets the border of the window to the pixel value you specify. If you attempt to perform this on an **InputOnly** window, a **BadMatch** error results.

XSetWindowBorder can generate **BadMatch** and **BadWindow** errors.

To change and repaint the border tile of a given window, use **XSetWindowBorderPixmap**.

```
XSetWindowBorderPixmap(display, w, border_pixmap)
      Display *display;
      Window w;
      Pixmap border_pixmap;
```

display Specifies the connection to the X server.

w Specifies the window.

border_pixmap Specifies the border pixmap or **CopyFromParent**.

The **XSetWindowBorderPixmap** function sets the border pixmap of the window to the pixmap you specify. The border pixmap can be freed immediately if no further explicit references to it are to be made. If you specify **CopyFromParent**, a copy of the parent window's border pixmap is used. If you attempt to perform this on an **InputOnly** window, a **BadMatch** error results.

XSetWindowBorderPixmap can generate **BadMatch**, **BadPixmap**, and **BadWindow** errors.

3.10. Translating Window Coordinates

Applications, mostly window managers, often need to perform a coordinate transformation from the coordinate space of one window to another window or need to determine which subwindow a coordinate lies in. **XTranslateCoordinates** fulfills these needs (and avoids any race conditions) by asking the X server to perform this operation.

```
Bool XTranslateCoordinates(display, src_w, dest_w, src_x, src_y, dest_x_return,
                           dest_y_return, child_return)
      Display *display;
      Window src_w, dest_w;
      int src_x, src_y;
      int *dest_x_return, *dest_y_return;
      Window *child_return;
```

display Specifies the connection to the X server.

src_w Specifies the source window.

dest_w Specifies the destination window.

src_x
src_y Specify the x and y coordinates within the source window.

dest_x_return

dest_y_return Return the x and y coordinates within the destination window.

child_return Returns the child if the coordinates are contained in a mapped child of the destination window.

The **XTranslateCoordinates** function takes the src_x and src_y coordinates relative to the source window's origin and returns these coordinates to dest_x_return and dest_y_return relative to the destination window's origin. If **XTranslateCoordinates** returns zero, src_w and dest_w are on different screens, and dest_x_return and dest_y_return are zero. If the coordinates are contained in a mapped child of dest_w, that child is returned to child_return. Otherwise, child_return is set to **None**.

XTranslateCoordinates can generate a **BadWindow** error.

Chapter 4

Window Information Functions

After you connect the display to the X server and create a window, you can use the Xlib window information functions to:

- Obtain information about a window
- Manipulate property lists
- Obtain and change window properties
- Manipulate selections

4.1. Obtaining Window Information

Xlib provides functions that you can use to obtain information about the window tree, the window's current attributes, the window's current geometry, or the current pointer coordinates. Because they are most frequently used by window managers, these functions all return a status to indicate whether the window still exists.

To obtain the parent, a list of children, and number of children for a given window, use **XQueryTree**.

```
Status XQueryTree(display, w, root_return, parent_return, children_return, nchildren_return)
      Display *display;
      Window w;
      Window *root_return;
      Window *parent_return;
      Window **children_return;
      unsigned int *nchildren_return;
```

display Specifies the connection to the X server.

w Specifies the window whose list of children, root, parent, and number of children you want to obtain.

root_return Returns the root window.

parent_return Returns the parent window.

children_return Returns a pointer to the list of children.

nchildren_return Returns the number of children.

The **XQueryTree** function returns the root ID, the parent window ID, a pointer to the list of children windows, and the number of children in the list for the specified window. The children are listed in current stacking order, from bottommost (first) to topmost (last). **XQueryTree** returns zero if it fails and nonzero if it succeeds. To free this list when it is no longer needed, use **XFree**.

To obtain the current attributes of a given window, use **XGetWindowAttributes**.

```
Status XGetWindowAttributes(display, w, window_attributes_return)
      Display *display;
      Window w;
      XWindowAttributes *window_attributes_return;
```

display Specifies the connection to the X server.

w Specifies the window whose current attributes you want to obtain.

window_attributes_return
Returns the specified window's attributes in the **XWindowAttributes** structure.

The **XGetWindowAttributes** function returns the current attributes for the specified window to an **XWindowAttributes** structure.

```
typedef struct {
	int x, y;                               /* location of window */
	int width, height;                      /* width and height of window */
	int border_width;                       /* border width of window */
	int depth;                              /* depth of window */
	Visual *visual;                         /* the associated visual structure */
	Window root;                            /* root of screen containing window */
	int class;                              /* InputOutput, InputOnly*/
	int bit_gravity;                        /* one of the bit gravity values */
	int win_gravity;                        /* one of the window gravity values */
	int backing_store;                      /* NotUseful, WhenMapped, Always */
	unsigned long backing_planes;           /* planes to be preserved if possible */
	unsigned long backing_pixel;            /* value to be used when restoring planes */
	Bool save_under;                        /* boolean, should bits under be saved? */
	Colormap colormap;                      /* color map to be associated with window */
	Bool map_installed;                     /* boolean, is color map currently installed*/
	int map_state;                          /* IsUnmapped, IsUnviewable, IsViewable */
	long all_event_masks;                   /* set of events all people have interest in*/
	long your_event_mask;                   /* my event mask */
	long do_not_propagate_mask;             /* set of events that should not propagate */
	Bool override_redirect;                 /* boolean value for override-redirect */
	Screen *screen;                         /* back pointer to correct screen */
} XWindowAttributes;
```

The x and y members are set to the upper-left outer corner relative to the parent window's origin. The width and height members are set to the inside size of the window, not including the border. The border_width member is set to the window's border width in pixels. The depth member is set to the depth of the window (that is, bits per pixel for the object). The visual member is a pointer to the screen's associated **Visual** structure. The root member is set to the root window of the screen containing the window. The class member is set to the window's class and can be either **InputOutput** or **InputOnly**.

The bit_gravity member is set to the window's bit gravity and can be one of the following:

ForgetGravity	**EastGravity**
NorthWestGravity	**SouthWestGravity**
NorthGravity	**SouthGravity**
NorthEastGravity	**SouthEastGravity**
WestGravity	**StaticGravity**
CenterGravity	

The win_gravity member is set to the window's window gravity and can be one of the following:

UnmapGravity	**EastGravity**

NorthWestGravity	**SouthWestGravity**
NorthGravity	**SouthGravity**
NorthEastGravity	**SouthEastGravity**
WestGravity	**StaticGravity**
CenterGravity	

For additional information on gravity, see section 3.3.

The backing_store member is set to indicate how the X server should maintain the contents of a window and can be **WhenMapped**, **Always**, or **NotUseful**. The backing_planes member is set to indicate (with bits set to 1) which bit planes of the window hold dynamic data that must be preserved in backing_stores and during save_unders. The backing_pixel member is set to indicate what values to use for planes not set in backing_planes.

The save_under member is set to **True** or **False**. The colormap member is set to the colormap for the specified window and can be a colormap ID or **None**. The map_installed member is set to indicate whether the colormap is currently installed and can be **True** or **False**. The map_state member is set to indicate the state of the window and can be **IsUnmapped**, **IsUnviewable**, or **IsViewable**. **IsUnviewable** is used if the window is mapped but some ancestor is unmapped.

The all_event_masks member is set to the bitwise inclusive OR of all event masks selected on the window by all clients. The your_event_mask member is set to the bitwise inclusive OR of all event masks selected by the querying client. The do_not_propagate_mask member is set to the bitwise inclusive OR of the set of events that should not propagate.

The override_redirect member is set to indicate whether this window overrides structure control facilities and can be **True** or **False**. Window manager clients should ignore the window if this member is **True**.

The screen member is set to a screen pointer that gives you a back pointer to the correct screen. This makes it easier to obtain the screen information without having to loop over the root window fields to see which field matches.

XGetWindowAttributes can generate **BadDrawable** and **BadWindow** errors.

To obtain the current geometry of a given drawable, use **XGetGeometry**.

```
Status XGetGeometry(display, d, root_return, x_return, y_return, width_return,
                    height_return, border_width_return, depth_return)
      Display *display;
      Drawable d;
      Window *root_return;
      int *x_return, *y_return;
      unsigned int *width_return, *height_return;
      unsigned int *border_width_return;
      unsigned int *depth_return;
```

display Specifies the connection to the X server.

d Specifies the drawable, which can be a window or a pixmap.

root_return Returns the root window.

x_return
y_return Return the x and y coordinates that define the location of the drawable. For a window, these coordinates specify the upper-left outer corner relative to its parent's origin. For pixmaps, these coordinates are always zero.

width_return
height_return Return the drawable's dimensions (width and height). For a window, these dimensions specify the inside size, not including the border.

border_width_return
Returns the border width in pixels. If the drawable is a pixmap, it returns zero.

depth_return Returns the depth of the drawable (bits per pixel for the object).

The **XGetGeometry** function returns the root window and the current geometry of the drawable. The geometry of the drawable includes the x and y coordinates, width and height, border width, and depth. These are described in the argument list. It is legal to pass to this function a window whose class is **InputOnly**.

To obtain the root window the pointer is currently on and the pointer coordinates relative to the root's origin, use **XQueryPointer**.

Bool XQueryPointer(*display*, *w*, *root_return*, *child_return*, *root_x_return*, *root_y_return*,
win_x_return, *win_y_return*, *mask_return*)
Display **display*;
Window *w*;
Window **root_return*, **child_return*;
int **root_x_return*, **root_y_return*;
int **win_x_return*, **win_y_return*;
unsigned int **mask_return*;

display Specifies the connection to the X server.

w Specifies the window.

root_return Returns the root window that the pointer is in.

child_return Returns the child window that the pointer is located in, if any.

root_x_return
root_y_return Return the pointer coordinates relative to the root window's origin.

win_x_return
win_y_return Return the pointer coordinates relative to the specified window.

mask_return Returns the current state of the modifier keys and pointer buttons.

The **XQueryPointer** function returns the root window the pointer is logically on and the pointer coordinates relative to the root window's origin. If **XQueryPointer** returns **False**, the pointer is not on the same screen as the specified window, and **XQueryPointer** returns **None** to child_return and zero to win_x_return and win_y_return. If **XQueryPointer** returns **True**, the pointer coordinates returned to win_x_return and win_y_return are relative to the origin of the specified window. In this case, **XQueryPointer** returns the child that contains the pointer, if any, or else **None** to child_return.

XQueryPointer returns the current logical state of the keyboard buttons and the modifier keys in mask_return It sets mask_return to the bitwise inclusive OR of one or more of the button or modifier key bitmasks to match the current state of the mouse buttons and the modifier keys.

Note that the logical state of a device (as seen through Xlib) may lag the physical state if device event processing is frozen (see section 7.4).

XQueryPointer can generate a **BadWindow** error.

4.2. Properties and Atoms

A property is a collection of named, typed data. The window system has a set of predefined properties (for example, the name of a window, size hints, and so on), and users can define any other arbitrary information and associate it with windows. Each property has a name, which is an ISO Latin-1 string. For each named property, a unique identifier (atom) is associated with it. A property also has a type, for example, string or integer. These types are also indicated using atoms, so arbitrary new types can be defined. Data of only one type may be associated with a single property name. Clients can store and retrieve properties associated with windows. For efficiency reasons, an atom is used rather than a character string. **XInternAtom** can be used to obtain the atom for property names.

A property is also stored in one of several possible formats. The X server can store the information as 8-bit quantities, 16-bit quantities, or 32-bit quantities. This permits the X server to present the data in the byte order that the client expects.

Note

> If you define further properties of complex type, you must encode and decode them yourself. These functions must be carefully written if they are to be portable. For further information about how to write a library extension, see appendix C.

The type of a property is defined by an atom, which allows for arbitrary extension in this type scheme.

Certain property names are predefined in the server for commonly used functions. The atoms for these properties are defined in **<X11/Xatom.h>**. To avoid name clashes with user symbols, the **#define** name for each atom has the XA_ prefix. For definitions of these properties, see section 4.3. For an explanation of the functions that let you get and set much of the information stored in these predefined properties, see chapter 9.

You can use properties to communicate other information between applications. The functions described in this section let you define new properties and get the unique atom IDs in your applications.

Although any particular atom can have some client interpretation within each of the name spaces, atoms occur in five distinct name spaces within the protocol:

- Selections
- Property names
- Property types
- Font properties
- Type of a **ClientMessage** event (none are built into the X server)

The built-in selection property names are:

PRIMARY
SECONDARY

The built-in property names are:

CUT_BUFFER0	RGB_GREEN_MAP
CUT_BUFFER1	RGB_RED_MAP
CUT_BUFFER2	RESOURCE_MANAGER
CUT_BUFFER3	WM_CLASS
CUT_BUFFER4	WM_CLIENT_MACHINE
CUT_BUFFER5	WM_COMMAND
CUT_BUFFER6	WM_HINTS

CUT_BUFFER7	WM_ICON_NAME
RGB_BEST_MAP	WM_ICON_SIZE
RGB_BLUE_MAP	WM_NAME
RGB_DEFAULT_MAP	WM_NORMAL_HINTS
RGB_GRAY_MAP	WM_ZOOM_HINTS
	WM_TRANSIENT_FOR

The built-in property types are:

ARC	POINT
ATOM	RGB_COLOR_MAP
BITMAP	RECTANGLE
CARDINAL	STRING
COLORMAP	VISUALID
CURSOR	WINDOW
DRAWABLE	WM_HINTS
FONT	WM_SIZE_HINTS
INTEGER	
PIXMAP	

The built-in font property names are:

MIN_SPACE	STRIKEOUT_DESCENT
NORM_SPACE	STRIKEOUT_ASCENT
MAX_SPACE	ITALIC_ANGLE
END_SPACE	X_HEIGHT
SUPERSCRIPT_X	QUAD_WIDTH
SUPERSCRIPT_Y	WEIGHT
SUBSCRIPT_X	POINT_SIZE
SUBSCRIPT_Y	RESOLUTION
UNDERLINE_POSITION	COPYRIGHT
UNDERLINE_THICKNESS	NOTICE
FONT_NAME	FAMILY_NAME
FULL_NAME	CAP_HEIGHT

For further information about font properties, see section 6.5.

To return an atom for a given name, use **XInternAtom**.

Atom XInternAtom(*display*, *atom_name*, *only_if_exists*)
    Display **display*;
    char **atom_name*;
    Bool *only_if_exists*;

display Specifies the connection to the X server.

atom_name Specifies the name associated with the atom you want returned.

only_if_exists Specifies a Boolean value that indicates whether **XInternAtom** creates the atom.

The **XInternAtom** function returns the atom identifier associated with the specified atom_name string. If only_if_exists is **False**, the atom is created if it does not exist. Therefore, **XInternAtom** can return **None**. You should use a null-terminated ISO Latin-1 string for atom_name. Case matters; the strings *thing*, *Thing*, and *thinG* all designate different atoms. The atom will remain defined even after the client's connection closes. It will become undefined only when the last connection to the X server closes.

XInternAtom can generate **BadAlloc** and **BadValue** errors.

To return a name for a given atom identifier, use **XGetAtomName**.

```
char *XGetAtomName(display, atom)
      Display *display;
      Atom atom;
```

display Specifies the connection to the X server.

atom Specifies the atom for the property name you want returned.

The **XGetAtomName** function returns the name associated with the specified atom. To free the resulting string, call **XFree**.

XGetAtomName can generate a **BadAtom** error.

4.3. Obtaining and Changing Window Properties

You can attach a property list to every window. Each property has a name, a type, and a value (see section 4.2). The value is an array of 8-bit, 16-bit, or 32-bit quantities, whose interpretation is left to the clients.

Xlib provides functions that you can use to obtain, change, update, or interchange window properties. In addition, Xlib provides other utility functions for predefined property operations (see chapter 9).

To obtain the type, format, and value of a property of a given window, use **XGetWindowProperty**.

```
int XGetWindowProperty(display, w, property, long_offset, long_length, delete, req_type,
                          actual_type_return, actual_format_return, nitems_return, bytes_after_return,
                          prop_return)
      Display *display;
      Window w;
      Atom property;
      long long_offset, long_length;
      Bool delete;
      Atom req_type;
      Atom *actual_type_return;
      int *actual_format_return;
      unsigned long *nitems_return;
      unsigned long *bytes_after_return;
      unsigned char **prop_return;
```

display Specifies the connection to the X server.

w Specifies the window whose property you want to obtain.

property Specifies the property name.

long_offset Specifies the offset in the specified property (in 32-bit quantities) where the data is to be retrieved.

long_length Specifies the length in 32-bit multiples of the data to be retrieved.

delete Specifies a Boolean value that determines whether the property is deleted.

req_type Specifies the atom identifier associated with the property type or **AnyPropertyType**.

actual_type_return
Returns the atom identifier that defines the actual type of the property.

actual_format_return
Returns the actual format of the property.

nitems_return Returns the actual number of 8-bit, 16-bit, or 32-bit items stored in the prop_return data.

bytes_after_return
Returns the number of bytes remaining to be read in the property if a partial read was performed.

prop_return Returns a pointer to the data in the specified format.

The **XGetWindowProperty** function returns the actual type of the property; the actual format of the property; the number of 8-bit, 16-bit, or 32-bit items transferred; the number of bytes remaining to be read in the property; and a pointer to the data actually returned. **XGetWindowProperty** sets the return arguments as follows:

- If the specified property does not exist for the specified window, **XGetWindowProperty** returns **None** to actual_type_return and the value zero to actual_format_return and bytes_after_return. The nitems_return argument is empty. In this case, the delete argument is ignored.
- If the specified property exists but its type does not match the specified type, **XGetWindowProperty** returns the actual property type to actual_type_return, the actual property format (never zero) to actual_format_return, and the property length in bytes (even if the actual_format_return is 16 or 32) to bytes_after_return. It also ignores the delete argument. The nitems_return argument is empty.
- If the specified property exists and either you assign **AnyPropertyType** to the req_type argument or the specified type matches the actual property type, **XGetWindowProperty** returns the actual property type to actual_type_return and the actual property format (never zero) to actual_format_return. It also returns a value to bytes_after_return and nitems_return, by defining the following values:

  N = actual length of the stored property in bytes
  (even if the format is 16 or 32)
  I = 4 * long_offset
  T = N - I
  L = MINIMUM(T, 4 * long_length)
  A = N - (I + L)

  The returned value starts at byte index I in the property (indexing from zero), and its length in bytes is L. If the value for long_offset causes L to be negative, a **BadValue** error results. The value of bytes_after_return is A, giving the number of trailing unread bytes in the stored property.

XGetWindowProperty always allocates one extra byte in prop_return (even if the property is zero length) and sets it to ASCII null so that simple properties consisting of characters do not have to be copied into yet another string before use. If delete is **True** and bytes_after_return is zero, **XGetWindowProperty** deletes the property from the window and generates a **PropertyNotify** event on the window.

The function returns **Success** if it executes successfully. To free the resulting data, use **XFree**.

XGetWindowProperty can generate **BadAtom**, **BadValue**, and **BadWindow** errors.

To obtain a given window's property list, use **XListProperties**.

```
Atom *XListProperties(display, w, num_prop_return)
      Display *display;
      Window w;
      int *num_prop_return;
```

display Specifies the connection to the X server.

w Specifies the window whose property list you want to obtain.

num_prop_return
Returns the length of the properties array.

The **XListProperties** function returns a pointer to an array of atom properties that are defined for the specified window or returns NULL if no properties were found. To free the memory allocated by this function, use **XFree**.

XListProperties can generate a **BadWindow** error.

To change a property of a given window, use **XChangeProperty**.

```
XChangeProperty(display, w, property, type, format, mode, data, nelements)
      Display *display;
      Window w;
      Atom property, type;
      int format;
      int mode;
      unsigned char *data;
      int nelements;
```

display Specifies the connection to the X server.

w Specifies the window whose property you want to change.

property Specifies the property name.

type Specifies the type of the property. The X server does not interpret the type but simply passes it back to an application that later calls **XGetWindowProperty**.

format Specifies whether the data should be viewed as a list of 8-bit, 16-bit, or 32-bit quantities. Possible values are 8, 16, and 32. This information allows the X server to correctly perform byte-swap operations as necessary. If the format is 16-bit or 32-bit, you must explicitly cast your data pointer to a (char *) in the call to **XChangeProperty**.

mode Specifies the mode of the operation. You can pass **PropModeReplace**, **PropModePrepend**, or **PropModeAppend**.

data Specifies the property data.

nelements Specifies the number of elements of the specified data format.

The **XChangeProperty** function alters the property for the specified window and causes the X server to generate a **PropertyNotify** event on that window. **XChangeProperty** performs the following:

- If mode is **PropModeReplace**, **XChangeProperty** discards the previous property value and stores the new data.
- If mode is **PropModePrepend** or **PropModeAppend**, **XChangeProperty** inserts the specified data before the beginning of the existing data or onto the end of the existing data, respectively. The type and format must match the existing property value, or a **BadMatch** error results. If the property is undefined, it is treated as defined with the correct type and format with zero-length data.

The lifetime of a property is not tied to the storing client. Properties remain until explicitly deleted, until the window is destroyed, or until the server resets. For a discussion of what happens when the connection to the X server is closed, see section 2.5. The maximum size of a property is server dependent and can vary dynamically depending on the amount of memory the server has available. (If there is insufficient space, a **BadAlloc** error results.)

XChangeProperty can generate **BadAlloc**, **BadAtom**, **BadMatch**, **BadValue**, and **BadWindow** errors.

To rotate a window's property list, use **XRotateWindowProperties**.

XRotateWindowProperties(*display, w, properties, num_prop, npositions*)
    Display **display*;
    Window *w*;
    Atom *properties*[];
    int *num_prop*;
    int *npositions*;

display Specifies the connection to the X server.

w Specifies the window.

properties Specifies the array of properties that are to be rotated.

num_prop Specifies the length of the properties array.

npositions Specifies the rotation amount.

The **XRotateWindowProperties** function allows you to rotate properties on a window and causes the X server to generate **PropertyNotify** events. If the property names in the properties array are viewed as being numbered starting from zero and if there are num_prop property names in the list, then the value associated with property name I becomes the value associated with property name (I + npositions) mod N for all I from zero to N – 1. The effect is to rotate the states by npositions places around the virtual ring of property names (right for positive npositions, left for negative npositions). If npositions mod N is nonzero, the X server generates a **PropertyNotify** event for each property in the order that they are listed in the array. If an atom occurs more than once in the list or no property with that name is defined for the window, a **BadMatch** error results. If a **BadAtom** or **BadMatch** error results, no properties are changed.

XRotateWindowProperties can generate **BadAtom**, **BadMatch**, and **BadWindow** errors.

To delete a property on a given window, use **XDeleteProperty**.

XDeleteProperty(*display, w, property*)
    Display **display*;
    Window *w*;
    Atom *property*;

display Specifies the connection to the X server.

w Specifies the window whose property you want to delete.

property Specifies the property name.

The **XDeleteProperty** function deletes the specified property only if the property was defined on the specified window and causes the X server to generate a **PropertyNotify** event on the window unless the property does not exist.

XDeleteProperty can generate **BadAtom** and **BadWindow** errors.

4.4. Selections

Selections are one method used by applications to exchange data. By using the property mechanism, applications can exchange data of arbitrary types and can negotiate the type of the data. A selection can be thought of as an indirect property with a dynamic type. That is, rather than having the property stored in the X server, the property is maintained by some client (the owner). A selection is global in nature (considered to belong to the user but be maintained by clients) rather than being private to a particular window subhierarchy or a particular set of clients.

Xlib provides functions that you can use to set, get, or request conversion of selections. This allows applications to implement the notion of current selection, which requires that notification be sent to applications when they no longer own the selection. Applications that support selection often highlight the current selection and so must be informed when another application has acquired the selection so that they can unhighlight the selection.

When a client asks for the contents of a selection, it specifies a selection target type. This target type can be used to control the transmitted representation of the contents. For example, if the selection is "the last thing the user clicked on" and that is currently an image, then the target type might specify whether the contents of the image should be sent in XY format or Z format.

The target type can also be used to control the class of contents transmitted, for example, asking for the "looks" (fonts, line spacing, indentation, and so forth) of a paragraph selection, not the text of the paragraph. The target type can also be used for other purposes. The protocol does not constrain the semantics.

To set the selection owner, use **XSetSelectionOwner**.

XSetSelectionOwner(*display*, *selection*, *owner*, *time*)
    Display **display*;
    Atom *selection*;
    Window *owner*;
    Time *time*;

display	Specifies the connection to the X server.
selection	Specifies the selection atom.
owner	Specifies the owner of the specified selection atom. You can pass a window or **None**.
time	Specifies the time. You can pass either a timestamp or **CurrentTime**.

The **XSetSelectionOwner** function changes the owner and last-change time for the specified selection and has no effect if the specified time is earlier than the current last-change time of the specified selection or is later than the current X server time. Otherwise, the last-change time is set to the specified time, with **CurrentTime** replaced by the current server time. If the owner window is specified as **None**, then the owner of the selection becomes **None** (that is, no owner). Otherwise, the owner of the selection becomes the client executing the request.

If the new owner (whether a client or **None**) is not the same as the current owner of the selection and the current owner is not **None**, the current owner is sent a **SelectionClear** event. If the client that is the owner of a selection is later terminated (that is, its connection is closed) or if the owner window it has specified in the request is later destroyed, the owner of the selection automatically reverts to **None**, but the last-change time is not affected. The selection atom is uninterpreted by the X server. **XGetSelectionOwner** returns the owner window, which is reported in **SelectionRequest** and **SelectionClear** events. Selections are global to the X server.

XSetSelectionOwner can generate **BadAtom** and **BadWindow** errors.

To return the selection owner, use **XGetSelectionOwner**.

```
Window XGetSelectionOwner(display, selection)
      Display *display;
      Atom selection;
```

display Specifies the connection to the X server.

selection Specifies the selection atom whose owner you want returned.

The **XGetSelectionOwner** function returns the window ID associated with the window that currently owns the specified selection. If no selection was specified, the function returns the constant **None**. If **None** is returned, there is no owner for the selection.

XGetSelectionOwner can generate a **BadAtom** error.

To request conversion of a selection, use **XConvertSelection**.

```
XConvertSelection(display, selection, target, property, requestor, time)
      Display *display;
      Atom selection, target;
      Atom property;
      Window requestor;
      Time time;
```

display Specifies the connection to the X server.

selection Specifies the selection atom.

target Specifies the target atom.

property Specifies the property name. You also can pass **None**.

requestor Specifies the requestor.

time Specifies the time. You can pass either a timestamp or **CurrentTime**.

XConvertSelection requests that the specified selection be converted to the specified target type:

- If the specified selection has an owner, the X server sends a **SelectionRequest** event to that owner.
- If no owner for the specified selection exists, the X server generates a **SelectionNotify** event to the requestor with property **None**.

In either event, the arguments are passed on unchanged. There are two predefined selection atoms: PRIMARY and SECONDARY.

XConvertSelection can generate **BadAtom** and **BadWindow** errors.

Chapter 5

Graphics Resource Functions

After you connect your program to the X server by calling **XOpenDisplay**, you can use the Xlib graphics resource functions to:

- Create, copy, and destroy colormaps
- Allocate, modify, and free color cells
- Read entries in a colormap
- Create and free pixmaps
- Create, copy, change, and destroy graphics contexts

A number of resources are used when performing graphics operations in X. Most information about performing graphics (for example, foreground color, background color, line style, and so on) are stored in resources called graphics contexts (GC). Most graphics operations (see chapter 6) take a GC as an argument. Although in theory it is possible to share GCs between applications, it is expected that applications will use their own GCs when performing operations. Sharing of GCs is highly discouraged because the library may cache GC state.

Each X window always has an associated colormap that provides a level of indirection between pixel values and colors displayed on the screen. Many of the hardware displays built today have a single colormap, so the primitives are written to encourage sharing of colormap entries between applications. Because colormaps are associated with windows, X will support displays with multiple colormaps and, indeed, different types of colormaps. If there are not sufficient colormap resources in the display, some windows may not be displayed in their true colors. A client or window manager can control which windows are displayed in their true colors if more than one colormap is required for the color resources the applications are using.

Off-screen memory or pixmaps are often used to define frequently used images for later use in graphics operations. Pixmaps are also used to define tiles or patterns for use as window backgrounds, borders, or cursors. A single bit-plane pixmap is sometimes referred to as a bitmap.

Note that some screens have very limited off-screen memory. Therefore, you should regard off-screen memory as a precious resource.

Graphics operations can be performed to either windows or pixmaps, which collectively are called drawables. Each drawable exists on a single screen and can only be used on that screen. GCs can also only be used with drawables of matching screens and depths.

5.1. Colormap Functions

Xlib provides functions that you can use to manipulate a colormap. This section discusses how to:

- Create, copy, and destroy a colormap
- Allocate, modify, and free color cells
- Read entries in a colormap

The following functions manipulate the representation of color on the screen. For each possible value that a pixel can take in a window, there is a color cell in the colormap. For example, if a window is 4 bits deep, pixel values 0 through 15 are defined. A colormap is a collection of color cells. A color cell consists of a triple of red, green, and blue.

As each pixel is read out of display memory, its value is taken and looked up in the colormap. The values of the cell determine what color is displayed on the screen. On a multiplane display with a black-and-white monitor (with grayscale but not color), these values can be combined to determine the brightness on the screen.

Screens always have a default colormap, and programs typically allocate cells out of this colormap. You should not write applications that monopolize color resources. On a screen that either cannot load the colormap or cannot have a fully independent colormap, only certain kinds of allocations may work. Depending on the hardware, one or more colormaps may be resident (installed) at one time. To install a colormap, use **XInstallColormap**. The **DefaultColormap** macro returns the default colormap. The **DefaultVisual** macro returns the default visual type for the specified screen. Colormaps are local to a particular screen. Possible visual types are **StaticGray**, **GrayScale**, **StaticColor**, **PseudoColor**, **TrueColor**, or **DirectColor** (see section 3.1).

The functions discussed in this section operate on an **XColor** structure, which contains:

```
typedef struct {
        unsigned long pixel;            /* pixel value */
        unsigned short red, green, blue;/* rgb values */
        char flags;                     /* DoRed, DoGreen, DoBlue */
        char pad;
} XColor;
```

The red, green, and blue values are scaled between 0 and 65535. On full in a color is a value of 65535 independent of the number of bits actually used in the display hardware. Half brightness in a color is a value of 32767, and off is 0. This representation gives uniform results for color values across different screens. In some functions, the flags member controls which of the red, green, and blue members is used and can be one or more of **DoRed**, **DoGreen**, and **DoBlue**.

The introduction of color changes the view a programmer should take when dealing with a bitmap display. For example, when printing text, you write a pixel value, which is defined as a specific color, rather than setting or clearing bits. Hardware will impose limits (the number of significant bits, for example) on these values. Typically, one allocates color cells or sets of color cells. If read-only, the pixel values for these colors can be shared among multiple applications, and the RGB values of the cell cannot be changed. If read/write, they are exclusively owned by the program, and the color cell associated with the pixel value may be changed at will.

5.1.1. Creating, Copying, and Destroying Colormaps

To create a colormap for a screen, use **XCreateColormap**.

Colormap XCreateColormap(*display*, *w*, *visual*, *alloc*)
    Display **display*;
    Window *w*;
    Visual **visual*;
    int *alloc*;

display Specifies the connection to the X server.

w Specifies the window on whose screen you want to create a colormap.

visual Specifies a pointer to a visual type supported on the screen. If the visual type is not one supported by the screen, a **BadMatch** error results.

alloc Specifies the colormap entries to be allocated. You can pass **AllocNone** or **AllocAll**.

The **XCreateColormap** function creates a colormap of the specified visual type for the screen on which the specified window resides and returns the colormap ID associated with it. Note that the specified window is only used to determine the screen.

The initial values of the colormap entries are undefined for the visual classes **GrayScale**, **PseudoColor**, and **DirectColor**. For **StaticGray**, **StaticColor**, and **TrueColor**, the entries have defined values, but those values are specific to the visual and are not defined by X. For **StaticGray**, **StaticColor**, and **TrueColor**, alloc must be **AllocNone**, or a **BadMatch** error results. For the other visual classes, if alloc is **AllocNone**, the colormap initially has no allocated entries, and clients can allocate them. For information about the visual types, see section 3.1.

If alloc is **AllocAll**, the entire colormap is allocated writable. The initial values of all allocated entries are undefined. For **GrayScale** and **PseudoColor**, the effect is as if an **XAllocColorCells** call returned all pixel values from zero to N – 1, where N is the colormap entries value in the specified visual. For **DirectColor**, the effect is as if an **XAllocColorPlanes** call returned a pixel value of zero and red_mask, green_mask, and blue_mask values containing the same bits as the corresponding masks in the specified visual. However, in all cases, none of these entries can be freed by using **XFreeColors**.

XCreateColormap can generate **BadAlloc**, **BadMatch**, **BadValue**, and **BadWindow** errors.

To create a new colormap when the allocation out of a previously shared colormap has failed because of resource exhaustion, use **XCopyColormapAndFree**.

```
Colormap XCopyColormapAndFree(display, colormap)
      Display *display;
      Colormap colormap;
```

display Specifies the connection to the X server.

colormap Specifies the colormap.

The **XCopyColormapAndFree** function creates a colormap of the same visual type and for the same screen as the specified colormap and returns the new colormap ID. It also moves all of the client's existing allocation from the specified colormap to the new colormap with their color values intact and their read-only or writable characteristics intact and frees those entries in the specified colormap. Color values in other entries in the new colormap are undefined. If the specified colormap was created by the client with alloc set to **AllocAll**, the new colormap is also created with **AllocAll**, all color values for all entries are copied from the specified colormap, and then all entries in the specified colormap are freed. If the specified colormap was not created by the client with **AllocAll**, the allocations to be moved are all those pixels and planes that have been allocated by the client using **XAllocColor**, **XAllocNamedColor**, **XAllocColorCells**, or **XAllocColorPlanes** and that have not been freed since they were allocated.

XCopyColormapAndFree can generate **BadAlloc** and **BadColor** errors.

To set the colormap of a given window, use **XSetWindowColormap**.

```
XSetWindowColormap(display, w, colormap)
      Display *display;
      Window w;
      Colormap colormap;
```

display Specifies the connection to the X server.

w Specifies the window.

colormap. Specifies the colormap.

The **XSetWindowColormap** function sets the specified colormap of the specified window. The colormap must have the same visual type as the window, or a **BadMatch** error results.

XSetWindowColormap can generate **BadColor**, **BadMatch**, and **BadWindow** errors.

To destroy a colormap, use **XFreeColormap**.

XFreeColormap(*display, colormap*)
    Display **display*;
    Colormap *colormap*;

display Specifies the connection to the X server.

colormap Specifies the colormap that you want to destroy.

The **XFreeColormap** function deletes the association between the colormap resource ID and the colormap and frees the colormap storage. However, this function has no effect on the default colormap for a screen. If the specified colormap is an installed map for a screen, it is uninstalled (see **XUninstallColormap**). If the specified colormap is defined as the colormap for a window (by **XCreateWindow**, **XSetWindowColormap**, or **XChangeWindowAttributes**), **XFreeColormap** changes the colormap associated with the window to **None** and generates a **ColormapNotify** event. X does not define the colors displayed for a window with a colormap of **None**.

XFreeColormap can generate a **BadColor** error.

5.1.2. Allocating, Modifying, and Freeing Color Cells

There are two ways of allocating color cells: explicitly as read-only entries by pixel value or read/write, where you can allocate a number of color cells and planes simultaneously. The read/write cells you allocate do not have defined colors until set with **XStoreColor** or **XStoreColors**.

To determine the color names, the X server uses a color database. Although you can change the values in a read/write color cell that is allocated by another application, this is considered "antisocial" behavior.

To allocate a read-only color cell, use **XAllocColor**.

Status XAllocColor(*display, colormap, screen_in_out*)
    Display **display*;
    Colormap *colormap*;
    XColor **screen_in_out*;

display Specifies the connection to the X server.

colormap Specifies the colormap.

screen_in_out Specifies and returns the values actually used in the colormap.

The **XAllocColor** function allocates a read-only colormap entry corresponding to the closest RGB values supported by the hardware. **XAllocColor** returns the pixel value of the color closest to the specified RGB elements supported by the hardware and returns the RGB values actually used. The corresponding colormap cell is read-only. In addition, **XAllocColor** returns nonzero if it succeeded or zero if it failed. Read-only colormap cells are shared among clients. When the last client deallocates a shared cell, it is deallocated. **XAllocColor** does not use or affect the flags in the **XColor** structure.

XAllocColor can generate a **BadColor** error.

To allocate a read-only color cell by name and return the closest color supported by the hardware, use **XAllocNamedColor**.

```
Status XAllocNamedColor(display, colormap, color_name, screen_def_return, exact_def_return)
      Display *display;
      Colormap colormap;
      char *color_name;
      XColor *screen_def_return, *exact_def_return;
```

display Specifies the connection to the X server.

colormap Specifies the colormap.

color_name Specifies the color name string (for example, red) whose color definition structure you want returned.

screen_def_return
Returns the closest RGB values provided by the hardware.

exact_def_return
Returns the exact RGB values.

The **XAllocNamedColor** function looks up the named color with respect to the screen that is associated with the specified colormap. It returns both the exact database definition and the closest color supported by the screen. The allocated color cell is read-only. You should use the ISO Latin-1 encoding; uppercase and lowercase do not matter.

XAllocNamedColor can generate a **BadColor** error.

To look up the name of a color, use **XLookupColor**.

```
Status XLookupColor(display, colormap, color_name, exact_def_return, screen_def_return)
      Display *display;
      Colormap colormap;
      char *color_name;
      XColor *exact_def_return, *screen_def_return;
```

display Specifies the connection to the X server.

colormap Specifies the colormap.

color_name Specifies the color name string (for example, red) whose color definition structure you want returned.

exact_def_return
Returns the exact RGB values.

screen_def_return
Returns the closest RGB values provided by the hardware.

The **XLookupColor** function looks up the string name of a color with respect to the screen associated with the specified colormap. It returns both the exact color values and the closest values provided by the screen with respect to the visual type of the specified colormap. You should use the ISO Latin-1 encoding; uppercase and lowercase do not matter. **XLookupColor** returns nonzero if the name existed in the color database or zero if it did not exist.

To allocate read/write color cell and color plane combinations for a **PseudoColor** model, use **XAllocColorCells**.

Status XAllocColorCells(*display, colormap, contig, plane_masks_return, nplanes,*
pixels_return, npixels)
Display **display*;
Colormap *colormap*;
Bool *contig*;
unsigned long *plane_masks_return*[ ];
unsigned int *nplanes*;
unsigned long *pixels_return*[ ];
unsigned int *npixels*;

display Specifies the connection to the X server.

colormap Specifies the colormap.

contig Specifies a Boolean value that indicates whether the planes must be contiguous.

plane_mask_return
Returns an array of plane masks.

nplanes Specifies the number of plane masks that are to be returned in the plane masks array.

pixels_return Returns an array of pixel values.

npixels Specifies the number of pixel values that are to be returned in the pixels_return array.

The **XAllocColorCells** function allocates read/write color cells. The number of colors must be positive and the number of planes nonnegative, or a **BadValue** error results. If ncolors and nplanes are requested, then ncolors pixels and nplane plane masks are returned. No mask will have any bits set to 1 in common with any other mask or with any of the pixels. By ORing together each pixel with zero or more masks, ncolors * $2^{nplanes}$ distinct pixels can be produced. All of these are allocated writable by the request. For **GrayScale** or **PseudoColor**, each mask has exactly one bit set to 1. For **DirectColor**, each has exactly three bits set to 1. If contig is **True** and if all masks are ORed together, a single contiguous set of bits set to 1 will be formed for **GrayScale** or **PseudoColor** and three contiguous sets of bits set to 1 (one within each pixel subfield) for **DirectColor**. The RGB values of the allocated entries are undefined. **XAllocColorCells** returns nonzero if it succeeded or zero if it failed.

XAllocColorCells can generate **BadColor** and **BadValue** errors.

To allocate read/write color resources for a **DirectColor** model, use **XAllocColorPlanes**.

Status XAllocColorPlanes(*display, colormap, contig, pixels_return, ncolors, nreds, ngreens,*
nblues, rmask_return, gmask_return, bmask_return)
Display **display*;
Colormap *colormap*;
Bool *contig*;
unsigned long *pixels_return*[ ];
int *ncolors*;
int *nreds*, *ngreens*, *nblues*;
unsigned long **rmask_return*, **gmask_return*, **bmask_return*;

display Specifies the connection to the X server.

colormap Specifies the colormap.

contig Specifies a Boolean value that indicates whether the planes must be contiguous.

pixels_return Returns an array of pixel values. **XAllocColorPlanes** returns the pixel values in this array.

ncolors Specifies the number of pixel values that are to be returned in the pixels_return array.

nreds
ngreens
nblues
Specify the number of red, green, and blue planes. The value you pass must be nonnegative.

rmask_return
gmask_return
bmask_return Return bit masks for the red, green, and blue planes.

The specified ncolors must be positive; and nreds, ngreens, and nblues must be nonnegative, or a **BadValue** error results. If ncolors colors, nreds reds, ngreens greens, and nblues blues are requested, ncolors pixels are returned; and the masks have nreds, ngreens, and nblues bits set to 1, respectively. If contig is **True**, each mask will have a contiguous set of bits set to 1. No mask will have any bits set to 1 in common with any other mask or with any of the pixels. For **DirectColor**, each mask will lie within the corresponding pixel subfield. By ORing together subsets of masks with each pixel value, ncolors * $2^{(nreds+ngreens+nblues)}$ distinct pixel values can be produced. All of these are allocated by the request. However, in the colormap, there are only ncolors * 2^{nreds} independent red entries, ncolors * $2^{ngreens}$ independent green entries, and ncolors * 2^{nblues} independent blue entries. This is true even for **PseudoColor**. When the colormap entry of a pixel value is changed (using **XStoreColors**, **XStoreColor**, or **XStoreNamedColor**), the pixel is decomposed according to the masks, and the corresponding independent entries are updated. **XAllocColorPlanes** returns nonzero if it succeeded or zero if it failed.

XAllocColorPlanes can generate **BadColor** and **BadValue** errors.

To store RGB values into colormap cells, use **XStoreColors**.

```
XStoreColors(display, colormap, color, ncolors)
      Display *display;
      Colormap colormap;
      XColor color[];
      int ncolors;
```

display Specifies the connection to the X server.

colormap Specifies the colormap.

color Specifies an array of color definition structures to be stored.

ncolors Specifies the number of **XColor** structures in the color definition array.

The **XStoreColors** function changes the colormap entries of the pixel values specified in the pixel members of the **XColor** structures. You specify which color components are to be changed by setting **DoRed**, **DoGreen**, and/or **DoBlue** in the flags member of the **XColor** structures. If the colormap is an installed map for its screen, the changes are visible immediately. **XStoreColors** changes the specified pixels if they are allocated writable in the colormap by any client, even if one or more pixels generates an error. If a specified pixel is not a valid index into the colormap, a **BadValue** error results. If a specified pixel either is unallocated or is allocated read-only, a **BadAccess** error results. If more than one pixel is in error, the one that gets reported is arbitrary.

XStoreColors can generate **BadAccess**, **BadColor**, and **BadValue** errors.

To store an RGB value in a single colormap cell, use **XStoreColor**.

```
XStoreColor(display, colormap, color)
      Display *display;
      Colormap colormap;
      XColor *color;
```

display Specifies the connection to the X server.

colormap Specifies the colormap.

color Specifies the pixel and RGB values.

The **XStoreColor** function changes the colormap entry of the pixel value specified in the pixel member of the **XColor** structure. You specified this value in the pixel member of the **XColor** structure. This pixel value must be a read/write cell and a valid index into the colormap. If a specified pixel is not a valid index into the colormap, a **BadValue** error results. **XStoreColor** also changes the red, green, and/or blue color components. You specify which color components are to be changed by setting **DoRed**, **DoGreen**, and/or **DoBlue** in the flags member of the **XColor** structure. If the colormap is an installed map for its screen, the changes are visible immediately.

XStoreColor can generate **BadAccess**, **BadColor**, and **BadValue** errors.

To set the color of a pixel to a named color, use **XStoreNamedColor**.

```
XStoreNamedColor(display, colormap, color, pixel, flags)
      Display *display;
      Colormap colormap;
      char *color;
      unsigned long pixel;
      int flags;
```

display Specifies the connection to the X server.

colormap Specifies the colormap.

color Specifies the color name string (for example, red).

pixel Specifies the entry in the colormap.

flags Specifies which red, green, and blue components are set.

The **XStoreNamedColor** function looks up the named color with respect to the screen associated with the colormap and stores the result in the specified colormap. The pixel argument determines the entry in the colormap. The flags argument determines which of the red, green, and blue components are set. You can set this member to the bitwise inclusive OR of the bits **DoRed**, **DoGreen**, and **DoBlue**. If the specified pixel is not a valid index into the colormap, a **BadValue** error results. If the specified pixel either is unallocated or is allocated read-only, a **BadAccess** error results. You should use the ISO Latin-1 encoding; uppercase and lowercase do not matter.

XStoreNamedColor can generate **BadAccess**, **BadColor**, **BadName**, and **BadValue** errors.

To free colormap cells, use **XFreeColors**.

```
XFreeColors(display, colormap, pixels, npixels, planes)
      Display *display;
      Colormap colormap;
      unsigned long pixels[];
      int npixels;
      unsigned long planes;
```

display Specifies the connection to the X server.

colormap Specifies the colormap.

pixels Specifies an array of pixel values that map to the cells in the specified colormap.

npixels Specifies the number of pixels.

planes Specifies the planes you want to free.

The **XFreeColors** function frees the cells represented by pixels whose values are in the pixels array. The planes argument should not have any bits set to 1 in common with any of the pixels. The set of all pixels is produced by ORing together subsets of the planes argument with the pixels. The request frees all of these pixels that were allocated by the client (using **XAllocColor**, **XAllocNamedColor**, **XAllocColorCells**, and **XAllocColorPlanes**). Note that freeing an individual pixel obtained from **XAllocColorPlanes** may not actually allow it to be reused until all of its related pixels are also freed.

All specified pixels that are allocated by the client in the colormap are freed, even if one or more pixels produce an error. If a specified pixel is not a valid index into the colormap, a **BadValue** error results. If a specified pixel is not allocated by the client (that is, is unallocated or is only allocated by another client), a **BadAccess** error results. If more than one pixel is in error, the one that gets reported is arbitrary.

XFreeColors can generate **BadAccess**, **BadColor**, and **BadValue** errors.

5.1.3. Reading Entries in a Colormap

The **XQueryColor** and **XQueryColors** functions return the RGB values stored in the specified colormap for the pixel value you pass in the pixel member of the **XColor** structure(s). The values returned for an unallocated entry are undefined. These functions also set the flags member in the **XColor** structure to all three colors. If a pixel is not a valid index into the specified colormap, a **BadValue** error results. If more than one pixel is in error, the one that gets reported is arbitrary.

To query the RGB values of a single specified pixel value, use **XQueryColor**.

```
XQueryColor(display, colormap, def_in_out)
      Display *display;
      Colormap colormap;
      XColor *def_in_out;
```

display Specifies the connection to the X server.

colormap Specifies the colormap.

def_in_out Specifies and returns the RGB values for the pixel specified in the structure.

The **XQueryColor** function returns the RGB values for each pixel in the **XColor** structures and sets the **DoRed**, **DoGreen**, and **DoBlue** flags.

XQueryColor can generate **BadColor** and **BadValue** errors.

To query the RGB values of an array of pixels stored in color structures, use **XQueryColors**.

```
XQueryColors(display, colormap, defs_in_out, ncolors)
      Display *display;
      Colormap colormap;
      XColor defs_in_out[];
      int ncolors;
```

display Specifies the connection to the X server.

colormap Specifies the colormap.

defs_in_out Specifies and returns an array of color definition structures for the pixel specified in the structure.

ncolors Specifies the number of **XColor** structures in the color definition array.

The **XQueryColors** function returns the RGB values for each pixel in the **XColor** structures and sets the **DoRed**, **DoGreen**, and **DoBlue** flags.

XQueryColors can generate **BadColor** and **BadValue** errors.

5.2. Creating and Freeing Pixmaps

Pixmaps can only be used on the screen on which they were created. Pixmaps are off-screen resources that are used for various operations, for example, defining cursors as tiling patterns or as the source for certain raster operations. Most graphics requests can operate either on a window or on a pixmap. A bitmap is a single bit-plane pixmap.

To create a pixmap of a given size, use **XCreatePixmap**.

```
Pixmap XCreatePixmap(display, d, width, height, depth)
      Display *display;
      Drawable d;
      unsigned int width, height;
      unsigned int depth;
```

display Specifies the connection to the X server.

d Specifies which screen the pixmap is created on.

width
height Specify the width and height, which define the dimensions of the pixmap.

depth Specifies the depth of the pixmap.

The **XCreatePixmap** function creates a pixmap of the width, height, and depth you specified and returns a pixmap ID that identifies it. It is valid to pass an **InputOnly** window to the drawable argument. The width and height arguments must be nonzero, or a **BadValue** error results. The depth argument must be one of the depths supported by the screen of the specified drawable, or a **BadValue** error results.

The server uses the specified drawable to determine on which screen to create the pixmap. The pixmap can be used only on this screen and only with other drawables of the same depth (see **XCopyPlane** for an exception to this rule). The initial contents of the pixmap are undefined.

XCreatePixmap can generate **BadAlloc**, **BadDrawable**, and **BadValue** errors.

To free all storage associated with a specified pixmap, use **XFreePixmap**.

```
XFreePixmap(display, pixmap)
      Display *display;
      Pixmap pixmap;
```

display Specifies the connection to the X server.

pixmap Specifies the pixmap.

The **XFreePixmap** function first deletes the association between the pixmap ID and the pixmap. Then, the X server frees the pixmap storage when there are no references to it. The pixmap should never be referenced again.

XFreePixmap can generate a **BadPixmap** error.

5.3. Manipulating Graphics Context/State

Most attributes of graphics operations are stored in Graphic Contexts (GCs). These include line width, line style, plane mask, foreground, background, tile, stipple, clipping region, end style, join style, and so on. Graphics operations (for example, drawing lines) use these values to determine the actual drawing operation. Extensions to X may add additional components to GCs. The contents of a GC are private to Xlib.

Xlib implements a write-back cache for all elements of a GC that are not resource IDs to allow Xlib to implement the transparent coalescing of changes to GCs. For example, a call to **XSetForeground** of a GC followed by a call to **XSetLineAttributes** results in only a single-change GC protocol request to the server. GCs are neither expected nor encouraged to be shared between client applications, so this write-back caching should present no problems. Applications cannot share GCs without external synchronization. Therefore, sharing GCs between applications is highly discouraged.

To set an attribute of a GC, set the appropriate member of the **XGCValues** structure and OR in the corresponding value bitmask in your subsequent calls to **XCreateGC**. The symbols for the value mask bits and the **XGCValues** structure are:

```
/* GC attribute value mask bits */

#define   GCFunction              (1L<<0)
#define   GCPlaneMask             (1L<<1)
#define   GCForeground            (1L<<2)
#define   GCBackground            (1L<<3)
#define   GCLineWidth             (1L<<4)
#define   GCLineStyle             (1L<<5)
#define   GCCapStyle              (1L<<6)
#define   GCJoinStyle             (1L<<7)
#define   GCFillStyle             (1L<<8)
#define   GCFillRule              (1L<<9)
#define   GCTile                  (1L<<10)
#define   GCStipple               (1L<<11)
#define   GCTileStipXOrigin       (1L<<12)
#define   GCTileStipYOrigin       (1L<<13)
#define   GCFont                  (1L<<14)
#define   GCSubwindowMode         (1L<<15)
#define   GCGraphicsExposures     (1L<<16)
#define   GCClipXOrigin           (1L<<17)
#define   GCClipYOrigin           (1L<<18)
#define   GCClipMask              (1L<<19)
#define   GCDashOffset            (1L<<20)
#define   GCDashList              (1L<<21)
#define   GCArcMode               (1L<<22)

/* Values */

typedef struct {
        int function;                  /* logical operation */
        unsigned long plane_mask;      /* plane mask */
        unsigned long foreground;      /* foreground pixel */
```

```
	unsigned long background;	/* background pixel */
	int line_width;	/* line width (in pixels) */
	int line_style;	/* LineSolid, LineOnOffDash, LineDoubleDash */
	int cap_style;	/* CapNotLast, CapButt, CapRound, CapProjecting */
	int join_style;	/* JoinMiter, JoinRound, JoinBevel */
	int fill_style;	/* FillSolid, FillTiled, FillStippled FillOpaqueStippled*/
	int fill_rule;	/* EvenOddRule, WindingRule */
	int arc_mode;	/* ArcChord, ArcPieSlice */
	Pixmap tile;	/* tile pixmap for tiling operations */
	Pixmap stipple;	/* stipple 1 plane pixmap for stippling */
	int ts_x_origin;	/* offset for tile or stipple operations */
	int ts_y_origin;
	Font font;	/* default text font for text operations */
	int subwindow_mode;	/* ClipByChildren, IncludeInferiors */
	Bool graphics_exposures;	/* boolean, should exposures be generated */
	int clip_x_origin;	/* origin for clipping */
	int clip_y_origin;
	Pixmap clip_mask;	/* bitmap clipping; other calls for rects */
	int dash_offset;	/* patterned/dashed line information */
	char dashes;
} XGCValues;
```

The default GC values are:

Component	Default
function	**GXcopy**
plane_mask	All ones
foreground	0
background	1
line_width	0
line_style	**LineSolid**
cap_style	**CapButt**
join_style	**JoinMiter**
fill_style	**FillSolid**
fill_rule	**EvenOddRule**
arc_mode	**ArcPieSlice**
tile	Pixmap of unspecified size filled with foreground pixel (that is, client specified pixel if any, else 0) (subsequent changes to foreground do not affect this pixmap)
stipple	Pixmap of unspecified size filled with ones
ts_x_origin	0
ts_y_origin	0
font	<implementation dependent>
subwindow_mode	**ClipByChildren**
graphics_exposures	**True**
clip_x_origin	0
clip_y_origin	0
clip_mask	**None**
dash_offset	0
dashes	4 (that is, the list [4, 4])

Note that foreground and background are not set to any values likely to be useful in a window.

The function attributes of a GC are used when you update a section of a drawable (the destination) with bits from somewhere else (the source). The function in a GC defines how the new destination bits are to be computed from the source bits and the old destination bits. **GXcopy** is typically the most useful because it will work on a color display, but special applications may use other functions, particularly in concert with particular planes of a color display. The 16 GC functions, defined in <**X11/X.h**>, are:

Function Name	Hex Code	Operation
GXclear	0x0	0
GXand	0x1	src AND dst
GXandReverse	0x2	src AND NOT dst
GXcopy	0x3	src
GXandInverted	0x4	(NOT src) AND dst
GXnoop	0x5	dst
GXxor	0x6	src XOR dst
GXor	0x7	src OR dst
GXnor	0x8	(NOT src) AND (NOT dst)
GXequiv	0x9	(NOT src) XOR dst
GXinvert	0xa	NOT dst
GXorReverse	0xb	src OR (NOT dst)
GXcopyInverted	0xc	NOT src
GXorInverted	0xd	(NOT src) OR dst
GXnand	0xe	(NOT src) OR (NOT dst)
GXset	0xf	1

Many graphics operations depend on either pixel values or planes in a GC. The planes attribute is of type long, and it specifies which planes of the destination are to be modified, one bit per plane. A monochrome display has only one plane and will be the least-significant bit of the word. As planes are added to the display hardware, they will occupy more significant bits in the plane mask.

In graphics operations, given a source and destination pixel, the result is computed bitwise on corresponding bits of the pixels. That is, a Boolean operation is performed in each bit plane. The plane_mask restricts the operation to a subset of planes. A macro constant **AllPlanes** can be used to refer to all planes of the screen simultaneously. The result is computed by the following:

((src FUNC dst) AND plane-mask) OR (dst AND (NOT plane-mask))

Range checking is not performed on the values for foreground, background, or plane_mask. They are simply truncated to the appropriate number of bits. The line-width is measured in pixels and either can be greater than or equal to one (wide line) or can be the special value zero (thin line).

Wide lines are drawn centered on the path described by the graphics request. Unless otherwise specified by the join-style or cap-style, the bounding box of a wide line with endpoints [x1, y1], [x2, y2] and width w is a rectangle with vertices at the following real coordinates:

[x1-(w*sn/2), y1+(w*cs/2)], [x1+(w*sn/2), y1-(w*cs/2)],
[x2-(w*sn/2), y2+(w*cs/2)], [x2+(w*sn/2), y2-(w*cs/2)]

Here sn is the sine of the angle of the line, and cs is the cosine of the angle of the line. A pixel is part of the line and so is drawn if the center of the pixel is fully inside the bounding box (which is viewed as having infinitely thin edges). If the center of the pixel is exactly on the bounding box, it is part of the line if and only if the interior is immediately to its right (x increasing direction). Pixels with centers on a horizontal edge are a special case and are part of the line if and only if the interior or the boundary is immediately below (y increasing direction) and the interior or the boundary is immediately to the right (x increasing direction).

Thin lines (zero line-width) are one-pixel-wide lines drawn using an unspecified, device-dependent algorithm. There are only two constraints on this algorithm.

1. If a line is drawn unclipped from [x1,y1] to [x2,y2] and if another line is drawn unclipped from [x1+dx,y1+dy] to [x2+dx,y2+dy], a point [x,y] is touched by drawing the first line if and only if the point [x+dx,y+dy] is touched by drawing the second line.
2. The effective set of points comprising a line cannot be affected by clipping. That is, a point is touched in a clipped line if and only if the point lies inside the clipping region and the point would be touched by the line when drawn unclipped.

A wide line drawn from [x1,y1] to [x2,y2] always draws the same pixels as a wide line drawn from [x2,y2] to [x1,y1], not counting cap-style and join-style. It is recommended that this property be true for thin lines, but this is not required. A line-width of zero may differ from a line-width of one in which pixels are drawn. This permits the use of many manufacturers' line drawing hardware, which may run many times faster than the more precisely specified wide lines.

In general, drawing a thin line will be faster than drawing a wide line of width one. However, because of their different drawing algorithms, thin lines may not mix well aesthetically with wide lines. If it is desirable to obtain precise and uniform results across all displays, a client should always use a line-width of one rather than a line-width of zero.

The line-style defines which sections of a line are drawn:

LineSolid	The full path of the line is drawn.
LineDoubleDash	The full path of the line is drawn, but the even dashes are filled differently than the odd dashes (see fill-style) with **CapButt** style used where even and odd dashes meet.
LineOnOffDash	Only the even dashes are drawn, and cap-style applies to all internal ends of the individual dashes, except **CapNotLast** is treated as **CapButt**.

The cap-style defines how the endpoints of a path are drawn:

CapNotLast	This is equivalent to **CapButt** except that for a line-width of zero the final endpoint is not drawn.
CapButt	The line is square at the endpoint (perpendicular to the slope of the line) with no projection beyond.
CapRound	The line has a circular arc with the diameter equal to the line-width, centered on the endpoint. (This is equivalent to **CapButt** for line-width of zero).
CapProjecting	The line is square at the end, but the path continues beyond the endpoint for a distance equal to half the line-width. (This is equivalent to **CapButt** for line-width of zero).

The join-style defines how corners are drawn for wide lines:

JoinMiter	The outer edges of two lines extend to meet at an angle. However, if the angle is less than 11 degrees, then a **JoinBevel** join-style is used instead.
JoinRound	The corner is a circular arc with the diameter equal to the line-width, centered on the joinpoint.
JoinBevel	The corner has **CapButt** endpoint styles with the triangular notch filled.

For a line with coincident endpoints (x1=x2, y1=y2), when the cap-style is applied to both endpoints, the semantics depends on the line-width and the cap-style:

CapNotLast	thin	The results are device-dependent, but the desired effect is that nothing is drawn.
CapButt	thin	The results are device-dependent, but the desired effect is that a single pixel is drawn.
CapRound	thin	The results are the same as for **CapButt**/thin.
CapProjecting	thin	The results are the same as for **Butt**/thin.
CapButt	wide	Nothing is drawn.
CapRound	wide	The closed path is a circle, centered at the endpoint, and with the diameter equal to the line-width.
CapProjecting	wide	The closed path is a square, aligned with the coordinate axes, centered at the endpoint, and with the sides equal to the line-width.

For a line with coincident endpoints (x1=x2, y1=y2), when the join-style is applied at one or both endpoints, the effect is as if the line was removed from the overall path. However, if the total path consists of or is reduced to a single point joined with itself, the effect is the same as when the cap-style is applied at both endpoints.

The tile/stipple and clip origins are interpreted relative to the origin of whatever destination drawable is specified in a graphics request. The tile pixmap must have the same root and depth as the GC, or a **BadMatch** error results. The stipple pixmap must have depth one and must have the same root as the GC, or a **BadMatch** error results. For stipple operations where the fill-style is **FillStippled** but not **FillOpaqueStippled**, the stipple pattern is tiled in a single plane and acts as an additional clip mask to be ANDed with the clip-mask. Although some sizes may be faster to use than others, any size pixmap can be used for tiling or stippling.

The fill-style defines the contents of the source for line, text, and fill requests. For all text and fill requests (for example, **XDrawText**, **XDrawText16**, **XFillRectangle**, **XFillPolygon**, and **XFillArc**); for line requests with line-style **LineSolid** (for example, **XDrawLine**, **XDrawSegments**, **XDrawRectangle**, **XDrawArc**); and for the even dashes for line requests with line-style **LineOnOffDash** or **LineDoubleDash**, the following apply:

FillSolid	Foreground
FillTiled	Tile
FillOpaqueStippled	A tile with the same width and height as stipple, but with background everywhere stipple has a zero and with foreground everywhere stipple has a one
FillStippled	Foreground masked by stipple

When drawing lines with line-style **LineDoubleDash**, the odd dashes are controlled by the fill-style in the following manner:

FillSolid	Background
FillTiled	Same as for even dashes
FillOpaqueStippled	Same as for even dashes
FillStippled	Background masked by stipple

Storing a pixmap in a GC might or might not result in a copy being made. If the pixmap is later used as the destination for a graphics request, the change might or might not be reflected in the GC. If the pixmap is used simultaneously in a graphics request both as a destination and as a tile or stipple, the results are undefined.

For optimum performance, you should draw as much as possible with the same GC (without changing its components). The costs of changing GC components relative to using different GCs depend upon the display hardware and the server implementation. It is quite likely that some amount of GC information will be cached in display hardware and that such hardware can only cache a small number of GCs.

The dashes value is actually a simplified form of the more general patterns that can be set with **XSetDashes**. Specifying a value of N is equivalent to specifying the two-element list [N, N] in **XSetDashes**. The value must be nonzero, or a **BadValue** error results.

The clip-mask restricts writes to the destination drawable. If the clip-mask is set to a pixmap, it must have depth one and have the same root as the GC, or a **BadMatch** error results. If clip-mask is set to **None**, the pixels are always drawn regardless of the clip origin. The clip-mask also can be set by calling the **XSetClipRectangles** or **XSetRegion** functions. Only pixels where the clip-mask has a bit set to 1 are drawn. Pixels are not drawn outside the area covered by the clip-mask or where the clip-mask has a bit set to 0. The clip-mask affects all graphics requests. The clip-mask does not clip sources. The clip-mask origin is interpreted relative to the origin of whatever destination drawable is specified in a graphics request.

You can set the subwindow-mode to **ClipByChildren** or **IncludeInferiors**. For **ClipByChildren**, both source and destination windows are additionally clipped by all viewable **InputOutput** children. For **IncludeInferiors**, neither source nor destination window is clipped by inferiors. This will result in including subwindow contents in the source and drawing through subwindow boundaries of the destination. The use of **IncludeInferiors** on a window of one depth with mapped inferiors of differing depth is not illegal, but the semantics are undefined by the core protocol.

The fill-rule defines what pixels are inside (drawn) for paths given in **XFillPolygon** requests and can be set to **EvenOddRule** or **WindingRule**. For **EvenOddRule**, a point is inside if an infinite ray with the point as origin crosses the path an odd number of times. For **WindingRule**, a point is inside if an infinite ray with the point as origin crosses an unequal number of clockwise and counterclockwise directed path segments. A clockwise directed path segment is one that crosses the ray from left to right as observed from the point. A counterclockwise segment is one that crosses the ray from right to left as observed from the point. The case where a directed line segment is coincident with the ray is uninteresting because you can simply choose a different ray that is not coincident with a segment.

For both **EvenOddRule** and **WindingRule**, a point is infinitely small, and the path is an infinitely thin line. A pixel is inside if the center point of the pixel is inside and the center point is not on the boundary. If the center point is on the boundary, the pixel is inside if and only if the polygon interior is immediately to its right (x increasing direction). Pixels with centers on a horizontal edge are a special case and are inside if and only if the polygon interior is immediately below (y increasing direction).

The arc-mode controls filling in the **XFillArcs** function and can be set to **ArcPieSlice** or **ArcChord**. For **ArcPieSlice**, the arcs are pie-slice filled. For **ArcChord**, the arcs are chord filled.

The graphics-exposure flag controls **GraphicsExpose** event generation for **XCopyArea** and **XCopyPlane** requests (and any similar requests defined by extensions).

To create a new GC that is usable on a given screen with a depth of drawable, use **XCreateGC**.

```
GC XCreateGC(display, d, valuemask, values)
      Display *display;
      Drawable d;
      unsigned long valuemask;
      XGCValues *values;
```

display Specifies the connection to the X server.

d Specifies the drawable.

valuemask Specifies which components in the GC are to be set using the information in the specified values structure. This argument is the bitwise inclusive OR of one or more of the valid GC component mask bits.

values Specifies any values as specified by the valuemask.

The **XCreateGC** function creates a graphics context and returns a GC. The GC can be used with any destination drawable having the same root and depth as the specified drawable. Use with other drawables results in a **BadMatch** error.

XCreateGC can generate **BadAlloc**, **BadDrawable**, **BadFont**, **BadMatch**, **BadPixmap**, and **BadValue** errors.

To copy components from a source GC to a destination GC, use **XCopyGC**.

```
XCopyGC(display, src, valuemask, dest)
      Display *display;
      GC src, dest;
      unsigned long valuemask;
```

display Specifies the connection to the X server.

src Specifies the components of the source GC.

valuemask Specifies which components in the GC are to be copied to the destination GC. This argument is the bitwise inclusive OR of one or more of the valid GC component mask bits.

dest Specifies the destination GC.

The **XCopyGC** function copies the specified components from the source GC to the destination GC. The source and destination GCs must have the same root and depth, or a **BadMatch** error results. The valuemask specifies which component to copy, as for **XCreateGC**.

XCopyGC can generate **BadAlloc**, **BadGC**, and **BadMatch** errors.

To change the components in a given GC, use **XChangeGC**.

```
XChangeGC(display, gc, valuemask, values)
      Display *display;
      GC gc;
      unsigned long valuemask;
      XGCValues *values;
```

display Specifies the connection to the X server.

gc Specifies the GC.

valuemask Specifies which components in the GC are to be changed using information in the specified values structure. This argument is the bitwise inclusive OR of one or more of the valid GC component mask bits.

values Specifies any values as specified by the valuemask.

The **XChangeGC** function changes the components specified by valuemask for the specified GC. The values argument contains the values to be set. The values and restrictions are the same as for **XCreateGC**. Changing the clip-mask overrides any previous **XSetClipRectangles** request on the context. Changing the dash-offset or dash-list overrides any previous **XSetDashes** request on the context. The order in which components are verified and altered is server-dependent. If an error is generated, a subset of the components may have been altered.

XChangeGC can generate **BadAlloc**, **BadFont**, **BadGC**, **BadMatch**, **BadPixmap**, and **BadValue** errors.

To free a given GC, use **XFreeGC**.

```
XFreeGC(display, gc)
      Display *display;
      GC gc;
```

display Specifies the connection to the X server.

gc Specifies the GC.

The **XFreeGC** function destroys the specified GC as well as all the associated storage.

XFreeGC can generate a **BadGC** error.

To obtain the **GContext** resource ID for a given GC, use **XGContextFromGC**.

```
GContext XGContextFromGC(gc)
      GC gc;
```

gc Specifies the GC for which you want the resource ID.

5.4. Using GC Convenience Routines

This section discusses how to set the:

- Foreground, background, plane mask, or function components
- Line attributes and dashes components
- Fill style and fill rule components
- Fill tile and stipple components
- Font component
- Clip region component
- Arc mode, subwindow mode, and graphics exposure components

5.4.1. Setting the Foreground, Background, Function, or Plane Mask

To set the foreground, background, plane mask, and function components for a given GC, use **XSetState**.

XSetState(*display*, *gc*, *foreground*, *background*, *function*, *plane_mask*)
    Display **display*;
    GC *gc*;
    unsigned long *foreground*, *background*;
    int *function*;
    unsigned long *plane_mask*;

display	Specifies the connection to the X server.
gc	Specifies the GC.
foreground	Specifies the foreground you want to set for the specified GC.
background	Specifies the background you want to set for the specified GC.
function	Specifies the function you want to set for the specified GC.
plane_mask	Specifies the plane mask.

XSetState can generate **BadAlloc**, **BadGC**, and **BadValue** errors.

To set the foreground of a given GC, use **XSetForeground**.

XSetForeground(*display*, *gc*, *foreground*)
    Display **display*;
    GC *gc*;
    unsigned long *foreground*;

display	Specifies the connection to the X server.
gc	Specifies the GC.
foreground	Specifies the foreground you want to set for the specified GC.

XSetForeground can generate **BadAlloc** and **BadGC** errors.

To set the background of a given GC, use **XSetBackground**.

XSetBackground(*display*, *gc*, *background*)
    Display **display*;
    GC *gc*;
    unsigned long *background*;

display	Specifies the connection to the X server.
gc	Specifies the GC.
background	Specifies the background you want to set for the specified GC.

XSetBackground can generate **BadAlloc** and **BadGC** errors.

To set the display function in a given GC, use **XSetFunction**.

XSetFunction(*display*, *gc*, *function*)
    Display **display*;
    GC *gc*;
    int *function*;

display	Specifies the connection to the X server.
gc	Specifies the GC.
function	Specifies the function you want to set for the specified GC.

XSetFunction can generate **BadAlloc**, **BadGC**, and **BadValue** errors.

To set the plane mask of a given GC, use **XSetPlaneMask**.

```
XSetPlaneMask(display, gc, plane_mask)
      Display *display;
      GC gc;
      unsigned long plane_mask;
```

display Specifies the connection to the X server.

gc Specifies the GC.

plane_mask Specifies the plane mask.

XSetPlaneMask can generate **BadAlloc** and **BadGC** errors.

5.4.2. Setting the Line Attributes and Dashes

To set the line drawing components of a given GC, use **XSetLineAttributes**.

```
XSetLineAttributes(display, gc, line_width, line_style, cap_style, join_style)
      Display *display;
      GC gc;
      unsigned int line_width;
      int line_style;
      int cap_style;
      int join_style;
```

display Specifies the connection to the X server.

gc Specifies the GC.

line_width Specifies the line-width you want to set for the specified GC.

line_style Specifies the line-style you want to set for the specified GC. You can pass **LineSolid**, **LineOnOffDash**, or **LineDoubleDash**.

cap_style Specifies the line-style and cap-style you want to set for the specified GC. You can pass **CapNotLast**, **CapButt**, **CapRound**, or **CapProjecting**.

join_style Specifies the line join-style you want to set for the specified GC. You can pass **JoinMiter**, **JoinRound**, or **JoinBevel**.

XSetLineAttributes can generate **BadAlloc**, **BadGC**, and **BadValue** errors.

To set the dash-offset and dash-list for dashed line styles of a given GC, use **XSetDashes**.

```
XSetDashes(display, gc, dash_offset, dash_list, n)
      Display *display;
      GC gc;
      int dash_offset;
      char dash_list[];
      int n;
```

display Specifies the connection to the X server.

gc Specifies the GC.

dash_offset Specifies the phase of the pattern for the dashed line-style you want to set for the specified GC.

dash_list Specifies the dash-list for the dashed line-style you want to set for the specified GC.

n Specifies the number of elements in dash_list.

The **XSetDashes** function sets the dash-offset and dash-list attributes for dashed line styles in the specified GC. There must be at least one element in the specified dash_list, or a **BadValue** error results. The initial and alternating elements (second, fourth, and so on) of the dash_list are the even dashes, and the others are the odd dashes. Each element specifies a dash length in pixels. All of the elements must be nonzero, or a **BadValue** error results. Specifying an odd-length list is equivalent to specifying the same list concatenated with itself to produce an even-length list.

The dash-offset defines the phase of the pattern, specifying how many pixels into the dash-list the pattern should actually begin in any single graphics request. Dashing is continuous through path elements combined with a join-style but is reset to the dash-offset each time a cap-style is applied at a line endpoint.

The unit of measure for dashes is the same for the ordinary coordinate system. Ideally, a dash length is measured along the slope of the line, but implementations are only required to match this ideal for horizontal and vertical lines. Failing the ideal semantics, it is suggested that the length be measured along the major axis of the line. The major axis is defined as the x axis for lines drawn at an angle of between –45 and +45 degrees or between 315 and 225 degrees from the x axis. For all other lines, the major axis is the y axis.

XSetDashes can generate **BadAlloc**, **BadGC**, and **BadValue** errors.

5.4.3. Setting the Fill Style and Fill Rule

To set the fill-style of a given GC, use **XSetFillStyle**.

XSetFillStyle(*display*, *gc*, *fill_style*)
    Display **display*;
    GC *gc*;
    int *fill_style*;

display Specifies the connection to the X server.

gc Specifies the GC.

fill_style Specifies the fill-style you want to set for the specified GC. You can pass **FillSolid**, **FillTiled**, **FillStippled**, or **FillOpaqueStippled**.

XSetFillStyle can generate **BadAlloc**, **BadGC**, and **BadValue** errors.

To set the fill-rule of a given GC, use **XSetFillRule**.

XSetFillRule(*display*, *gc*, *fill_rule*)
    Display **display*;
    GC *gc*;
    int *fill_rule*;

display Specifies the connection to the X server.

gc Specifies the GC.

fill_rule Specifies the fill-rule you want to set for the specified GC. You can pass **EvenOddRule** or **WindingRule**.

XSetFillRule can generate **BadAlloc**, **BadGC**, and **BadValue** errors.

5.4.4. Setting the Fill Tile and Stipple

Some displays have hardware support for tiling or stippling with patterns of specific sizes. Tiling and stippling operations that restrict themselves to those specific sizes run much faster than such operations with arbitrary size patterns. Xlib provides functions that you can use to determine the best size, tile, or stipple for the display as well as to set the tile or stipple shape and the tile or stipple origin.

To obtain the best size of a tile, stipple, or cursor, use **XQueryBestSize**.

Status XQueryBestSize(*display*, *class*, *which_screen*, *width*, *height*, *width_return*, *height_return*)
    Display **display*;
    int *class*;
    Drawable *which_screen*;
    unsigned int *width*, *height*;
    unsigned int **width_return*, **height_return*;

display Specifies the connection to the X server.

class Specifies the class that you are interested in. You can pass **TileShape**, **CursorShape**, or **StippleShape**.

which_screen Specifies any drawable on the screen.

width
height Specify the width and height.

width_return
height_return Return the width and height of the object best supported by the display hardware.

The **XQueryBestSize** function returns the best or closest size to the specified size. For **CursorShape**, this is the largest size that can be fully displayed on the screen specified by which_screen. For **TileShape**, this is the size that can be tiled fastest. For **StippleShape**, this is the size that can be stippled fastest. For **CursorShape**, the drawable indicates the desired screen. For **TileShape** and **StippleShape**, the drawable indicates the screen and possibly the window class and depth. An **InputOnly** window cannot be used as the drawable for **TileShape** or **StippleShape**, or a **BadMatch** error results.

XQueryBestSize can generate **BadDrawable**, **BadMatch**, and **BadValue** errors.

To obtain the best fill tile shape, use **XQueryBestTile**.

Status XQueryBestTile(*display*, *which_screen*, *width*, *height*, *width_return*, *height_return*)
    Display **display*;
    Drawable *which_screen*;
    unsigned int *width*, *height*;
    unsigned int **width_return*, **height_return*;

display Specifies the connection to the X server.

which_screen Specifies any drawable on the screen.

width
height Specify the width and height.

width_return
height_return Return the width and height of the object best supported by the display hardware.

The **XQueryBestTile** function returns the best or closest size, that is, the size that can be tiled fastest on the screen specified by which_screen. The drawable indicates the screen and possibly the window class and depth. If an **InputOnly** window is used as the drawable, a **BadMatch** error results.

XQueryBestTile can generate **BadDrawable** and **BadMatch** errors.

To obtain the best stipple shape, use **XQueryBestStipple**.

Status XQueryBestStipple(*display*, *which_screen*, *width*, *height*, *width_return*, *height_return*)
      Display **display*;
      Drawable *which_screen*;
      unsigned int *width*, *height*;
      unsigned int **width_return*, **height_return*;

display Specifies the connection to the X server.

which_screen Specifies any drawable on the screen.

width
height Specify the width and height.

width_return
height_return Return the width and height of the object best supported by the display hardware.

The **XQueryBestStipple** function returns the best or closest size, that is, the size that can be stippled fastest on the screen specified by which_screen. The drawable indicates the screen and possibly the window class and depth. If an **InputOnly** window is used as the drawable, a **BadMatch** error results.

XQueryBestStipple can generate **BadDrawable** and **BadMatch** errors.

To set the fill tile of a given GC, use **XSetTile**.

XSetTile(*display*, *gc*, *tile*)
      Display **display*;
      GC *gc*;
      Pixmap *tile*;

display Specifies the connection to the X server.

gc Specifies the GC.

tile Specifies the fill tile you want to set for the specified GC.

The tile and GC must have the same depth, or a **BadMatch** error results.

XSetTile can generate **BadAlloc**, **BadGC**, **BadMatch**, and **BadPixmap** errors.

To set the stipple of a given GC, use **XSetStipple**.

XSetStipple(*display*, *gc*, *stipple*)
      Display **display*;
      GC *gc*;
      Pixmap *stipple*;

display Specifies the connection to the X server.

gc Specifies the GC.

stipple Specifies the stipple you want to set for the specified GC.

The stipple and GC must have the same depth, or a **BadMatch** error results.

XSetStipple can generate **BadAlloc**, **BadGC**, **BadMatch**, and **BadPixmap** errors.

To set the tile or stipple origin of a given GC, use **XSetTSOrigin**.

XSetTSOrigin(*display*, *gc*, *ts_x_origin*, *ts_y_origin*)
      Display **display*;
      GC *gc*;
      int *ts_x_origin*, *ts_y_origin*;

display Specifies the connection to the X server.

gc Specifies the GC.

ts_x_origin
ts_y_origin Specify the x and y coordinates of the tile and stipple origin.

When graphics requests call for tiling or stippling, the parent's origin will be interpreted relative to whatever destination drawable is specified in the graphics request.

XSetTSOrigin can generate **BadAlloc** and **BadGC** error.

5.4.5. Setting the Current Font

To set the current font of a given GC, use **XSetFont**.

```
XSetFont(display, gc, font)
      Display *display;
      GC gc;
      Font font;
```

display Specifies the connection to the X server.

gc Specifies the GC.

font Specifies the font.

XSetFont can generate **BadAlloc**, **BadFont**, and **BadGC** errors.

5.4.6. Setting the Clip Region

Xlib provides functions that you can use to set the clip-origin and the clip-mask or set the clip-mask to a list of rectangles.

To set the clip-origin of a given GC, use **XSetClipOrigin**.

```
XSetClipOrigin(display, gc, clip_x_origin, clip_y_origin)
      Display *display;
      GC gc;
      int clip_x_origin, clip_y_origin;
```

display Specifies the connection to the X server.

gc Specifies the GC.

clip_x_origin
clip_y_origin Specify the x and y coordinates of the clip-mask origin.

The clip-mask origin is interpreted relative to the origin of whatever destination drawable is specified in the graphics request.

XSetClipOrigin can generate **BadAlloc** and **BadGC** errors.

To set the clip-mask of a given GC to the specified pixmap, use **XSetClipMask**.

```
XSetClipMask(display, gc, pixmap)
      Display *display;
      GC gc;
      Pixmap pixmap;
```

display Specifies the connection to the X server.

gc Specifies the GC.

pixmap Specifies the pixmap or **None**.

If the clip-mask is set to **None**, the pixels are are always drawn (regardless of the clip-origin).

XSetClipMask can generate **BadAlloc**, **BadGC**, **BadMatch**, and **BadValue** errors.

To set the clip-mask of a given GC to the specified list of rectangles, use **XSetClipRectangles**.

XSetClipRectangles(*display*, *gc*, *clip_x_origin*, *clip_y_origin*, *rectangles*, *n*, *ordering*)
    Display **display*;
    GC *gc*;
    int *clip_x_origin*, *clip_y_origin*;
    XRectangle *rectangles*[];
    int *n*;
    int *ordering*;

display Specifies the connection to the X server.

gc Specifies the GC.

clip_x_origin
clip_y_origin Specify the x and y coordinates of the clip-mask origin.

rectangles Specifies an array of rectangles that define the clip-mask.

n Specifies the number of rectangles.

ordering Specifies the ordering relations on the rectangles. You can pass **Unsorted**, **YSorted**, **YXSorted**, or **YXBanded**.

The **XSetClipRectangles** function changes the clip-mask in the specified GC to the specified list of rectangles and sets the clip origin. The output is clipped to remain contained within the rectangles. The clip-origin is interpreted relative to the origin of whatever destination drawable is specified in a graphics request. The rectangle coordinates are interpreted relative to the clip-origin. The rectangles should be nonintersecting, or the graphics results will be undefined. Note that the list of rectangles can be empty, which effectively disables output. This is the opposite of passing **None** as the clip-mask in **XCreateGC**, **XChangeGC**, and **XSetClipMask**.

If known by the client, ordering relations on the rectangles can be specified with the ordering argument. This may provide faster operation by the server. If an incorrect ordering is specified, the X server may generate a **BadMatch** error, but it is not required to do so. If no error is generated, the graphics results are undefined. **Unsorted** means the rectangles are in arbitrary order. **YSorted** means that the rectangles are nondecreasing in their Y origin. **YXSorted** additionally constrains **YSorted** order in that all rectangles with an equal Y origin are nondecreasing in their X origin. **YXBanded** additionally constrains **YXSorted** by requiring that, for every possible Y scanline, all rectangles that include that scanline have an identical Y origins and Y extents.

XSetClipRectangles can generate **BadAlloc**, **BadGC**, **BadMatch**, and **BadValue** errors.

Xlib provides a set of basic functions for performing region arithmetic. For information about these functions, see chapter 10.

5.4.7. Setting the Arc Mode, Subwindow Mode, and Graphics Exposure

To set the arc mode of a given GC, use **XSetArcMode**.

XSetArcMode(*display*, *gc*, *arc_mode*)
    Display **display*;
    GC *gc*;
    int *arc_mode*;

display Specifies the connection to the X server.

gc Specifies the GC.

arc_mode Specifies the arc mode. You can pass **ArcChord** or **ArcPieSlice**.

XSetArcMode can generate **BadAlloc**, **BadGC**, and **BadValue** errors.

To set the subwindow mode of a given GC, use **XSetSubwindowMode**.

```
XSetSubwindowMode(display, gc, subwindow_mode)
      Display *display;
      GC gc;
      int subwindow_mode;
```

display Specifies the connection to the X server.

gc Specifies the GC.

subwindow_mode
Specifies the subwindow mode. You can pass **ClipByChildren** or **IncludeInferiors**.

XSetSubwindowMode can generate **BadAlloc**, **BadGC**, and **BadValue** errors.

To set the graphics-exposures flag of a given GC, use **XSetGraphicsExposures**.

```
XSetGraphicsExposures(display, gc, graphics_exposures)
      Display *display;
      GC gc;
      Bool graphics_exposures;
```

display Specifies the connection to the X server.

gc Specifies the GC.

graphics_exposures
Specifies a Boolean value that indicates whether you want **GraphicsExpose** and **NoExpose** events to be reported when calling **XCopyArea** and **XCopyPlane** with this GC.

XSetGraphicsExposures can generate **BadAlloc**, **BadGC**, and **BadValue** errors.

Chapter 6

Graphics Functions

Once you have connected the display to the X server, you can use the Xlib graphics functions to:

- Clear and copy areas
- Draw points, lines, rectangles, and arcs
- Fill areas
- Manipulate fonts
- Draw text
- Transfer images between clients and the server
- Manipulate cursors

If the same drawable and GC is used for each call, Xlib batches back-to-back calls to **XDrawPoint**, **XDrawLine**, **XDrawRectangle**, **XFillArc**, and **XFillRectangle**. Note that this reduces the total number of requests sent to the server.

6.1. Clearing Areas

Xlib provides functions that you can use to clear an area or the entire window. Because pixmaps do not have defined backgrounds, they cannot be filled by using the functions described in this section. Instead, to accomplish an analogous operation on a pixmap, you should use **XFillRectangle**, which sets the pixmap to a known value.

To clear a rectangular area of a given window, use **XClearArea**.

```
XClearArea(display, w, x, y, width, height, exposures)
      Display *display;
      Window w;
      int x, y;
      unsigned int width, height;
      Bool exposures;
```

display Specifies the connection to the X server.

w Specifies the window.

x
y Specify the x and y coordinates, which are relative to the origin of the window and specify the upper-left corner of the rectangle.

width
height Specify the width and height, which are the dimensions of the rectangle.

exposures Specifies a Boolean value that indicates if **Expose** events are to be generated.

The **XClearArea** function paints a rectangular area in the specified window according to the specified dimensions with the window's background pixel or pixmap. The subwindow-mode effectively is **ClipByChildren**. If width is zero, it is replaced with the current width of the window minus x. If height is zero, it is replaced with the current height of the window minus y. If the window has a defined background tile, the rectangle clipped by any children is filled with this tile. If the window has background **None**, the contents of the window are not changed. In either case, if exposures is

True, one or more **Expose** events are generated for regions of the rectangle that are either visible or are being retained in a backing store. If you specify a window whose class is **InputOnly**, a **BadMatch** error results.

XClearArea can generate **BadMatch**, **BadValue**, and **BadWindow** errors.

To clear the entire area in a given window, use **XClearWindow**.

```
XClearWindow(display, w)
      Display *display;
      Window w;
```

display Specifies the connection to the X server.

w Specifies the window.

The **XClearWindow** function clears the entire area in the specified window and is equivalent to **XClearArea** (display, w, 0, 0, 0, 0, **False**). If the window has a defined background tile, the rectangle is tiled with a plane-mask of all ones and **GXcopy** function. If the window has background **None**, the contents of the window are not changed. If you specify a window whose class is **InputOnly**, a **BadMatch** error results.

XClearWindow can generate **BadMatch** and **BadWindow** errors.

6.2. Copying Areas

Xlib provides functions that you can use to copy an area or a bit plane.

To copy an area between drawables of the same root and depth, use **XCopyArea**.

```
XCopyArea(display, src, dest, gc, src_x, src_y, width, height, dest_x, dest_y)
      Display *display;
      Drawable src, dest;
      GC gc;
      int src_x, src_y;
      unsigned int width, height;
      int dest_x, dest_y;
```

display Specifies the connection to the X server.

src
dest Specify the source and destination rectangles to be combined.

gc Specifies the GC.

src_x
src_y Specify the x and y coordinates, which are relative to the origin of the source rectangle and specify its upper-left corner.

width
height Specify the width and height, which are the dimensions of both the source and destination rectangles.

dest_x
dest_y Specify the x and y coordinates, which are relative to the origin of the destination rectangle and specify its upper-left corner.

The **XCopyArea** function combines the specified rectangle of src with the specified rectangle of dest. The drawables must have the same root and depth, or a **BadMatch** error results.

If regions of the source rectangle are obscured and have not been retained in backing store or if regions outside the boundaries of the source drawable are specified, those regions are not copied. Instead, the following occurs on all corresponding destination regions that are either visible or are retained in backing store. If the destination is a window with a background other than **None**, corresponding regions of the destination are tiled with that background (with plane-mask of all ones and **GXcopy** function). Regardless of tiling or whether the destination is a window or a pixmap, if graphics-exposures is **True**, then **GraphicsExpose** events for all corresponding destination regions are generated. If graphics-exposures is **True** but no **GraphicsExpose** events are generated, a **NoExpose** event is generated. Note that by default graphics-exposures is **True** in new GCs.

This function uses these GC components: function, plane-mask, subwindow-mode, graphics-exposures, clip-x-origin, clip-y-origin, and clip-mask.

XCopyArea can generate **BadDrawable**, **BadGC**, and **BadMatch** errors.

To copy a single bit plane of a given drawable, use **XCopyPlane**.

```
XCopyPlane(display, src, dest, gc, src_x, src_y, width, height, dest_x, dest_y, plane)
      Display *display;
      Drawable src, dest;
      GC gc;
      int src_x, src_y;
      unsigned int width, height;
      int dest_x, dest_y;
      unsigned long plane;
```

display Specifies the connection to the X server.

src
dest Specify the source and destination rectangles to be combined.

gc Specifies the GC.

src_x
src_y Specify the x and y coordinates, which are relative to the origin of the source rectangle and specify its upper-left corner.

width
height Specify the width and height, which are the dimensions of both the source and destination rectangles.

dest_x
dest_y Specify the x and y coordinates, which are relative to the origin of the destination rectangle and specify its upper-left corner.

plane Specifies the bit plane. You must set exactly one bit to 1.

The **XCopyPlane** function uses a single bit plane of the specified source rectangle combined with the specified GC to modify the specified rectangle of dest. The drawables must have the same root but need not have the same depth. If the drawables do not have the same root, a **BadMatch** error results. If plane does not have exactly one bit set to 1 and the values of planes must be less than 2^n, where n is the depth of scr, a **BadValue** error results.

Effectively, **XCopyPlane** forms a pixmap of the same depth as the rectangle of dest and with a size specified by the source region. It uses the foreground/background pixels in the GC (foreground everywhere the bit plane in src contains a bit set to 1, background everywhere the bit plane in src contains a bit set to 0) and the equivalent of a **CopyArea** potocol request is performed with all the same exposure semantics. This can also be thought of as using the specified region of the source bit plane as a stipple with a fill-style of **FillOpaqueStippled** for filling a rectangular area of the destination.

This function uses these GC components: function, plane-mask, foreground, background, subwindow-mode, graphics-exposures, clip-x-origin, clip-y-origin, and clip-mask.

XCopyPlane can generate **BadDrawable**, **BadGC**, **BadMatch**, and **BadValue** errors.

6.3. Drawing Points, Lines, Rectangles, and Arcs

Xlib provides functions that you can use to draw:

- A single point or multiple points
- A single line or multiple lines
- A single rectangle or multiple rectangles
- A single arc or multiple arcs

Some of the functions described in the following sections use these structures:

```
typedef struct {
	short x1, y1, x2, y2;
} XSegment;

typedef struct {
	short x, y;
} XPoint;

typedef struct {
	short x, y;
	unsigned short width, height;
} XRectangle;

typedef struct {
	short x, y;
	unsigned short width, height;
	short angle1, angle2;		/* Degrees * 64 */
} XArc;
```

All x and y members are signed integers. The width and height members are 16-bit unsigned integers. You should be careful not to generate coordinates and sizes out of the 16-bit ranges, because the protocol only has 16-bit fields for these values.

6.3.1. Drawing Single and Multiple Points

To draw a single point in a given drawable, use **XDrawPoint**.

XDrawPoint(*display*, *d*, *gc*, *x*, *y*)
    Display **display*;
    Drawable *d*;
    GC *gc*;
    int *x*, *y*;

display Specifies the connection to the X server.

d Specifies the drawable.

gc Specifies the GC.

x
y Specify the x and y coordinates where you want the point drawn.

To draw multiple points in a given drawable, use **XDrawPoints**.

```
XDrawPoints(display, d, gc, points, npoints, mode)
      Display *display;
      Drawable d;
      GC gc;
      XPoint *points;
      int npoints;
      int mode;
```

display	Specifies the connection to the X server.
d	Specifies the drawable.
gc	Specifies the GC.
points	Specifies a pointer to an array of points.
npoints	Specifies the number of points in the array.
mode	Specifies the coordinate mode. You can pass **CoordModeOrigin** or **CoordModePrevious**.

The **XDrawPoint** function uses the foreground pixel and function components of the GC to draw a single point into the specified drawable; **XDrawPoints** draws multiple points this way. **CoordModeOrigin** treats all coordinates as relative to the origin, and **CoordModePrevious** treats all coordinates after the first as relative to the previous point. **XDrawPoints** draws the points in the order listed in the array.

Both functions use these GC components: function, plane-mask, foreground, subwindow-mode, clip-x-origin, clip-y-origin, and clip-mask.

XDrawPoint can generate **BadDrawable**, **BadGC**, and **BadMatch** errors. **XDrawPoints** can generate **BadDrawable**, **BadGC**, **BadMatch**, and **BadValue** errors.

6.3.2. Drawing Single and Multiple Lines

To draw a single line between two points in a given drawable, use **XDrawLine**.

```
XDrawLine(display, d, gc, x1, y1, x2, y2)
      Display *display;
      Drawable d;
      GC gc;
      int x1, y1, x2, y2;
```

display	Specifies the connection to the X server.
d	Specifies the drawable.
gc	Specifies the GC.
x1	
y1	
x2	
y2	Specify the points (x1, y1) and (x2, y2) to be connected.

To draw multiple lines in a given drawable, use **XDrawLines**.

```
XDrawLines(display, d, gc, points, npoints, mode)
      Display *display;
      Drawable d;
      GC gc;
      XPoint *points;
      int npoints;
      int mode;
```

display	Specifies the connection to the X server.
d	Specifies the drawable.
gc	Specifies the GC.
points	Specifies a pointer to an array of points.
npoints	Specifies the number of points in the array.
mode	Specifies the coordinate mode. You can pass **CoordModeOrigin** or **CoordModePrevious**.

To draw multiple, unconnected lines in a given drawable, use **XDrawSegments**.

XDrawSegments(*display*, *d*, *gc*, *segments*, *nsegments*)
    Display **display*;
    Drawable *d*;
    GC *gc*;
    XSegment **segments*;
    int *nsegments*;

display	Specifies the connection to the X server.
d	Specifies the drawable.
gc	Specifies the GC.
segments	Specifies a pointer to an array of segments.
nsegments	Specifies the number of segments in the array.

The **XDrawLine** function uses the components of the specified GC to draw a line between the specified set of points (x1, y1) and (x2, y2). It does not perform joining at coincident endpoints. For any given line, **XDrawLine** does not draw a pixel more than once. If lines intersect, the intersecting pixels are drawn multiple times.

The **XDrawLines** function uses the components of the specified GC to draw npoints−1 lines between each pair of points (point[i], point[i+1]) in the array of **XPoint** structures. It draws the lines in the order listed in the array. The lines join correctly at all intermediate points, and if the first and last points coincide, the first and last lines also join correctly. For any given line, **XDrawLines** does not draw a pixel more than once. If thin (zero line-width) lines intersect, the intersecting pixels are drawn multiple times. If wide lines intersect, the intersecting pixels are drawn only once, as though the entire **PolyLine** protocol request were a single, filled shape. **CoordModeOrigin** treats all coordinates as relative to the origin, and **CoordModePrevious** treats all coordinates after the first as relative to the previous point.

The **XDrawSegments** function draws multiple, unconnected lines. For each segment, **XDrawSegments** draws a line between (x1, y1) and (x2, y2). It draws the lines in the order listed in the array of **XSegment** structures and does not perform joining at coincident endpoints. For any given line, **XDrawSegments** does not draw a pixel more than once. If lines intersect, the intersecting pixels are drawn multiple times.

All three functions use these GC components: function, plane-mask, line-width, line-style, cap-style, fill-style, subwindow-mode, clip-x-origin, clip-y-origin, and clip-mask. The **XDrawLines** function also uses the join-style GC component. All three functions also use these GC mode-dependent components: foreground, background, tile, stipple, tile-stipple-x-origin, tile-stipple-y-origin, dash-offset, and dash-list.

XDrawLine, **XDrawLines**, and **XDrawSegments** can generate **BadDrawable**, **BadGC**, and **BadMatch** errors. **XDrawLines** also can generate **BadValue** errors.

6.3.3. Drawing Single and Multiple Rectangles

To draw the outline of a single rectangle in a given drawable, use **XDrawRectangle**.

```
XDrawRectangle(display, d, gc, x, y, width, height)
    Display *display;
    Drawable d;
    GC gc;
    int x, y;
    unsigned int width, height;
```

display Specifies the connection to the X server.

d Specifies the drawable.

gc Specifies the GC.

x
y Specify the x and y coordinates, which specify the upper-left corner of the rectangle.

width
height Specify the width and height, which specify the dimensions of the rectangle.

To draw the outline of multiple rectangles in a given drawable, use **XDrawRectangles**.

```
XDrawRectangles(display, d, gc, rectangles, nrectangles)
    Display *display;
    Drawable d;
    GC gc;
    XRectangle rectangles[];
    int nrectangles;
```

display Specifies the connection to the X server.

d Specifies the drawable.

gc Specifies the GC.

rectangles Specifies a pointer to an array of rectangles.

nrectangles Specifies the number of rectangles in the array.

The **XDrawRectangle** and **XDrawRectangles** functions draw the outlines of the specified rectangle or rectangles as if a five-point **PolyLine** protocol request were specified for each rectangle:

[x,y] [x+width,y] [x+width,y+height] [x,y+height] [x,y]

For the specified rectangle or rectangles, these functions do not draw a pixel more than once. **XDrawRectangles** draws the rectangles in the order listed in the array. If rectangles intersect, the intersecting pixels are drawn multiple times.

Both functions use these GC components: function, plane-mask, line-width, line-style, join-style, fill-style, subwindow-mode, clip-x-origin, clip-y-origin, and clip-mask. They also use these GC mode-dependent components: foreground, background, tile, stipple, tile-stipple-x-origin, tile-stipple-y-origin, dash-offset, and dash-list.

XDrawRectangle and **XDrawRectangles** can generate **BadDrawable**, **BadGC**, and **BadMatch** errors.

6.3.4. Drawing Single and Multiple Arcs

To draw a single arc in a given drawable, use **XDrawArc**.

```
XDrawArc(display, d, gc, x, y, width, height, angle1, angle2)
      Display *display;
      Drawable d;
      GC gc;
      int x, y;
      unsigned int width, height;
      int angle1, angle2;
```

display	Specifies the connection to the X server.
d	Specifies the drawable.
gc	Specifies the GC.
x *y*	Specify the x and y coordinates, which are relative to the origin of the drawable and specify the upper-left corner of the bounding rectangle.
width *height*	Specify the width and height, which are the major and minor axes of the arc.
angle1	Specifies the start of the arc relative to the three-o'clock position from the center, in units of degrees * 64.
angle2	Specifies the path and extent of the arc relative to the start of the arc, in units of degrees * 64.

To draw multiple arcs in a given drawable, use **XDrawArcs**.

```
XDrawArcs(display, d, gc, arcs, narcs)
      Display *display;
      Drawable d;
      GC gc;
      XArc *arcs;
      int narcs;
```

display	Specifies the connection to the X server.
d	Specifies the drawable.
gc	Specifies the GC.
arcs	Specifies a pointer to an array of arcs.
narcs	Specifies the number of arcs in the array.

XDrawArc draws a single circular or elliptical arc, and **XDrawArcs** draws multiple circular or elliptical arcs. Each arc is specified by a rectangle and two angles. The center of the circle or ellipse is the center of the rectangle, and the major and minor axes are specified by the width and height. Positive angles indicate counterclockwise motion, and negative angles indicate clockwise motion. If the magnitude of angle2 is greater than 360 degrees, **XDrawArc** or **XDrawArcs** truncates it to 360 degrees.

For an arc specified as $[x, y, width, height, angle1, angle2]$, the origin of the major and minor axes is at $[x + \frac{width}{2}, y + \frac{height}{2}]$, and the infinitely thin path describing the entire circle or ellipse intersects the horizontal axis at $[x, y + \frac{height}{2}]$ and $[x + width, y + \frac{height}{2}]$ and intersects the vertical axis at $[x + \frac{width}{2}, y]$ and $[x + \frac{width}{2}, y + height]$. These coordinates can be fractional and so are not truncated to discrete coordinates. The path should be defined by the ideal mathematical path. For a wide line with line-width lw, the bounding outlines for filling are given by the two infinitely thin paths consisting of all points whose perpendicular distance from the path of the circle/ellipse is equal to lw/2 (which may be a fractional value). The cap-style and join-style are applied the same as for a line corresponding to the tangent of the circle/ellipse at the endpoint.

For an arc specified as [*x* , *y* , *width* , *height* , *angle* 1, *angle* 2], the angles must be specified in the effectively skewed coordinate system of the ellipse (for a circle, the angles and coordinate systems are identical). The relationship between these angles and angles expressed in the normal coordinate system of the screen (as measured with a protractor) is as follows:

$$\text{skewed-angle} = \text{atan}\left(\tan(\text{normal-angle}) * \frac{width}{height}\right) + adjust$$

The skewed-angle and normal-angle are expressed in radians (rather than in degrees scaled by 64) in the range $[0, 2\pi]$ and where atan returns a value in the range $[-\frac{\pi}{2}, \frac{\pi}{2}]$ and adjust is:

0	for normal-angle in the range $[0, \frac{\pi}{2}]$
π	for normal-angle in the range $[\frac{\pi}{2}, \frac{3\pi}{2}]$
2π	for normal-angle in the range $[\frac{3\pi}{2}, 2\pi]$

For any given arc, **XDrawArc** and **XDrawArcs** do not draw a pixel more than once. If two arcs join correctly and if the line-width is greater than zero and the arcs intersect, **XDrawArc** and **XDrawArcs** do not draw a pixel more than once. Otherwise, the intersecting pixels of intersecting arcs are drawn multiple times. Specifying an arc with one endpoint and a clockwise extent draws the same pixels as specifying the other endpoint and an equivalent counterclockwise extent, except as it affects joins.

If the last point in one arc coincides with the first point in the following arc, the two arcs will join correctly. If the first point in the first arc coincides with the last point in the last arc, the two arcs will join correctly. By specifying one axis to be zero, a horizontal or vertical line can be drawn. Angles are computed based solely on the coordinate system and ignore the aspect ratio.

Both functions use these GC components: function, plane-mask, line-width, line-style, cap-style, join-style, fill-style, subwindow-mode, clip-x-origin, clip-y-origin, and clip-mask. They also use these GC mode-dependent components: foreground, background, tile, stipple, tile-stipple-x-origin, tile-stipple-y-origin, dash-offset, and dash-list.

XDrawArc and **XDrawArcs** can generate **BadDrawable**, **BadGC**, and **BadMatch** errors.

6.4. Filling Areas

Xlib provides functions that you can use to fill:

- A single rectangle or multiple rectangles
- A single polygon
- A single arc or multiple arcs

6.4.1. Filling Single and Multiple Rectangles

To fill a single rectangular area in a given drawable, use **XFillRectangle**.

XFillRectangle(*display, d, gc, x, y, width, height*)
    Display **display*;
    Drawable *d*;
    GC *gc*;
    int *x*, *y*;
    unsigned int *width*, *height*;

display	Specifies the connection to the X server.
d	Specifies the drawable.
gc	Specifies the GC.
x *y*	Specify the x and y coordinates, which are relative to the origin of the drawable and specify the upper-left corner of the rectangle.
width *height*	Specify the width and height, which are the dimensions of the rectangle to be filled.

To fill multiple rectangular areas in a given drawable, use **XFillRectangles**.

XFillRectangles(*display, d, gc, rectangles, nrectangles*)
    Display **display*;
    Drawable *d*;
    GC *gc*;
    XRectangle **rectangles*;
    int *nrectangles*;

display	Specifies the connection to the X server.
d	Specifies the drawable.
gc	Specifies the GC.
rectangles	Specifies a pointer to an array of rectangles.
nrectangles	Specifies the number of rectangles in the array.

The **XFillRectangle** and **XFillRectangles** functions fill the specified rectangle or rectangles as if a four-point **FillPolygon** protocol request were specified for each rectangle:

[x,y] [x+width,y] [x+width,y+height] [x,y+height]

Each function uses the x and y coordinates, width and height dimensions, and GC you specify.

XFillRectangles fills the rectangles in the order listed in the array. For any given rectangle, **XFillRectangle** and **XFillRectangles** do not draw a pixel more than once. If rectangles intersect, the intersecting pixels are drawn multiple times.

Both functions use these GC components: function, plane-mask, fill-style, subwindow-mode, clip-x-origin, clip-y-origin, and clip-mask. They also use these GC mode-dependent components: foreground, background, tile, stipple, tile-stipple-x-origin, and tile-stipple-y-origin.

XFillRectangle and **XFillRectangles** can generate **BadDrawable**, **BadGC**, and **BadMatch** errors.

6.4.2. Filling a Single Polygon

To fill a polygon area in a given drawable, use **XFillPolygon**.

```
XFillPolygon(display, d, gc, points, npoints, shape, mode)
      Display *display;
      Drawable d;
      GC gc;
      XPoint *points;
      int npoints;
      int shape;
      int mode;
```

display	Specifies the connection to the X server.
d	Specifies the drawable.
gc	Specifies the GC.
points	Specifies a pointer to an array of points.
npoints	Specifies the number of points in the array.
shape	Specifies a shape that helps the server to improve performance. You can pass **Complex**, **Convex**, or **Nonconvex**.
mode	Specifies the coordinate mode. You can pass **CoordModeOrigin** or **CoordModePrevious**.

XFillPolygon fills the region closed by the specified path. The path is closed automatically if the last point in the list does not coincide with the first point. **XFillPolygon** does not draw a pixel of the region more than once. **CoordModeOrigin** treats all coordinates as relative to the origin, and **CoordModePrevious** treats all coordinates after the first as relative to the previous point.

Depending on the specified shape, the following occurs:

- If shape is **Complex**, the path may self-intersect.
- If shape is **Convex**, the path is wholly convex. If known by the client, specifying **Convex** can improve performance. If you specify **Convex** for a path that is not convex, the graphics results are undefined.
- If shape is **Nonconvex**, the path does not self-intersect, but the shape is not wholly convex. If known by the client, specifying **Nonconvex** instead of **Complex** may improve performance. If you specify **Nonconvex** for a self-intersecting path, the graphics results are undefined.

The fill-rule of the GC controls the filling behavior of self-intersecting polygons.

This function uses these GC components: function, plane-mask, fill-style, fill-rule, subwindow-mode, clip-x-origin, clip-y-origin, and clip-mask. It also uses these GC mode-dependent components: foreground, background, tile, stipple, tile-stipple-x-origin, and tile-stipple-y-origin.

XFillPolygon can generate **BadDrawable**, **BadGC**, **BadMatch**, and **BadValue** errors.

6.4.3. Filling Single and Multiple Arcs

To fill a single arc in a given drawable, use **XFillArc**.

```
XFillArc(display, d, gc, x, y, width, height, angle1, angle2)
      Display *display;
      Drawable d;
      GC gc;
      int x, y;
      unsigned int width, height;
      int angle1, angle2;
```

display Specifies the connection to the X server.

d Specifies the drawable.

gc Specifies the GC.

x
y Specify the x and y coordinates, which are relative to the origin of the drawable and specify the upper-left corner of the bounding rectangle.

width
height Specify the width and height, which are the major and minor axes of the arc.

angle1 Specifies the start of the arc relative to the three-o'clock position from the center, in units of degrees * 64.

angle2 Specifies the path and extent of the arc relative to the start of the arc, in units of degrees * 64.

To fill multiple arcs in a given drawable, use **XFillArcs**.

```
XFillArcs(display, d, gc, arcs, narcs)
      Display *display;
      Drawable d;
      GC gc;
      XArc *arcs;
      int narcs;
```

display Specifies the connection to the X server.

d Specifies the drawable.

gc Specifies the GC.

arcs Specifies a pointer to an array of arcs.

narcs Specifies the number of arcs in the array.

For each arc, **XFillArc** or **XFillArcs** fills the region closed by the infinitely thin path described by the specified arc and, depending on the arc-mode specified in the GC, one or two line segments. For **ArcChord**, the single line segment joining the endpoints of the arc is used. For **ArcPieSlice**, the two line segments joining the endpoints of the arc with the center point are used. **XFillArcs** fills the arcs in the order listed in the array. For any given arc, **XFillArc** and **XFillArcs** do not draw a pixel more than once. If regions intersect, the intersecting pixels are drawn multiple times.

Both functions use these GC components: function, plane-mask, fill-style, arc-mode, subwindow-mode, clip-x-origin, clip-y-origin, and clip-mask. They also use these GC mode-dependent components: foreground, background, tile, stipple, tile-stipple-x-origin, and tile-stipple-y-origin.

XFillArc and **XFillArcs** can generate **BadDrawable**, **BadGC**, and **BadMatch** errors.

6.5. Font Metrics

A font is a graphical description of a set of characters that are used to increase efficiency whenever a set of small, similar sized patterns are repeatedly used.

This section discusses how to:

- Load and free fonts
- Obtain and free font names
- Set and retrieve the font search path
- Compute character string sizes
- Return logical extents
- Query character string sizes

The X server loads fonts whenever a program requests a new font. The server can cache fonts for quick lookup. Fonts are global across all screens in a server. Several levels are possible when dealing with fonts. Most applications simply use **XLoadQueryFont** to load a font and query the font metrics.

Characters in fonts are regarded as masks. Except for image text requests, the only pixels modified are those in which bits are set to 1 in the character. This means that it makes sense to draw text using stipples or tiles (for example, many menus gray-out unusable entries).

The **XFontStruct** structure contains all of the information for the font and consists of the font-specific information as well as a pointer to an array of **XCharStruct** structures for the characters contained in the font. The **XFontStruct**, **XFontProp**, and **XCharStruct** structures contain:

```
typedef struct {
        short lbearing;                 /* origin to left edge of raster */
        short rbearing;                 /* origin to right edge of raster */
        short width;                    /* advance to next char's origin */
        short ascent;                   /* baseline to top edge of raster */
        short descent;                  /* baseline to bottom edge of raster */
        unsigned short attributes;      /* per char flags (not predefined) */
} XCharStruct;

typedef struct {
        Atom   name;
        unsigned long card32;
} XFontProp;

typedef struct {                        /* normal 16 bit characters are two bytes */
    unsigned char byte1;
    unsigned char byte2;
} XChar2b;

typedef struct {
        XExtData *ext_data;             /* hook for extension to hang data */
        Font fid;                       /* Font id for this font */
        unsigned direction;             /* hint about the direction font is painted */
        unsigned min_char_or_byte2;     /* first character */
        unsigned max_char_or_byte2;     /* last character */
        unsigned min_byte1;             /* first row that exists */
        unsigned max_byte1;             /* last row that exists */
        Bool all_chars_exist;           /* flag if all characters have nonzero size */
        unsigned default_char;          /* char to print for undefined character */
        int n_properties;               /* how many properties there are */
```

```
        XFontProp *properties;          /* pointer to array of additional properties */
        XCharStruct min_bounds;         /* minimum bounds over all existing char */
        XCharStruct max_bounds;         /* maximum bounds over all existing char */
        XCharStruct *per_char;          /* first_char to last_char information */
        int ascent;                     /* logical extent above baseline for spacing */
        int descent;                    /* logical decent below baseline for spacing */
} XFontStruct;
```

X supports single byte/character, two bytes/character matrix, and 16-bit character text operations. Note that any of these forms can be used with a font, but a single byte/character text request can only specify a single byte (that is, the first row of a 2-byte font). You should view 2-byte fonts as a two-dimensional matrix of defined characters: byte1 specifies the range of defined rows and byte2 defines the range of defined columns of the font. Single byte/character fonts have one row defined, and the byte2 range specified in the structure defines a range of characters.

The bounding box of a character is defined by the **XCharStruct** of that character. When characters are absent from a font, the default_char is used. When fonts have all characters of the same size, only the information in the **XFontStruct** min and max bounds are used.

The members of the **XFontStruct** have the following semantics:

- The direction member can be either **FontLeftToRight** or **FontRightToLeft**. It is just a hint as to whether most **XCharStruct** elements have a positive (**FontLeftToRight**) or a negative (**FontRightToLeft**) character width metric. The core protocol defines no support for vertical text.
- If the min_byte1 and max_byte1 members are both zero, min_char_or_byte2 specifies the linear character index corresponding to the first element of the per_char array, and max_char_or_byte2 specifies the linear character index of the last element.

  If either min_byte1 or max_byte1 are nonzero, both min_char_or_byte2 and max_char_or_byte2 are less than 256, and the 2-byte character index values corresponding to the per_char array element N (counting from 0) are:

      byte1 = N/D + min_byte1
      byte2 = N\D + min_char_or_byte2

  where:

      D = max_char_or_byte2 – min_char_or_byte2 + 1
      / = integer division
      \ = integer modulus

- If the per_char pointer is NULL, all glyphs between the first and last character indexes inclusive have the same information, as given by both min_bounds and max_bounds.
- If all_chars_exist is **True**, all characters in the per_char array have nonzero bounding boxes.
- The default_char member specifies the character that will be used when an undefined or nonexistent character is printed. The default_char is a 16-bit character (not a 2-byte character). For a font using 2-byte matrix format, the default_char has byte1 in the most-significant byte and byte2 in the least-significant byte. If the default_char itself specifies an undefined or nonexistent character, no printing is performed for an undefined or nonexistent character.
- The min_bounds and max_bounds members contain the most extreme values of each individual **XCharStruct** component over all elements of this array (and ignore nonexistent characters). The bounding box of the font (the smallest

rectangle enclosing the shape obtained by superimposing all of the characters at the same origin [x,y]) has its upper-left coordinate at:

[x + min_bounds.lbearing, y – max_bounds.ascent]

Its width is:

max_bounds.rbearing – min_bounds.lbearing

Its height is:

max_bounds.ascent + max_bounds.descent

- The ascent member is the logical extent of the font above the baseline that is used for determining line spacing. Specific characters may extend beyond this.
- The descent member is the logical extent of the font at or below the baseline that is used for determining line spacing. Specific characters may extend beyond this.
- If the baseline is at Y-coordinate y, the logical extent of the font is inclusive between the Y-coordinate values (y – font.ascent) and (y + font.descent – 1). Typically, the minimum interline spacing between rows of text is given by ascent + descent.

For a character origin at [x,y], the bounding box of a character (that is, the smallest rectangle that encloses the character's shape) described in terms of **XCharStruct** components is a rectangle with its upper-left corner at:

[x + lbearing, y – ascent]

Its width is:

rbearing – lbearing

Its height is:

ascent + descent

The origin for the next character is defined to be:

[x + width, y]

The lbearing member defines the extent of the left edge of the character ink from the origin. The rbearing member defines the extent of the right edge of the character ink from the origin. The ascent member defines the extent of the top edge of the character ink from the origin. The descent member defines the extent of the bottom edge of the character ink from the origin. The width member defines the logical width of the character.

Note that the baseline (the y position of the character origin) is logically viewed as being the scanline just below nondescending characters. When descent is zero, only pixels with Y-coordinates less than y are drawn, and the origin is logically viewed as being coincident with the left edge of a nonkerned character. When lbearing is zero, no pixels with X-coordinate less than x are drawn. Any of the **XCharStruct** metric members could be negative. If the width is negative, the next character will be placed to the left of the current origin.

The X protocol does not define the interpretation of the attributes member in the **XCharStruct** structure. A nonexistent character is represented with all members of its **XCharStruct** set to zero.

A font is not guaranteed to have any properties. The interpretation of the property value (for example, long or unsigned long) must be derived from *a priori* knowledge of the property. When possible, fonts should have at least the properties listed in the following table. With atom names, uppercase and lowercase matter. The following built-in property atoms can be found in <**X11/Xatom.h**>:

Property Name	Type	Description
MIN_SPACE	unsigned	The minimum interword spacing, in pixels.
NORM_SPACE	unsigned	The normal interword spacing, in pixels.
MAX_SPACE	unsigned	The maximum interword spacing, in pixels.
END_SPACE	unsigned	The additional spacing at the end of sentences, in pixels.
SUPERSCRIPT_X SUPERSCRIPT_Y	int	Offset from the character origin where superscripts should begin, in pixels. If the origin is at [x,y], then superscripts should begin at [x + SUPERSCRIPT_X, y – SUPERSCRIPT_Y].
SUBSCRIPT_X SUBSCRIPT_Y	int	Offset from the character origin where subscripts should begin, in pixels. If the origin is at [x,y], then subscripts should begin at [x + SUPERSCRIPT_X, y + SUPERSCRIPT_Y].
UNDERLINE_POSITION	int	Y offset from the baseline to the top of an underline, in pixels. If the baseline is Y-coordinate y, then the top of the underline is at (y + UNDERLINE_POSITION).
UNDERLINE_THICKNESS	unsigned	Thickness of the underline, in pixels.
STRIKEOUT_ASCENT STRIKEOUT_DESCENT	int	Vertical extents for boxing or voiding characters, in pixels. If the baseline is at Y-coordinate y, then the top of the strikeout box is at (y – STRIKEOUT_ASCENT), and the height of the box is (STRIKEOUT_ASCENT + STRIKEOUT_DESCENT).
ITALIC_ANGLE	int	The angle of the dominant staffs of characters in the font, in degrees scaled by 64, relative to the three-o'clock position from the character origin, with positive indicating counterclockwise motion (as in **XDrawArc**).
X_HEIGHT	int	1 ex as in TeX, but expressed in units of pixels. Often the height of lowercase x.
QUAD_WIDTH	int	1 em as in TeX, but expressed in units of pixels. Often the width of the digits 0-9.
CAP_HEIGHT	int	Y offset from the baseline to the top of the capital letters, ignoring accents, in pixels. If the baseline is at Y-coordinate y, then the top of the capitals is at (y – CAP_HEIGHT).
WEIGHT	unsigned	The weight or boldness of the font, expressed as a value between 0 and 1000.

Property Name	Type	Description
POINT_SIZE	unsigned	The point size of this font at the ideal resolution, expressed in 1/10 points.
RESOLUTION	unsigned	The number of pixels per point, expressed in 1/100, at which this font was created.

6.5.1. Loading and Freeing Fonts

Xlib provides functions that you can use to load fonts, get font information, unload fonts, and free font information. A few font functions use a **GContext** resource ID or a font ID interchangeably.

To load a given font, use **XLoadFont**.

```
Font XLoadFont(display, name)
     Display *display;
     char *name;
```

display Specifies the connection to the X server.

name Specifies the name of the font, which is a null-terminated string.

The **XLoadFont** function loads the specified font and returns its associated font ID. The name should be ISO Latin-1 encoding; uppercase and lowercase do not matter. If **XLoadFont** was unsuccessful at loading the specified font, a **BadName** error results. Fonts are not associated with a particular screen and can be stored as a component of any GC. When the font is no longer needed, call **XUnloadFont**.

XLoadFont can generate **BadAlloc** and **BadName** errors.

To return information about an available font, use **XQueryFont**.

```
XFontStruct *XQueryFont(display, font_ID)
     Display *display;
     XID font_ID;
```

display Specifies the connection to the X server.

font_ID Specifies the font ID or the **GContext** ID.

The **XQueryFont** function returns a pointer to the **XFontStruct** structure, which contains information associated with the font. You can query a font or the font stored in a GC. The font ID stored in the **XFontStruct** structure will be the **GContext** ID, and you need to be careful when using this ID in other functions (see **XGContextFromGC**). To free this data, use **XFreeFontInfo**.

To perform a **XLoadFont** and **XQueryFont** in a single operation, use **XLoadQueryFont**.

```
XFontStruct *XLoadQueryFont(display, name)
     Display *display;
     char *name;
```

display Specifies the connection to the X server.

name Specifies the name of the font, which is a null-terminated string.

The **XLoadQueryFont** function provides the most common way for accessing a font. **XLoadQueryFont** both opens (loads) the specified font and returns a pointer to the appropriate **XFontStruct** structure. If the font does not exist, **XLoadQueryFont** returns NULL.

XLoadQueryFont can generate a **BadAlloc** error.

To unload the font and free the storage used by the font structure that was allocated by **XQueryFont** or **XLoadQueryFont**, use **XFreeFont**.

```
XFreeFont(display, font_struct)
      Display *display;
      XFontStruct *font_struct;
```

display Specifies the connection to the X server.

font_struct Specifies the storage associated with the font.

The **XFreeFont** function deletes the association between the font resource ID and the specified font and frees the **XFontStruct** structure. The font itself will be freed when no other resource references it. The data and the font should not be referenced again.

XFreeFont can generate a **BadFont** error.

To return a given font property, use **XGetFontProperty**.

```
Bool XGetFontProperty(font_struct, atom, value_return)
      XFontStruct *font_struct;
      Atom atom;
      unsigned long *value_return;
```

font_struct Specifies the storage associated with the font.

atom Specifies the atom for the property name you want returned.

value_return Returns the value of the font property.

Given the atom for that property, the **XGetFontProperty** function returns the value of the specified font property. **XGetFontProperty** also returns **False** if the property was not defined or **True** if it was defined. A set of predefined atoms exists for font properties, which can be found in **<X11/Xatom.h>**. This set contains the standard properties associated with a font. Although it is not guaranteed, it is likely that the predefined font properties will be present.

To unload a font that was loaded by **XLoadFont**, use **XUnloadFont**.

```
XUnloadFont(display, font)
      Display *display;
      Font font;
```

display Specifies the connection to the X server.

font Specifies the font.

The **XUnloadFont** function deletes the association between the font resource ID and the specified font. The font itself will be freed when no other resource references it. The font should not be referenced again.

XUnloadFont can generate a **BadFont** error.

6.5.2. Obtaining and Freeing Font Names and Information

You obtain font names and information by matching a wildcard specification when querying a font type for a list of available sizes and so on.

To return a list of the available font names, use **XListFonts**.

```
char **XListFonts(display, pattern, maxnames, actual_count_return)
      Display *display;
      char *pattern;
      int maxnames;
      int *actual_count_return;
```

display Specifies the connection to the X server.

pattern Specifies the null-terminated pattern string that can contain wildcard characters.

maxnames Specifies the maximum number of names to be returned.

actual_count_return
Returns the actual number of font names.

The **XListFonts** function returns an array of available font names (as controlled by the font search path; see **XSetFontPath**) that match the string you passed to the pattern argument. The string should be ISO Latin-1; uppercase and lowercase do not matter. Each string is terminated by an ASCII null. The pattern string can contain any characters, but each asterisk (*) is a wildcard for any number of characters, and each question mark (?) is a wildcard for a single character. The client should call **XFreeFontNames** when finished with the result to free the memory.

To free a font name array, use **XFreeFontNames**.

```
XFreeFontNames(list)
      char *list[];
```

list Specifies the array of strings you want to free.

The **XFreeFontNames** function frees the array and strings returned by **XListFonts** or **XListFontsWithInfo**.

To obtain the names and information about available fonts, use **XListFontsWithInfo**.

```
char **XListFontsWithInfo(display, pattern, maxnames, count_return, info_return)
      Display *display;
      char *pattern;
      int maxnames;
      int *count_return;
      XFontStruct **info_return;
```

display Specifies the connection to the X server.

pattern Specifies the null-terminated pattern string that can contain wildcard characters.

maxnames Specifies the maximum number of names to be returned.

count_return Returns the actual number of matched font names.

info_return Returns a pointer to the font information.

The **XListFontsWithInfo** function returns a list of font names that match the specified pattern and their associated font information. The list of names is limited to size specified by maxnames. The information returned for each font is identical to what **XLoadQueryFont** would return except that the per-character metrics are not returned. The pattern string can contain any characters, but each asterisk (*) is a wildcard for any number of characters, and each question mark (?) is a wildcard for a single character. To free the allocated name array, the client should call **XFreeFontNames**. To free the the font information array, the client should call **XFreeFontInfo**.

To free the the font information array, use **XFreeFontInfo**.

```
XFreeFontInfo( names, free_info, actual_count)
      char **names;
      XFontStruct *free_info;
      int actual_count;
```

names Specifies the list of font names returned by **XListFontsWithInfo**.

free_info Specifies the pointer to the font information returned by **XListFontsWithInfo**.

actual_count Specifies the actual number of matched font names returned by **XListFontsWithInfo**.

6.5.3. Setting and Retrieving the Font Search Path

To set the font search path, use **XSetFontPath**.

```
XSetFontPath ( display, directories, ndirs)
      Display *display;
      char **directories;
      int ndirs;
```

display Specifies the connection to the X server.

directories Specifies the directory path used to look for a font. Setting the path to the empty list restores the default path defined for the X server.

ndirs Specifies the number of directories in the path.

The **XSetFontPath** function defines the directory search path for font lookup. There is only one search path per X server, not one per client. The interpretation of the strings is operating system dependent, but they are intended to specify directories to be searched in the order listed. Also, the contents of these strings are operating system dependent and are not intended to be used by client applications. Usually, the X server is free to cache font information internally rather than having to read fonts from files. In addition, the X server is guaranteed to flush all cached information about fonts for which there currently are no explicit resource IDs allocated. The meaning of an error from this request is operating system dependent.

XSetFontPath can generate a **BadValue** error.

To get the current font search path, use **XGetFontPath**.

```
char **XGetFontPath ( display, npaths_return)
      Display *display;
      int *npaths_return;
```

display Specifies the connection to the X server.

npaths_return Returns the number of strings in the font path array.

The **XGetFontPath** function allocates and returns an array of strings containing the search path. When it is no longer needed, the data in the font path should be freed by using **XFreeFontPath**.

To free data returned by **XGetFontPath**, use **XFreeFontPath**.

```
XFreeFontPath ( list)
      char **list;
```

list Specifies the array of strings you want to free.

The **XFreeFontPath** function frees the data allocated by **XGetFontPath**.

6.5.4. Computing Character String Sizes

Xlib provides functions that you can use to compute the width, the logical extents, and the server information about 8-bit and 2-byte text strings. The width is computed by adding the character widths of all the characters. It does not matter if the font is an 8-bit or 2-byte font. These functions return the sum of the character metrics, in pixels.

To determine the width of an 8-bit character string, use **XTextWidth**.

```
int XTextWidth(font_struct, string, count)
      XFontStruct *font_struct;
      char *string;
      int count;
```

font_struct Specifies the font used for the width computation.

string Specifies the character string.

count Specifies the character count in the specified string.

To determine the width of a 2-byte character string, use **XTextWidth16**.

```
int XTextWidth16(font_struct, string, count)
      XFontStruct *font_struct;
      XChar2b *string;
      int count;
```

font_struct Specifies the font used for the width computation.

string Specifies the character string.

count Specifies the character count in the specified string.

6.5.5. Computing Logical Extents

To compute the bounding box of an 8-bit character string in a given font, use **XTextExtents**.

```
XTextExtents(font_struct, string, nchars, direction_return, font_ascent_return,
            font_descent_return, overall_return)
      XFontStruct *font_struct;
      char *string;
      int nchars;
      int *direction_return;
      int *font_ascent_return, *font_descent_return;
      XCharStruct *overall_return;
```

font_struct Specifies a pointer to the **XFontStruct** structure.

string Specifies the character string.

nchars Specifies the number of characters in the character string.

direction_return
Returns the value of the direction hint (**FontLeftToRight** or **FontRightToLeft**).

font_ascent_return
Returns the font ascent.

font_descent_return
Returns the font descent.

overall_return Returns the overall size in the specified **XCharStruct** structure.

To compute the bounding box of a 2-byte character string in a given font, use **XTextExtents16**.

```
XTextExtents16(font_struct, string, nchars, direction_return, font_ascent_return,
        font_descent_return, overall_return)
    XFontStruct *font_struct;
    XChar2b *string;
    int nchars;
    int *direction_return;
    int *font_ascent_return, *font_descent_return;
    XCharStruct *overall_return;
```

font_struct Specifies a pointer to the **XFontStruct** structure.

string Specifies the character string.

nchars Specifies the number of characters in the character string.

direction_return
Returns the value of the direction hint (**FontLeftToRight** or **FontRightToLeft**).

font_ascent_return
Returns the font ascent.

font_descent_return
Returns the font descent.

overall_return Returns the overall size in the specified **XCharStruct** structure.

The **XTextExtents** and **XTextExtents16** functions perform the size computation locally and, thereby, avoid the round-trip overhead of **XQueryTextExtents** and **XQueryTextExtents16**. Both functions return an **XCharStruct** structure, whose members are set to the values as follows.

The ascent member is set to the maximum of the ascent metrics of all characters in the string. The descent member is set to the maximum of the descent metrics. The width member is set to the sum of the character-width metrics of all characters in the string. For each character in the string, let W be the sum of the character-width metrics of all characters preceding it in the string. Let L be the left-side-bearing metric of the character plus W. Let R be the right-side-bearing metric of the character plus W. The lbearing member is set to the minimum L of all characters in the string. The rbearing member is set to the maximum R.

For fonts defined with linear indexing rather than 2-byte matrix indexing, each **XChar2b** structure is interpreted as a 16-bit number with byte1 as the most-significant byte. If the font has no defined default character, undefined characters in the string are taken to have all zero metrics.

6.5.6. Querying Character String Sizes

To query the server for the bounding box of an 8-bit character string in a given font, use **XQueryTextExtents**.

XQueryTextExtents(*display*, *font_ID*, *string*, *nchars*, *direction_return*, *font_ascent_return*, *font_descent_return*, *overall_return*)
    Display **display*;
    XID *font_ID*;
    char **string*;
    int *nchars*;
    int **direction_return*;
    int **font_ascent_return*, **font_descent_return*;
    XCharStruct **overall_return*;

display Specifies the connection to the X server.

font_ID Specifies either the font ID or the **GContext** ID that contains the font.

string Specifies the character string.

nchars Specifies the number of characters in the character string.

direction_return
Returns the value of the direction hint (**FontLeftToRight** or **FontRightToLeft**).

font_ascent_return
Returns the font ascent.

font_descent_return
Returns the font descent.

overall_return Returns the overall size in the specified **XCharStruct** structure.

To query the server for the bounding box of a 2-byte character string in a given font, use **XQueryTextExtents16**.

XQueryTextExtents16(*display*, *font_ID*, *string*, *nchars*, *direction_return*, *font_ascent_return*, *font_descent_return*, *overall_return*)
    Display **display*;
    XID *font_ID*;
    XChar2b **string*;
    int *nchars*;
    int **direction_return*;
    int **font_ascent_return*, **font_descent_return*;
    XCharStruct **overall_return*;

display Specifies the connection to the X server.

font_ID Specifies either the font ID or the **GContext** ID that contains the font.

string Specifies the character string.

nchars Specifies the number of characters in the character string.

direction_return
Returns the value of the direction hint (**FontLeftToRight** or **FontRightToLeft**).

font_ascent_return
Returns the font ascent.

font_descent_return
Returns the font descent.

overall_return Returns the overall size in the specified **XCharStruct** structure.

The **XQueryTextExtents** and **XQueryTextExtents16** functions return the bounding box of the specified 8-bit and 16-bit character string in the specified font or the font contained in the specified GC. These functions query the X server and, therefore, suffer the round-trip overhead that is avoided by **XTextExtents** and **XTextExtents16**. Both functions return a **XCharStruct** structure, whose members are set to the values as follows.

The ascent member is set to the maximum of the ascent metrics of all characters in the string. The descent member is set to the maximum of the descent metrics. The width member is set to the sum of the character-width metrics of all characters in the string. For each character in the string, let W be the sum of the character-width metrics of all characters preceding it in the string. Let L be the left-side-bearing metric of the character plus W. Let R be the right-side-bearing metric of the character plus W. The lbearing member is set to the minimum L of all characters in the string. The rbearing member is set to the maximum R.

For fonts defined with linear indexing rather than 2-byte matrix indexing, each **XChar2b** structure is interpreted as a 16-bit number with byte1 as the most-significant byte. If the font has no defined default character, undefined characters in the string are taken to have all zero metrics.

XQueryTextExtents and **XQueryTextExtents16** can generate **BadFont** and **BadGC** errors.

6.6. Drawing Text

This section discusses how to draw:

- Complex text
- Text characters
- Image text characters

The fundamental text functions **XDrawText** and **XDrawText16** use the following structures.

```
typedef struct {
        char *chars;            /* pointer to string */
        int nchars;             /* number of characters */
        int delta;              /* delta between strings */
        Font font;              /* Font to print it in, None don't change */
} XTextItem;

typedef struct {
        XChar2b *chars;         /* pointer to two-byte characters */
        int nchars;             /* number of characters */
        int delta;              /* delta between strings */
        Font font;              /* font to print it in, None don't change */
} XTextItem16;
```

If the font member is not **None**, the font is changed before printing and also is stored in the GC. If an error was generated during text drawing, the previous items may have been drawn. The baseline of the characters are drawn starting at the x and y coordinates that you pass in the text drawing functions.

For example, consider the background rectangle drawn by **XDrawImageString**. If you want the upper-left corner of the background rectangle to be at pixel coordinate (x,y), pass the (x,y + ascent) as the baseline origin coordinates to the text functions. The ascent is the font ascent, as given in the **XFontStruct** structure. If you want the lower-left corner of the background rectangle to be at pixel coordinate (x,y), pass the (x,y – descent + 1) as the baseline origin coordinates to the text functions. The descent is the font descent, as given in the **XFontStruct** structure.

6.6.1. Drawing Complex Text

To draw 8-bit characters in a given drawable, use **XDrawText**.

```
XDrawText(display, d, gc, x, y, items, nitems)
      Display *display;
      Drawable d;
      GC gc;
      int x, y;
      XTextItem *items;
      int nitems;
```

display	Specifies the connection to the X server.
d	Specifies the drawable.
gc	Specifies the GC.
x	
y	Specify the x and y coordinates, which are relative to the origin of the specified drawable and define the origin of the first character.
items	Specifies a pointer to an array of text items.
nitems	Specifies the number of text items in the array.

To draw 2-byte characters in a given drawable, use **XDrawText16**.

```
XDrawText16(display, d, gc, x, y, items, nitems)
      Display *display;
      Drawable d;
      GC gc;
      int x, y;
      XTextItem16 *items;
      int nitems;
```

display	Specifies the connection to the X server.
d	Specifies the drawable.
gc	Specifies the GC.
x	
y	Specify the x and y coordinates, which are relative to the origin of the specified drawable and define the origin of the first character.
items	Specifies a pointer to an array of text items.
nitems	Specifies the number of text items in the array.

The **XDrawText16** function is similar to **XDrawText** except that it uses 2-byte or 16-bit characters. Both functions allow complex spacing and font shifts between counted strings.

Each text item is processed in turn. A font member other than **None** in an item causes the font to be stored in the GC and used for subsequent text. A text element delta specifies an additional change in the position along the x axis before the string is drawn. The delta is always added to the character origin and is not dependent on any characteristics of the font. Each character image, as defined by the font in the GC, is treated as an additional mask for a fill operation on the drawable. The drawable is modified only where the font character has a bit set to 1. If a text item generates a **BadFont** error, the previous text items may have been drawn.

For fonts defined with linear indexing rather than 2-byte matrix indexing, each **XChar2b** structure is interpreted as a 16-bit number with byte1 as the most-significant byte.

Both functions use these GC components: function, plane-mask, fill-style, font, subwindow-mode, clip-x-origin, clip-y-origin, and clip-mask. They also use these GC mode-dependent components: foreground, background, tile, stipple, tile-stipple-x-origin, and tile-stipple-y-origin.

XDrawText and **XDrawText16** can generate **BadDrawable**, **BadFont**, **BadGC**, and **BadMatch** errors.

6.6.2. Drawing Text Characters

To draw 8-bit characters in a given drawable, use **XDrawString**.

XDrawString(*display*, *d*, *gc*, *x*, *y*, *string*, *length*)
    Display **display*;
    Drawable *d*;
    GC *gc*;
    int *x*, *y*;
    char **string*;
    int *length*;

display Specifies the connection to the X server.

d Specifies the drawable.

gc Specifies the GC.

x
y Specify the x and y coordinates, which are relative to the origin of the specified drawable and define the origin of the first character.

string Specifies the character string.

length Specifies the number of characters in the string argument.

To draw 2-byte characters in a given drawable, use **XDrawString16**.

XDrawString16(*display*, *d*, *gc*, *x*, *y*, *string*, *length*)
    Display **display*;
    Drawable *d*;
    GC *gc*;
    int *x*, *y*;
    XChar2b **string*;
    int *length*;

display Specifies the connection to the X server.

d Specifies the drawable.

gc Specifies the GC.

x
y Specify the x and y coordinates, which are relative to the origin of the specified drawable and define the origin of the first character.

string Specifies the character string.

length Specifies the number of characters in the string argument.

Each character image, as defined by the font in the GC, is treated as an additional mask for a fill operation on the drawable. The drawable is modified only where the font character has a bit set to 1. For fonts defined with 2-byte matrix indexing and used with **XDrawString16**, each byte is used as a byte2 with a byte1 of zero.

Both functions use these GC components: function, plane-mask, fill-style, font, subwindow-mode, clip-x-origin, clip-y-origin, and clip-mask. They also use these GC mode-dependent components: foreground, background, tile, stipple, tile-stipple-x-origin, and tile-stipple-y-origin.

XDrawString and **XDrawString16** can generate **BadDrawable**, **BadGC**, and **BadMatch** errors.

6.6.3. Drawing Image Text Characters

Some applications, in particular terminal emulators, need to print image text in which both the foreground and background bits of each character are painted. This prevents annoying flicker on many displays.

To draw 8-bit image text characters in a given drawable, use **XDrawImageString**.

```
XDrawImageString(display, d, gc, x, y, string, length)
      Display *display;
      Drawable d;
      GC gc;
      int x, y;
      char *string;
      int length;
```

display	Specifies the connection to the X server.
d	Specifies the drawable.
gc	Specifies the GC.
x	
y	Specify the x and y coordinates, which are relative to the origin of the specified drawable and define the origin of the first character.
string	Specifies the character string.
length	Specifies the number of characters in the string argument.

To draw 2-byte image text characters in a given drawable, use **XDrawImageString16**.

```
XDrawImageString16(display, d, gc, x, y, string, length)
      Display *display;
      Drawable d;
      GC gc;
      int x, y;
      XChar2b *string;
      int length;
```

display	Specifies the connection to the X server.
d	Specifies the drawable.
gc	Specifies the GC.
x	
y	Specify the x and y coordinates, which are relative to the origin of the specified drawable and define the origin of the first character.
string	Specifies the character string.
length	Specifies the number of characters in the string argument.

The **XDrawImageString16** function is similar to **XDrawImageString** except that it uses 2-byte or 16-bit characters. Both functions also use both the foreground and background pixels of the GC in the destination.

The effect is first to fill a destination rectangle with the background pixel defined in the GC and then to paint the text with the foreground pixel. The upper-left corner of the filled rectangle is at:

[x, y – font-ascent]

The width is:

overall-width

The height is:

font-ascent + font-descent

The overall-width, font-ascent, and font-descent are as would be returned by **XQueryTextExtents** using gc and string. The function and fill-style defined in the GC are ignored for these functions. The effective function is **GXcopy**, and the effective fill-style is **FillSolid**.

For fonts defined with 2-byte matrix indexing and used with **XDrawImageString**, each byte is used as a byte2 with a byte1 of zero.

Both functions use these GC components: plane-mask, foreground, background, font, subwindow-mode, clip-x-origin, clip-y-origin, and clip-mask.

XDrawImageString and **XDrawImageString16** can generate **BadDrawable**, **BadGC**, and **BadMatch** errors.

6.7. Transferring Images between Client and Server

Xlib provides functions that you can use to transfer images between a client and the server. Because the server may require diverse data formats, Xlib provides an image object that fully describes the data in memory and that provides for basic operations on that data. You should reference the data through the image object rather than referencing the data directly. However, some implementations of the Xlib library may efficiently deal with frequently used data formats by replacing functions in the procedure vector with special case functions. Supported operations include destroying the image, getting a pixel, storing a pixel, extracting a subimage of an image, and adding a constant to an image (see chapter 10).

All the image manipulation functions discussed in this section make use of the **XImage** data structure, which describes an image as it exists in the client's memory.

```
typedef struct _XImage {
	int width, height;		/* size of image */
	int xoffset;			/* number of pixels offset in X direction */
	int format;			/* XYBitmap, XYPixmap, ZPixmap */
	char *data;			/* pointer to image data */
	int byte_order;			/* data byte order, LSBFirst, MSBFirst */
	int bitmap_unit;		/* quant. of scanline 8, 16, 32 */
	int bitmap_bit_order;		/* LSBFirst, MSBFirst */
	int bitmap_pad;			/* 8, 16, 32 either XY or ZPixmap */
	int depth;			/* depth of image */
	int bytes_per_line;		/* accelerator to next scanline */
	int bits_per_pixel;		/* bits per pixel (ZPixmap) */
	unsigned long red_mask;		/* bits in z arrangement */
	unsigned long green_mask;
	unsigned long blue_mask;
	char *obdata;			/* hook for the object routines to hang on */
	struct funcs {			/* image manipulation routines */
		struct _XImage *(*create_image)();
		int (*destroy_image)();
		unsigned long (*get_pixel)();
```

```
                int (*put_pixel)();
                struct _XImage *(*sub_image)();
                int (*add_pixel)();
        } f;
} XImage;
```

You may request that some of the members (for example, height, width, and xoffset) be changed when the image is sent to the server. That is, you may send a subset of the image. Other members (for example, byte_order, bitmap_unit, and so forth) are characteristics of both the image and the server. If these members differ between the image and the server, **XPutImage** makes the appropriate conversions. The first byte of the first scanline of plane n is located at the address (data + (n * height * bytes_per_line)).

To combine an image in memory with a rectangle of a drawable on the display, use **XPutImage**.

XPutImage(*display*, *d*, *gc*, *image*, *src_x*, *src_y*, *dest_x*, *dest_y*, *width*, *height*)
      Display **display*;
      Drawable *d*;
      GC *gc*;
      XImage **image*;
      int *src_x*, *src_y*;
      int *dest_x*, *dest_y*;
      unsigned int *width*, *height*;

display	Specifies the connection to the X server.
d	Specifies the drawable.
gc	Specifies the GC.
image	Specifies the image you want combined with the rectangle.
src_x	Specifies the offset in X from the left edge of the image defined by the **XImage** data structure.
src_y	Specifies the offset in Y from the top edge of the image defined by the **XImage** data structure.
dest_x *dest_y*	Specify the x and y coordinates, which are relative to the origin of the drawable and are the coordinates of the subimage.
width *height*	Specify the width and height of the subimage, which define the dimensions of the rectangle.

The **XPutImage** function combines an image in memory with a rectangle of the specified drawable. If **XYBitmap** format is used, the depth must be one, or a **BadMatch** error results. The foreground pixel in the GC defines the source for the one bits in the image, and the background pixel defines the source for the zero bits. For **XYPixmap** and **ZPixmap**, the depth must match the depth of the drawable, or a **BadMatch** error results. The section of the image defined by the src_x, src_y, width, and height arguments is drawn on the specified part of the drawable.

This function uses these GC components: function, plane-mask, subwindow-mode, clip-x-origin, clip-y-origin, and clip-mask. It also uses these GC mode-dependent components: foreground and background.

XPutImage can generate **BadDrawable**, **BadGC**, **BadMatch**, and **BadValue** errors.

To return the contents of a rectangle in a given drawable on the display, use **XGetImage**. This function specifically supports rudimentary screen dumps.

XImage *XGetImage(*display, d, x, y, width, height, plane_mask, format*)
    Display **display*;
    Drawable *d*;
    int *x*, *y*;
    unsigned int *width*, *height*;
    long *plane_mask*;
    int *format*;

display	Specifies the connection to the X server.
d	Specifies the drawable.
x *y*	Specify the x and y coordinates, which are relative to the origin of the drawable and define the upper-left corner of the rectangle.
width *height*	Specify the width and height of the subimage, which define the dimensions of the rectangle.
plane_mask	Specifies the plane mask.
format	Specifies the format for the image. You can pass **XYBitmap**, **XYPixmap**, or **ZPixmap**.

The **XGetImage** function returns a pointer to an **XImage** structure. This structure provides you with the contents of the specified rectangle of the drawable in the format you specify. If the format argument is **XYPixmap**, the image contains only the bit planes you passed to the plane_mask argument. If the plane_mask argument only requests a subset of the planes of the display, the depth of the returned image will be the number of planes requested. If the format argument is **ZPixmap**, **XGetImage** returns as zero the bits in all planes not specified in the plane_mask argument. The function performs no range checking on the values in plane_mask and ignores extraneous bits.

XGetImage returns the depth of the image to the depth member of the **XImage** structure. The depth of the image is as specified when the drawable was created, except when getting a subset of the planes in **XYPixmap** format, when the depth is given by the number of bits set to 1 in plane_mask.

If the drawable is a pixmap, the given rectangle must be wholly contained within the pixmap, or a **BadMatch** error results. If the drawable is a window, the window must be viewable, and it must be the case that if there were no inferiors or overlapping windows, the specified rectangle of the window would be fully visible on the screen and wholly contained within the outside edges of the window, or a **BadMatch** error results. Note that the borders of the window can be included and read with this request. If the window has backing-store, the backing-store contents are returned for regions of the window that are obscured by noninferior windows. If the window does not have backing-store, the returned contents of such obscured regions are undefined. The returned contents of visible regions of inferiors of a different depth than the specified window's depth are also undefined. The pointer cursor image is not included in the returned contents.

XGetImage can generate **BadDrawable**, **BadMatch**, and **BadValue** errors.

To copy the contents of a rectangle on the display to a location within a preexisting image structure, use **XGetSubImage**.

XImage *XGetSubImage(*display*, *d*, *x*, *y*, *width*, *height*, *plane_mask*, *format*, *dest_image*, *dest_x*, *dest_y*)
    Display **display*;
    Drawable *d*;
    int *x*, *y*;
    unsigned int *width*, *height*;
    unsigned long *plane_mask*;
    int *format*;
    XImage **dest_image*;
    int *dest_x*, *dest_y*;

display Specifies the connection to the X server.

d Specifies the drawable.

x
y Specify the x and y coordinates, which are relative to the origin of the drawable and define the upper-left corner of the rectangle.

width
height Specify the width and height of the subimage, which define the dimensions of the rectangle.

plane_mask Specifies the plane mask.

format Specifies the format for the image. You can pass **XYBitmap**, **XYPixmap**, or **ZPixmap**.

dest_image Specify the destination image.

dest_x
dest_y Specify the x and y coordinates, which are relative to the origin of the destination rectangle, specify its upper-left corner, and determine where the subimage is placed in the destination image.

The **XGetSubImage** function updates dest_image with the specified subimage in the same manner as **XGetImage**. If the format argument is **XYPixmap**, the image contains only the bit planes you passed to the plane_mask argument. If the format argument is **ZPixmap**, **XGetSubImage** returns as zero the bits in all planes not specified in the plane_mask argument. The function performs no range checking on the values in plane_mask and ignores extraneous bits. As a convenience, **XGetSubImage** returns a pointer to the same **XImage** structure specified by dest_image.

The depth of the destination **XImage** structure must be the same as that of the drawable. If the specified subimage does not fit at the specified location on the destination image, the right and bottom edges are clipped. If the drawable is a pixmap, the given rectangle must be wholly contained within the pixmap, or a **BadMatch** error results. If the drawable is a window, the window must be viewable, and it must be the case that if there were no inferiors or overlapping windows, the specified rectangle of the window would be fully visible on the screen and wholly contained within the outside edges of the window, or a **BadMatch** error results. If the window has backing-store, then the backing-store contents are returned for regions of the window that are obscured by noninferior windows. If the window does not have backing-store, the returned contents of such obscured regions are undefined. The returned contents of visible regions of inferiors of a different depth than the specified window's depth are also undefined.

XGetSubImage can generate **BadDrawable**, **BadGC**, **BadMatch**, and **BadValue** errors.

6.8. Cursors

This section discusses how to:

- Create a cursor
- Change or destroy a cursor
- Define the cursor for a window

Each window can have a different cursor defined for it. Whenever the pointer is in a visible window, it is set to the cursor defined for that window. If no cursor was defined for that window, the cursor is the one defined for the parent window.

From X's perspective, a cursor consists of a cursor source, mask, colors, and a hotspot. The mask pixmap determines the shape of the cursor and must be a depth of one. The source pixmap must have a depth of one, and the colors determine the colors of the source. The hotspot defines the point on the cursor that is reported when a pointer event occurs. There may be limitations imposed by the hardware on cursors as to size and whether a mask is implemented. **XQueryBestCursor** can be used to find out what sizes are possible. It is intended that most standard cursors will be stored as a special font.

6.8.1. Creating a Cursor

Xlib provides functions that you can use to create a font, bitmap, or glyph cursor.

To create a cursor from a standard font, use **XCreateFontCursor**.

```
#include <X11/cursorfont.h>

Cursor XCreateFontCursor(display, shape)
      Display *display;
      unsigned int shape;
```

display	Specifies the connection to the X server.
shape	Specifies the shape of the cursor.

X provides a set of standard cursor shapes in a special font named cursor. Applications are encouraged to use this interface for their cursors because the font can be customized for the individual display type. The shape argument specifies which glyph of the standard fonts to use.

The hotspot comes from the information stored in the cursor font. The initial colors of a cursor are a black foreground and a white background (see **XRecolorCursor**). For further information about cursor shapes, see appendix B.

XCreateFontCursor can generate **BadAlloc** and **BadValue** errors.

To create a cursor from two bitmaps, use **XCreatePixmapCursor**.

```
Cursor XCreatePixmapCursor(display, source, mask, foreground_color, background_color, x, y)
      Display *display;
      Pixmap source;
      Pixmap mask;
      XColor *foreground_color;
      XColor *background_color;
      unsigned int x, y;
```

display	Specifies the connection to the X server.
source	Specifies the shape of the source cursor.
mask	Specifies the cursor's source bits to be displayed or **None**.

foreground_color
Specifies the RGB values for the foreground of the source.

background_color
Specifies the RGB values for the background of the source.

x
y Specify the x and y coordinates, which indicate the hotspot relative to the source's origin.

The **XCreatePixmapCursor** function creates a cursor and returns the cursor ID associated with it. The foreground and background RGB values must be specified using foreground_color and background_color, even if the X server only has a **StaticGray** or **GrayScale** screen. The foreground color is used for the pixels set to 1 in the source, and the background color is used for the pixels set to 0. Both source and mask, if specified, must have depth one (or a **BadMatch** error results) but can have any root. The mask argument defines the shape of the cursor. The pixels set to 1 in the mask define which source pixels are displayed, and the pixels set to 0 define which pixels are ignored. If no mask is given, all pixels of the source are displayed. The mask, if present, must be the same size as the pixmap defined by the source argument, or a **BadMatch** error results. The hotspot must be a point within the source, or a **BadMatch** error results.

The components of the cursor can be transformed arbitrarily to meet display limitations. The pixmaps can be freed immediately if no further explicit references to them are to be made. Subsequent drawing in the source or mask pixmap has an undefined effect on the cursor. The X server might or might not make a copy of the pixmap.

XCreatePixmapCursor can generate **BadAlloc** and **BadPixmap** errors.

To create a cursor from font glyphs, use **XCreateGlyphCursor**.

Cursor XCreateGlyphCursor(*display*, *source_font*, *mask_font*, *source_char*, *mask_char*,
    foreground_color, *background_color*)
  Display **display*;
  Font *source_font*, *mask_font*;
  unsigned int *source_char*, *mask_char*;
  XColor **foreground_color*;
  XColor **background_color*;

display Specifies the connection to the X server.

source_font Specifies the font for the source glyph.

mask_font Specifies the font for the mask glyph or **None**.

source_char Specifies the character glyph for the source.

mask_char Specifies the glyph character for the mask.

foreground_color
Specifies the RGB values for the foreground of the source.

background_color
Specifies the RGB values for the background of the source.

The **XCreateGlyphCursor** function is similar to **XCreatePixmapCursor** except that the source and mask bitmaps are obtained from the specified font glyphs. The source_char must be a defined glyph in source_font, or a **BadValue** error results. If mask_font is given, mask_char must be a defined glyph in mask_font, or a **BadValue** error results. The mask_font and character are optional. The origins of the source_char and mask_char (if defined) glyphs are positioned coincidently and define the hotspot. The source_char and mask_char need not have the same bounding box metrics, and there is no restriction on the placement of the hotspot relative to the bounding boxes. If no mask_char is given, all pixels of the source are displayed. You can free the fonts immediately by calling **XFreeFont** if no further explicit references to them are to be made.

For 2-byte matrix fonts, the 16-bit value should be formed with the byte1 member in the most-significant byte and the byte2 member in the least-significant byte.

XCreateGlyphCursor can generate **BadAlloc**, **BadFont**, and **BadValue** errors.

6.8.2. Changing and Destroying Cursors

Xlib provides functions that you can use to change the cursor color, destroy the cursor, and determine the best cursor size.

To change the color of a given cursor, use **XRecolorCursor**.

```
XRecolorCursor(display, cursor, foreground_color, background_color)
      Display *display;
      Cursor cursor;
      XColor *foreground_color, *background_color;
```

display Specifies the connection to the X server.

cursor Specifies the cursor.

foreground_color
Specifies the RGB values for the foreground of the source.

background_color
Specifies the RGB values for the background of the source.

The **XRecolorCursor** function changes the color of the specified cursor, and if the cursor is being displayed on a screen, the change is visible immediately.

XRecolorCursor can generate a **BadCursor** error.

To free (destroy) a given cursor, use **XFreeCursor**.

```
XFreeCursor(display, cursor)
      Display *display;
      Cursor cursor;
```

display Specifies the connection to the X server.

cursor Specifies the cursor.

The **XFreeCursor** function deletes the association between the cursor resource ID and the specified cursor. The cursor storage is freed when no other resource references it. The specified cursor ID should not be referred to again.

XFreeCursor can generate a **BadCursor** error.

To determine useful cursor sizes, use **XQueryBestCursor**.

```
Status XQueryBestCursor(display, d, width, height, width_return, height_return)
      Display *display;
      Drawable d;
      unsigned int width, height;
      unsigned int *width_return, *height_return;
```

display Specifies the connection to the X server.

d Specifies the drawable, which indicates the screen.

width

height Specify the width and height of the cursor that you want the size information for.

width_return
height_return Return the best width and height that is closest to the specified width and height.

Some displays allow larger cursors than other displays. The **XQueryBestCursor** function provides a way to find out what size cursors are actually possible on the display. It returns the largest size that can be displayed. Applications should be prepared to use smaller cursors on displays that cannot support large ones.

XQueryBestCursor can generate a **BadDrawable** error.

6.8.3. Defining the Cursor

Xlib provides functions that you can use to define or undefine the cursor that should be displayed in a window.

To define which cursor will be used in a window, use **XDefineCursor**.

```
XDefineCursor(display, w, cursor)
      Display *display;
      Window w;
      Cursor cursor;
```

display Specifies the connection to the X server.

w Specifies the window.

cursor Specifies the cursor that is to be displayed or **None**.

If a cursor is set, it will be used when the pointer is in the window. If the cursor is **None**, it is equivalent to **XUndefineCursor**.

XDefineCursor can generate **BadCursor** and **BadWindow** errors.

To undefine the cursor in a given window, use **XUndefineCursor**.

```
XUndefineCursor(display, w)
      Display *display;
      Window w;
```

display Specifies the connection to the X server.

w Specifies the window.

The **XUndefineCursor** undoes the effect of a previous **XDefineCursor** for this window. When the pointer is in the window, the parent's cursor will now be used. On the root window, the default cursor is restored.

XUndefineCursor can generate a **BadWindow** error.

Chapter 7

Window Manager Functions

Although it is difficult to categorize functions as application only or window manager only, the functions in this chapter are most often used by window managers. It is not expected that these functions will be used by most application programs. You can use the Xlib window manager functions to:

- Change the parent of a window
- Control the lifetime of a window
- Determine resident colormaps
- Grab the pointer
- Grab the keyboard
- Grab the server
- Control event processing
- Manipulate the keyboard and pointer settings
- Control the screen saver
- Control host access

7.1. Changing the Parent of a Window

To change a window's parent to another window on the same screen, use **XReparentWindow**. There is no way to move a window between screens.

```
XReparentWindow(display, w, parent, x, y)
      Display *display;
      Window w;
      Window parent;
      int x, y;
```

display Specifies the connection to the X server.

w Specifies the window.

parent Specifies the parent window.

x
y Specify the x and y coordinates of the position in the new parent window.

If the specified window is mapped, **XReparentWindow** automatically performs an **UnmapWindow** request on it, removes it from its current position in the hierarchy, and inserts it as the child of the specified parent. The window is placed in the stacking order on top with respect to sibling windows.

After reparenting the specified window, **XReparentWindow** causes the X server to generate a **ReparentNotify** event. The override_redirect member returned in this event is set to the window's corresponding attribute. Window manager clients usually should ignore this window if this member is set to **True**. Finally, if the specified window was originally mapped, the X server automatically performs a **MapWindow** request on it.

The X server performs normal exposure processing on formerly obscured windows. The X server might not generate **Expose** events for regions from the initial **UnmapWindow** request that are immediately obscured by the final **MapWindow** request. A

BadMatch error results if:

- The new parent window is not on the same screen as the old parent window.
- The new parent window is the specified window or an inferior of the specified window.
- The specified window has a **ParentRelative** background, and the new parent window is not the same depth as the specified window.

XReparentWindow can generate **BadMatch** and **BadWindow** errors.

7.2. Controlling the Lifetime of a Window

The save-set of a client is a list of other clients' windows that, if they are inferiors of one of the client's windows at connection close, should not be destroyed and should be remapped if they are unmapped. For further information about close-connection processing, see section 2.6. To allow an application's window to survive when a window manager that has reparented a window fails, Xlib provides the save-set functions that you can use to control the longevity of subwindows that are normally destroyed when the parent is destroyed. For example, a window manager that wants to add decoration to a window by adding a frame might reparent an application's window. When the frame is destroyed, the application's window should not be destroyed but be returned to its previous place in the window hierarchy.

The X server automatically removes windows from the save-set when they are destroyed.

To add or remove a window from the client's save-set, use **XChangeSaveSet**.

```
XChangeSaveSet(display, w, change_mode)
    Display *display;
    Window w;
    int change_mode;
```

display Specifies the connection to the X server.

w Specifies the window that you want to add to or delete from the client's save-set.

change_mode Specifies the mode. You can pass **SetModeInsert** or **SetModeDelete**.

Depending on the specified mode, **XChangeSaveSet** either inserts or deletes the specified window from the client's save-set. The specified window must have been created by some other client, or a **BadMatch** error results.

XChangeSaveSet can generate **BadMatch**, **BadValue**, and **BadWindow** errors.

To add a window to the client's save-set, use **XAddToSaveSet**.

```
XAddToSaveSet(display, w)
    Display *display;
    Window w;
```

display Specifies the connection to the X server.

w Specifies the window that you want to add to the client's save-set.

The **XAddToSaveSet** function adds the specified window to the client's save-set. The specified window must have been created by some other client, or a **BadMatch** error results.

XAddToSaveSet can generate **BadMatch** and **BadWindow** errors.

To remove a window from the client's save-set, use **XRemoveFromSaveSet**.

```
XRemoveFromSaveSet(display, w)
      Display *display;
      Window w;
```

display Specifies the connection to the X server.

w Specifies the window that you want to delete from the client's save-set.

The **XRemoveFromSaveSet** function removes the specified window from the client's save-set. The specified window must have been created by some other client, or a **BadMatch** error results.

XRemoveFromSaveSet can generate **BadMatch** and **BadWindow** errors.

7.3. Determining Resident Colormaps

Xlib provides functions that you can use to install a colormap, uninstall a colormap, and obtain a list of installed colormaps.

At any time, there is a subset of the installed maps that is viewed as an ordered list and is called the required list. The length of the required list is at most M, where M is the minimum number of installed colormaps specified for the screen in the connection setup. The required list is maintained as follows. When a colormap is specified to **XInstallColormap**, it is added to the head of the list; the list is truncated at the tail, if necessary, to keep its length to at most M. When a colormap is specified to **XUninstallColormap** and it is in the required list, it is removed from the list. A colormap is not added to the required list when it is implicitly installed by the X server, and the X server cannot implicitly uninstall a colormap that is in the required list.

To install a colormap, use **XInstallColormap**.

```
XInstallColormap(display, colormap)
      Display *display;
      Colormap colormap;
```

display Specifies the connection to the X server.

colormap Specifies the colormap.

The **XInstallColormap** function installs the specified colormap for its associated screen. All windows associated with this colormap immediately display with true colors. You associated the windows with this colormap when you created them by calling **XCreateWindow**, **XCreateSimpleWindow**, **XChangeWindowAttributes**, or **XSetWindowColormap**.

If the specified colormap is not already an installed colormap, the X server generates a **ColormapNotify** event on each window that has that colormap. In addition, for every other colormap that is installed as a result of a call to **XInstallColormap**, the X server generates a **ColormapNotify** event on each window that has that colormap.

XInstallColormap can generate a **BadColor** error.

To uninstall a colormap, use **XUninstallColormap**.

```
XUninstallColormap(display, colormap)
      Display *display;
      Colormap colormap;
```

display Specifies the connection to the X server.

colormap Specifies the colormap.

The **XUninstallColormap** function removes the specified colormap from the required list for its screen. As a result, the specified colormap might be uninstalled, and the X server might implicitly install or uninstall additional colormaps. Which colormaps get installed or uninstalled is server-dependent except that the required list must remain installed.

If the specified colormap becomes uninstalled, the X server generates a **ColormapNotify** event on each window that has that colormap. In addition, for every other colormap that is installed or uninstalled as a result of a call to **XUninstallColormap**, the X server generates a **ColormapNotify** event on each window that has that colormap.

XUninstallColormap can generate a **BadColor** error.

To obtain a list of the currently installed colormaps for a given screen, use **XListInstalledColormaps**.

```
Colormap *XListInstalledColormaps(display, w, num_return)
      Display *display;
      Window w;
      int *num_return;
```

display Specifies the connection to the X server.

w Specifies the window that determines the screen.

num_return Returns the number of currently installed colormaps.

The **XListInstalledColormaps** function returns a list of the currently installed colormaps for the screen of the specified window. The order of the colormaps in the list is not significant and is no explicit indication of the required list. When the allocated list is no longer needed, free it by using **XFree**.

XListInstalledColormaps can generate a **BadWindow** error.

7.4. Pointer Grabbing

Xlib provides functions that you can use to control input from the pointer, which usually is a mouse. Window managers most often use these facilities to implement certain styles of user interfaces. Some toolkits also need to use these facilities for special purposes.

Usually, as soon as keyboard and mouse events occur, the X server delivers them to the appropriate client, which is determined by the window and input focus. The X server provides sufficient control over event delivery to allow window managers to support mouse ahead and various other styles of user interface. Many of these user interfaces depend upon synchronous delivery of events. The delivery of pointer and keyboard events can be controlled independently.

When mouse buttons or keyboard keys are grabbed, events will be sent to the grabbing client rather than the normal client who would have received the event. If the keyboard or pointer is in asynchronous mode, further mouse and keyboard events will continue to be processed. If the keyboard or pointer is in synchronous mode, no further events are processed until the grabbing client allows them (see **XAllowEvents**). The keyboard or pointer is considered frozen during this interval. The event that triggered the grab can also be replayed.

Note that the logical state of a device (as seen by client applications) may lag the physical state if device event processing is frozen.

There are two kinds of grabs: active and passive. An active grab occurs when a single client grabs the keyboard and/or pointer explicitly (see **XGrabPointer** and **XGrabKeyboard**). A passive grab occurs when clients grab a particular keyboard key or pointer button in a window, and the grab will activate when the key or button is actually pressed. Passive grabs are convenient for implementing reliable pop-up menus. For example, you can guarantee that the pop-up is mapped before the up pointer button event occurs by grabbing a button requesting synchronous behavior. The down event will trigger the grab and freeze further processing of pointer events until you have the chance to map the pop-up window. You can then allow further event processing. The up event will then be correctly processed relative to the pop-up window.

For many operations, there are functions that take a time argument. The X server includes a timestamp in various events. One special time, called **CurrentTime**, represents the current server time. The X server maintains the time when the input focus was last changed, when the keyboard was last grabbed, when the pointer was last grabbed, or when a selection was last changed. Your application may be slow reacting to an event. You often need some way to specify that your request should not occur if another application has in the meanwhile taken control of the keyboard, pointer, or selection. By providing the timestamp from the event in the request, you can arrange that the operation not take effect if someone else has performed an operation in the meanwhile.

A timestamp is a time value, expressed in milliseconds. It typically is the time since the last server reset. Timestamp values wrap around (after about 49.7 days). The server, given its current time is represented by timestamp T, always interprets timestamps from clients by treating half of the timestamp space as being later in time than T. One timestamp value, named **CurrentTime**, is never generated by the server. This value is reserved for use in requests to represent the current server time.

For many functions in this section, you pass pointer event mask bits. The valid pointer event mask bits are: **ButtonPressMask**, **ButtonReleaseMask**, **EnterWindowMask**, **LeaveWindowMask**, **PointerMotionMask**, **PointerMotionHintMask**, **Button1MotionMask**, **Button2MotionMask**, **Button3MotionMask**, **Button4MotionMask**, **Button5MotionMask**, **ButtonMotionMask**, and **KeyMapStateMask**. For other functions in this section, you pass keymask bits. The valid keymask bits are: **ShiftMask**, **LockMask**, **ControlMask**, **Mod1Mask**, **Mod2Mask**, **Mod3Mask**, **Mod4Mask**, and **Mod5Mask**.

To grab the pointer, use **XGrabPointer**.

int XGrabPointer(*display*, *grab_window*, *owner_events*, *event_mask*, *pointer_mode*,
        keyboard_mode, *confine_to*, *cursor*, *time*)
    Display **display*;
    Window *grab_window*;
    Bool *owner_events*;
    unsigned int *event_mask*;
    int *pointer_mode*, *keyboard_mode*;
    Window *confine_to*;
    Cursor *cursor*;
    Time *time*;

display Specifies the connection to the X server.

grab_window Specifies the grab window.

owner_events Specifies a Boolean value that indicates whether the pointer events are to be reported as usual or reported with respect to the grab window if selected by the event mask.

event_mask Specifies which pointer events are reported to the client. The mask is the bitwise inclusive OR of the valid pointer event mask bits.

pointer_mode Specifies further processing of pointer events. You can pass **GrabModeSync** or **GrabModeAsync**.

keyboard_mode Specifies further processing of keyboard events. You can pass **GrabModeSync** or **GrabModeAsync**.

confine_to Specifies the window to confine the pointer in or **None**.

cursor Specifies the cursor that is to be displayed during the grab or **None**.

time Specifies the time. You can pass either a timestamp or **CurrentTime**.

The **XGrabPointer** function actively grabs control of the pointer and returns **GrabSuccess** if the grab was successful. Further pointer events are reported only to the grabbing client. **XGrabPointer** overrides any active pointer grab by this client. If owner_events is **False**, all generated pointer events are reported with respect to grab_window and are reported only if selected by event_mask. If owner_events is **True** and if a generated pointer event would normally be reported to this client, it is reported as usual. Otherwise, the event is reported with respect to the grab_window and is reported only if selected by event_mask. For either value of owner_events, unreported events are discarded.

If the pointer_mode is **GrabModeAsync**, pointer event processing continues as usual. If the pointer is currently frozen by this client, the processing of events for the pointer is resumed. If the pointer_mode is **GrabModeSync**, the state of the pointer, as seen by client applications, appears to freeze, and the X server generates no further pointer events until the grabbing client calls **XAllowEvents** or until the pointer grab is released. Actual pointer changes are not lost while the pointer is frozen; they are simply queued in the server for later processing.

If the keyboard_mode is **GrabModeAsync**, keyboard event processing is unaffected by activation of the grab. If the keyboard_mode is **GrabModeSync**, the state of the keyboard, as seen by client applications, appears to freeze, and the X server generates no further keyboard events until the grabbing client calls **XAllowEvents** or until the pointer grab is released. Actual keyboard changes are not lost while the pointer is frozen; they are simply queued in the server for later processing.

If a cursor is specified, it is displayed regardless of what window the pointer is in. If **None** is specified, the normal cursor for that window is displayed when the pointer is in grab_window or one of its subwindows; otherwise, the cursor for grab_window is displayed.

If a confine_to window is specified, the pointer is restricted to stay contained in that window. The confine_to window need have no relationship to the grab_window. If the pointer is not initially in the confine_to window, it is warped automatically to the closest edge just before the grab activates and enter/leave events are generated as usual. If the confine_to window is subsequently reconfigured, the pointer is warped automatically, as necessary, to keep it contained in the window.

The time argument allows you to avoid certain circumstances that come up if applications take a long time to respond or if there are long network delays. Consider a situation where you have two applications, both of which normally grab the pointer when clicked on. If both applications specify the timestamp from the event, the second application may wake up faster and successfully grab the pointer before the first application. The first application then will get an indication that the other application grabbed the pointer before its request was processed.

XGrabPointer generates **EnterNotify** and **LeaveNotify** events.

Either if grab_window or confine_to window is not viewable or if the confine_to window lies completely outside the boundaries of the root window, **XGrabPointer** fails and returns **GrabNotViewable**. If the pointer is actively grabbed by some other client, it fails and returns **AlreadyGrabbed**. If the pointer is frozen by an active grab of another client, it fails and returns **GrabFrozen**. If the specified time is earlier than the last-pointer-grab time or later than the current X server time, it fails and returns **GrabInvalidTime**. Otherwise, the last-pointer-grab time is set to the specified time (**CurrentTime** is replaced by the current X server time).

XGrabPointer can generate **BadCursor**, **BadValue**, and **BadWindow** errors.

To ungrab the pointer, use **XUngrabPointer**.

```
XUngrabPointer(display, time)
      Display *display;
      Time time;
```

display Specifies the connection to the X server.

time Specifies the time. You can pass either a timestamp or **CurrentTime**.

The **XUngrabPointer** function releases the pointer and any queued events if this client has actively grabbed the pointer from **XGrabPointer**, **XGrabButton**, or from a normal button press. **XUngrabPointer** does not release the pointer if the specified time is earlier than the last-pointer-grab time or is later than the current X server time. It also generates **EnterNotify** and **LeaveNotify** events. The X server performs an **UngrabPointer** request automatically if the event window or confine_to window for an active pointer grab becomes not viewable or if window reconfiguration causes the confine_to window to lie completely outside the boundaries of the root window.

To change an active pointer grab, use **XChangeActivePointerGrab**.

```
XChangeActivePointerGrab(display, event_mask, cursor, time)
      Display *display;
      unsigned int event_mask;
      Cursor cursor;
      Time time;
```

display Specifies the connection to the X server.

event_mask Specifies which pointer events are reported to the client. The mask is the bitwise inclusive OR of the valid pointer event mask bits.

cursor Specifies the cursor that is to be displayed or **None**.

time Specifies the time. You can pass either a timestamp or **CurrentTime**.

The **XChangeActivePointerGrab** function changes the specified dynamic parameters if the pointer is actively grabbed by the client and if the specified time is no earlier than the last-pointer-grab time and no later than the current X server time. This function has no effect on the passive parameters of a **XGrabButton**. The interpretation of event_mask and cursor is the same as described in **XGrabPointer**.

XChangeActivePointerGrab can generate **BadCursor** and **BadValue** errors.

To grab a pointer button, use **XGrabButton**.

```
XGrabButton(display, button, modifiers, grab_window, owner_events, event_mask,
            pointer_mode, keyboard_mode, confine_to, cursor)
      Display *display;
      unsigned int button;
      unsigned int modifiers;
      Window grab_window;
      Bool owner_events;
      unsigned int event_mask;
      int pointer_mode, keyboard_mode;
      Window confine_to;
      Cursor cursor;
```

display Specifies the connection to the X server.

button	Specifies the pointer button that is to be grabbed or **AnyButton**.
modifiers	Specifies the set of keymasks or **AnyModifier**. The mask is the bitwise inclusive OR of the valid keymask bits.
grab_window	Specifies the grab window.
owner_events	Specifies a Boolean value that indicates whether the pointer events are to be reported as usual or reported with respect to the grab window if selected by the event mask.
event_mask	Specifies which pointer events are reported to the client. The mask is the bitwise inclusive OR of the valid pointer event mask bits.
pointer_mode	Specifies further processing of pointer events. You can pass **GrabModeSync** or **GrabModeAsync**.
keyboard_mode	Specifies further processing of keyboard events. You can pass **GrabModeSync** or **GrabModeAsync**.
confine_to	Specifies the window to confine the pointer in or **None**.
cursor	Specifies the cursor that is to be displayed or **None**.

The **XGrabButton** function establishes a passive grab. In the future, the pointer is actively grabbed (as for **XGrabPointer**), the last-pointer-grab time is set to the time at which the button was pressed (as transmitted in the **ButtonPress** event), and the **ButtonPress** event is reported if all of the following conditions are true:

- The pointer is not grabbed, and the specified button is logically pressed when the specified modifier keys are logically down, and no other buttons or modifier keys are logically down.
- The grab_window contains the pointer.
- The confine_to window (if any) is viewable.
- A passive grab on the same button/key combination does not exist on any ancestor of grab_window.

The interpretation of the remaining arguments is as for **XGrabPointer**. The active grab is terminated automatically when the logical state of the pointer has all buttons released (independent of the state of the logical modifier keys).

Note that the logical state of a device (as seen by client applications) may lag the physical state if device event processing is frozen.

This request overrides all previous grabs by the same client on the same button/key combinations on the same window. A modifiers of **AnyModifier** is equivalent to issuing the grab request for all possible modifier combinations (including the combination of no modifiers). It is not required that all modifiers specified have currently assigned KeyCodes. A button of **AnyButton** is equivalent to issuing the request for all possible buttons. Otherwise, it is not required that the specified button currently be assigned to a physical button.

If some other client has already issued a **XGrabButton** with the same button/key combination on the same window, a **BadAccess** error results. When using **AnyModifier** or **AnyButton**, the request fails completely, and a **BadAccess** error results (no grabs are established) if there is a conflicting grab for any combination. **XGrabButton** has no effect on an active grab.

XGrabButton can generate **BadCursor**, **BadValue**, and **BadWindow** errors.

To ungrab a pointer button, use **XUngrabButton**.

XUngrabButton(*display*, *button*, *modifiers*, *grab_window*)
    Display **display*;
    unsigned int *button*;
    unsigned int *modifiers*;
    Window *grab_window*;

display Specifies the connection to the X server.

button Specifies the pointer button that is to be released or **AnyButton**.

modifiers Specifies the set of keymasks or **AnyModifier**. The mask is the bitwise inclusive OR of the valid keymask bits.

grab_window Specifies the grab window.

The **XUngrabButton** function releases the passive button/key combination on the specified window if it was grabbed by this client. A modifiers of **AnyModifier** is equivalent to issuing the ungrab request for all possible modifier combinations, including the combination of no modifiers. A button of **AnyButton** is equivalent to issuing the request for all possible buttons. **XUngrabButton** has no effect on an active grab.

XUngrabButton can generate **BadValue** and **BadWindow** errors.

7.5. Keyboard Grabbing

Xlib provides functions that you can use to grab or ungrab the keyboard as well as allow events.

For many functions in this section, you pass keymask bits. The valid keymask bits are: **ShiftMask**, **LockMask**, **ControlMask**, **Mod1Mask**, **Mod2Mask**, **Mod3Mask**, **Mod4Mask**, and **Mod5Mask**.

To grab the keyboard, use **XGrabKeyboard**.

int XGrabKeyboard(*display*, *grab_window*, *owner_events*, *pointer_mode*, *keyboard_mode*, *time*)
    Display **display*;
    Window *grab_window*;
    Bool *owner_events*;
    int *pointer_mode*, *keyboard_mode*;
    Time *time*;

display Specifies the connection to the X server.

grab_window Specifies the grab window.

owner_events Specifies a Boolean value that indicates whether the pointer events are to be reported as usual or reported with respect to the grab window if selected by the event mask.

pointer_mode Specifies further processing of pointer events. You can pass **GrabModeSync** or **GrabModeAsync**.

keyboard_mode Specifies further processing of keyboard events. You can pass **GrabModeSync** or **GrabModeAsync**.

time Specifies the time. You can pass either a timestamp or **CurrentTime**.

The **XGrabKeyboard** function actively grabs control of the keyboard and generates **FocusIn** and **FocusOut** events. Further key events are reported only to the grabbing client. **XGrabKeyboard** overrides any active keyboard grab by this client. If owner_events is **False**, all generated key events are reported with respect to grab_window. If owner_events is **True** and if a generated key event would normally be reported to this client, it is reported normally; otherwise, the event is reported with respect to the grab_window. Both **KeyPress** and **KeyRelease** events are always reported, independent of any event selection made by the client.

If the keyboard_mode argument is **GrabModeAsync**, keyboard event processing continues as usual. If the keyboard is currently frozen by this client, then processing of keyboard events is resumed. If the keyboard_mode argument is **GrabModeSync**, the state of the keyboard (as seen by client applications) appears to freeze, and the X server generates no further keyboard events until the grabbing client issues a releasing **XAllowEvents** call or until the keyboard grab is released. Actual keyboard changes are not lost while the keyboard is frozen; they are simply queued in the server for later processing.

If pointer_mode is **GrabModeAsync**, pointer event processing is unaffected by activation of the grab. If pointer_mode is **GrabModeSync**, the state of the pointer (as seen by client applications) appears to freeze, and the X server generates no further pointer events until the grabbing client issues a releasing **XAllowEvents** call or until the keyboard grab is released. Actual pointer changes are not lost while the pointer is frozen; they are simply queued in the server for later processing.

If the keyboard is actively grabbed by some other client, **XGrabKeyboard** fails and returns **AlreadyGrabbed**. If grab_window is not viewable, it fails and returns **GrabNotViewable**. If the keyboard is frozen by an active grab of another client, it fails and returns **GrabFrozen**. If the specified time is earlier than the last-keyboard-grab time or later than the current X server time, it fails and returns **GrabInvalidTime**. Otherwise, the last-keyboard-grab time is set to the specified time (**CurrentTime** is replaced by the current X server time).

XGrabKeyboard can generate **BadValue** and **BadWindow** errors.

To ungrab the keyboard, use **XUngrabKeyboard**.

XUngrabKeyboard (*display*, *time*)
    Display **display*;
    Time *time*;

display	Specifies the connection to the X server.
time	Specifies the time. You can pass either a timestamp or **CurrentTime**.

The **XUngrabKeyboard** function releases the keyboard and any queued events if this client has it actively grabbed from either **XGrabKeyboard** or **XGrabKey**. **XUngrabKeyboard** does not release the keyboard and any queued events if the specified time is earlier than the last-keyboard-grab time or is later than the current X server time. It also generates **FocusIn** and **FocusOut** events. The X server automatically performs an **UngrabKeyboard** request if the event window for an active keyboard grab becomes not viewable.

To passively grab a single key of the keyboard, use **XGrabKey**.

XGrabKey (*display*, *keycode*, *modifiers*, *grab_window*, *owner_events*, *pointer_mode*,
        keyboard_mode)
    Display **display*;
    int *keycode*;
    unsigned int *modifiers*;
    Window *grab_window*;
    Bool *owner_events*;
    int *pointer_mode*, *keyboard_mode*;

display	Specifies the connection to the X server.
keycode	Specifies the KeyCode or **AnyKey**.
modifiers	Specifies the set of keymasks or **AnyModifier**. The mask is the bitwise inclusive OR of the valid keymask bits.

grab_window Specifies the grab window.

owner_events Specifies a Boolean value that indicates whether the pointer events are to be reported as usual or reported with respect to the grab window if selected by the event mask.

pointer_mode Specifies further processing of pointer events. You can pass **GrabModeSync** or **GrabModeAsync**.

keyboard_mode Specifies further processing of keyboard events. You can pass **GrabModeSync** or **GrabModeAsync**.

The **XGrabKey** function establishes a passive grab on the keyboard. In the future, the keyboard is actively grabbed (as for **XGrabKeyboard**), the last-keyboard-grab time is set to the time at which the key was pressed (as transmitted in the **KeyPress** event), and the **KeyPress** event is reported if all of the following conditions are true:

- The keyboard is not grabbed and the specified key (which can itself be a modifier key) is logically pressed when the specified modifier keys are logically down, and no other modifier keys are logically down.
- Either the grab_window is an ancestor of (or is) the focus window, or the grab_window is a descendant of the focus window and contains the pointer.
- A passive grab on the same key combination does not exist on any ancestor of grab_window.

The interpretation of the remaining arguments is as for **XGrabKeyboard**. The active grab is terminated automatically when the logical state of the keyboard has the specified key released (independent of the logical state of the modifier keys).

Note that the logical state of a device (as seen by client applications) may lag the physical state if device event processing is frozen.

A modifiers argument of **AnyModifier** is equivalent to issuing the request for all possible modifier combinations (including the combination of no modifiers). It is not required that all modifiers specified have currently assigned KeyCodes. A keycode argument of **AnyKey** is equivalent to issuing the request for all possible KeyCodes. Otherwise, the specified keycode must be in the range specified by min_keycode and max_keycode in the connection setup, or a **BadValue** error results.

If some other client has issued a **XGrabKey** with the same key combination on the same window, a **BadAccess** error results. When using **AnyModifier** or **AnyKey**, the request fails completely, and a **BadAccess** error results (no grabs are established) if there is a conflicting grab for any combination.

XGrabKey can generate **BadAccess**, **BadValue**, and **BadWindow** errors.

To ungrab a key, use **XUngrabKey**.

```
XUngrabKey(display, keycode, modifiers, grab_window)
      Display *display;
      int keycode;
      unsigned int modifiers;
      Window grab_window;
```

display Specifies the connection to the X server.

keycode Specifies the KeyCode or **AnyKey**.

modifiers Specifies the set of keymasks or **AnyModifier**. The mask is the bitwise inclusive OR of the valid keymask bits.

grab_window Specifies the grab window.

The **XUngrabKey** function releases the key combination on the specified window if it was grabbed by this client. It has no effect on an active grab. A modifiers of

AnyModifier is equivalent to issuing the request for all possible modifier combinations (including the combination of no modifiers). A keycode argument of **AnyKey** is equivalent to issuing the request for all possible key codes.

XUngrabKey can generate **BadValue** and **BadWindow** errors.

To allow further events to be processed when the device has been frozen, use **XAllowEvents**.

XAllowEvents(*display*, *event_mode*, *time*)
    Display **display*;
    int *event_mode*;
    Time *time*;

display	Specifies the connection to the X server.
event_mode	Specifies the event mode. You can pass **AsyncPointer**, **SyncPointer**, **AsyncKeyboard**, **SyncKeyboard**, **ReplayPointer**, **ReplayKeyboard**, **AsyncBoth**, or **SyncBoth**.
time	Specifies the time. You can pass either a timestamp or **CurrentTime**.

The **XAllowEvents** function releases some queued events if the client has caused a device to freeze. It has no effect if the specified time is earlier than the last-grab time of the most recent active grab for the client or if the specified time is later than the current X server time. Depending on the event_mode argument, the following occurs:

AsyncPointer	If the pointer is frozen by the client, pointer event processing continues as usual. If the pointer is frozen twice by the client on behalf of two separate grabs, **AsyncPointer** thaws for both. **AsyncPointer** has no effect if the pointer is not frozen by the client, but the pointer need not be grabbed by the client.
SyncPointer	If the pointer is frozen and actively grabbed by the client, pointer event processing continues as usual until the next **ButtonPress** or **ButtonRelease** event is reported to the client. At this time, the pointer again appears to freeze. However, if the reported event causes the pointer grab to be released, the pointer does not freeze. **SyncPointer** has no effect if the pointer is not frozen by the client or if the pointer is not grabbed by the client.
ReplayPointer	If the pointer is actively grabbed by the client and is frozen as the result of an event having been sent to the client (either from the activation of a **XGrabButton** or from a previous **XAllowEvents** with mode **SyncPointer** but not from a **XGrabPointer**), the pointer grab is released and that event is completely reprocessed. This time, however, the function ignores any passive grabs at or above (towards the root of) the grab_window of the grab just released. The request has no effect if the pointer is not grabbed by the client or if the pointer is not frozen as the result of an event.
AsyncKeyboard	If the keyboard is frozen by the client, keyboard event processing continues as usual. If the keyboard is frozen twice by the client on behalf of two separate grabs, **AsyncKeyboard** thaws for both. **AsyncKeyboard** has no effect if the keyboard is not frozen by the client, but the keyboard need not be grabbed by the client.

SyncKeyboard	If the keyboard is frozen and actively grabbed by the client, keyboard event processing continues as usual until the next **KeyPress** or **KeyRelease** event is reported to the client. At this time, the keyboard again appears to freeze. However, if the reported event causes the keyboard grab to be released, the keyboard does not freeze. **SyncKeyboard** has no effect if the keyboard is not frozen by the client or if the keyboard is not grabbed by the client.
ReplayKeyboard	If the keyboard is actively grabbed by the client and is frozen as the result of an event having been sent to the client (either from the activation of a **XGrabKey** or from a previous **XAllowEvents** with mode **SyncKeyboard** but not from a **XGrabKeyboard**), the keyboard grab is released and that event is completely reprocessed. This time, however, the function ignores any passive grabs at or above (towards the root of) the grab_window of the grab just released. The request has no effect if the keyboard is not grabbed by the client or if the keyboard is not frozen as the result of an event.
SyncBoth	If both pointer and keyboard are frozen by the client, event processing for both devices continues as usual until the next **ButtonPress**, **ButtonRelease**, **KeyPress**, or **KeyRelease** event is reported to the client for a grabbed device (button event for the pointer, key event for the keyboard), at which time the devices again appear to freeze. However, if the reported event causes the grab to be released, then the devices do not freeze (but if the other device is still grabbed, then a subsequent event for it will still cause both devices to freeze). **SyncBoth** has no effect unless both pointer and keyboard are frozen by the client. If the pointer or keyboard is frozen twice by the client on behalf of two separate grabs, **SyncBoth** thaws for both (but a subsequent freeze for **SyncBoth** will only freeze each device once).
AsyncBoth	If the pointer and the keyboard are frozen by the client, event processing for both devices continues as usual. If a device is frozen twice by the client on behalf of two separate grabs, **AsyncBoth** thaws for both. **AsyncBoth** has no effect unless both pointer and keyboard are frozen by the client.

AsyncPointer, **SyncPointer**, and **ReplayPointer** have no effect on the processing of keyboard events. **AsyncKeyboard**, **SyncKeyboard**, and **ReplayKeyboard** have no effect on the processing of pointer events. It is possible for both a pointer grab and a keyboard grab (by the same or different clients) to be active simultaneously. If a device is frozen on behalf of either grab, no event processing is performed for the device. It is possible for a single device to be frozen because of both grabs. In this case, the freeze must be released on behalf of both grabs before events can again be processed.

XAllowEvents can generate a **BadValue** error.

7.6. Server Grabbing

Xlib provides functions that you can use to grab and ungrab the server. These functions can be used to control processing of output on other connections by the window system server. While the server is grabbed, no processing of requests or close downs on any other connection will occur. A client closing its connection automatically ungrabs the server. Although grabbing the server is highly discouraged, it is sometimes necessary.

To grab the server, use **XGrabServer**.

```
XGrabServer(display)
    Display *display;
```

display Specifies the connection to the X server.

The **XGrabServer** function disables processing of requests and close downs on all other connections than the one this request arrived on. You should not grab the X server any more than is absolutely necessary.

To ungrab the server, use **XUngrabServer**.

```
XUngrabServer(display)
    Display *display;
```

display Specifies the connection to the X server.

The **XUngrabServer** function restarts processing of requests and close downs on other connections. You should avoid grabbing the X server as much as possible.

7.7. Miscellaneous Control Functions

This section discusses how to:

- Control the input focus
- Control the pointer
- Kill clients

7.7.1. Controlling Input Focus

Xlib provides functions that you can use to move the pointer position as well as to set and get the input focus.

To move the pointer to an arbitrary point on the screen, use **XWarpPointer**.

```
XWarpPointer(display, src_w, dest_w, src_x, src_y, src_width, src_height, dest_x,
        dest_y)
      Display *display;
      Window src_w, dest_w;
      int src_x, src_y;
      unsigned int src_width, src_height;
      int dest_x, dest_y;
```

display Specifies the connection to the X server.

src_w Specifies the source window or **None**.

dest_w Specifies the destination window or **None**.

src_x
src_y
src_width
src_height Specify a rectangle in the source window.

dest_x
dest_y Specify the x and y coordinates within the destination window.

If dest_w is **None**, **XWarpPointer** moves the pointer by the offsets (dest_x, dest_y) relative to the current position of the pointer. If dest_w is a window, **XWarpPointer** moves the pointer to the offsets (dest_x, dest_y) relative to the origin of dest_w. However, if src_w is a window, the move only takes place if the specified rectangle src_w contains the pointer.

The src_x and src_y coordinates are relative to the origin of src_w. If src_height is zero, it is replaced with the current height of src_w minus src_y. If src_width is zero, it is replaced with the current width of src_w minus src_x.

There is seldom any reason for calling this function. The pointer should normally be left to the user. If you do use this function, however, it generates events just as if the user had instantaneously moved the pointer from one position to another. Note that you cannot use **XWarpPointer** to move the pointer outside the confine_to window of an active pointer grab. An attempt to do so will only move the pointer as far as the closest edge of the confine_to window.

XWarpPointer can generate a **BadWindow** error.

To set the input focus, use **XSetInputFocus**.

XSetInputFocus(*display*, *focus*, *revert_to*, *time*)
    Display **display*;
    Window *focus*;
    int *revert_to*;
    Time *time*;

display Specifies the connection to the X server.

focus Specifies the window, **PointerRoot**, or **None**.

revert_to Specifies where the input focus reverts to if the window becomes not viewable. You can pass **RevertToParent**, **RevertToPointerRoot**, or **RevertToNone**.

time Specifies the time. You can pass either a timestamp or **CurrentTime**.

The **XSetInputFocus** function changes the input focus and the last-focus-change time. It has no effect if the specified time is earlier than the current last-focus-change time or is later than the current X server time. Otherwise, the last-focus-change time is set to the specified time (**CurrentTime** is replaced by the current X server time). **XSetInputFocus** causes the X server to generate **FocusIn** and **FocusOut** events.

Depending on the focus argument, the following occurs:

- If focus is **None**, all keyboard events are discarded until a new focus window is set, and the revert_to argument is ignored.
- If focus is a window, it becomes the keyboard's focus window. If a generated keyboard event would normally be reported to this window or one of its inferiors, the event is reported as usual. Otherwise, the event is reported relative to the focus window.
- If focus is **PointerRoot**, the focus window is dynamically taken to be the root window of whatever screen the pointer is on at each keyboard event. In this case, the revert_to argument is ignored.

The specified focus window must be viewable at the time **XSetInputFocus** is called, or a **BadMatch** error results. If the focus window later becomes not viewable, the X server evaluates the revert_to argument to determine the new focus window as follows:

- If revert_to is **RevertToParent**, the focus reverts to the parent (or the closest viewable ancestor), and the new revert_to value is taken to be **RevertToNone**.
- If revert_to is **RevertToPointerRoot** or **RevertToNone**, the focus reverts to **PointerRoot** or **None**, respectively. When the focus reverts, the X server generates **FocusIn** and **FocusOut** events, but the last-focus-change time is not affected.

XSetInputFocus can generate **BadMatch**, **BadValue**, and **BadWindow** errors.

To obtain the current input focus, use **XGetInputFocus**.

XGetInputFocus(*display*, *focus_return*, *revert_to_return*)
    Display **display*;
    Window **focus_return*;
    int **revert_to_return*;

display Specifies the connection to the X server.

focus_return Returns the focus window, **PointerRoot**, or **None**.

revert_to_return
Returns the current focus state (**RevertToParent**, **RevertToPointerRoot**, or **RevertToNone**).

The **XGetInputFocus** function returns the focus window and the current focus state.

7.7.2. Killing Clients

Xlib provides functions that you can use to control the lifetime of resources owned by a client or to cause the connection to a client to be destroyed.

To change a client's close-down mode, use **XSetCloseDownMode**.

XSetCloseDownMode(*display*, *close_mode*)
    Display **display*;
    int *close_mode*;

display Specifies the connection to the X server.

close_mode Specifies the client close-down mode. You can pass **DestroyAll**, **RetainPermanent**, or **RetainTemporary**.

The **XSetCloseDownMode** defines what will happen to the client's resources at connection close. A connection starts in **DestroyAll** mode. For information on what happens to the client's resources when the close_mode argument is **RetainPermanent** or **RetainTemporary**, see section 2.6.

XSetCloseDownMode can generate a **BadValue** error.

To destroy a client, use **XKillClient**.

XKillClient(*display*, *resource*)
    Display **display*;
    XID *resource*;

display Specifies the connection to the X server.

resource Specifies any resource associated with the client that you want to destroy or **AllTemporary**.

The **XKillClient** function forces a close-down of the client that created the resource if a valid resource is specified. If the client has already terminated in either **RetainPermanent** or **RetainTemporary** mode, all of the client's resources are destroyed. If **AllTemporary** is specified, the resources of all clients that have terminated in **RetainTemporary** are destroyed (see section 2.6). This permits implementation of window manager facilities that aid debugging. A client can set its close-down mode to **RetainTemporary**. If the client then crashes, its windows would not be destroyed. The programmer can then inspect the application's window tree and use the window manager to destroy the zombie windows.

XKillClient can generate a **BadValue** error.

7.8. Keyboard and Pointer Settings

Xlib provides functions that you can use to change the keyboard control, obtain a list of the auto-repeat keys, turn keyboard auto-repeat on or off, ring the bell, set or obtain the pointer button or keyboard mapping, and obtain a bit vector for the keyboard.

This section discusses the user-preference options of bell, key click, pointer behavior, and so on. The default values for many of these functions are determined by command line arguments to the X server and, on UNIX-based systems, are typically set in the **/etc/ttys** file. Not all implementations will actually be able to control all of these parameters.

The **XChangeKeyboardControl** function changes control of a keyboard and operates on a **XKeyboardControl** structure:

```
/* Mask bits for ChangeKeyboardControl */

#define   KBKeyClickPercent       (1L<<0)
#define   KBBellPercent           (1L<<1)
#define   KBBellPitch             (1L<<2)
#define   KBBellDuration          (1L<<3)
#define   KBLed                   (1L<<4)
#define   KBLedMode               (1L<<5)
#define   KBKey                   (1L<<6)
#define   KBAutoRepeatMode        (1L<<7)

/* Values */

typedef struct {
        int key_click_percent;
        int bell_percent;
        int bell_pitch;
        int bell_duration;
        int led;
        int led_mode;             /* LedModeOn, LedModeOff */
        int key;
        int auto_repeat_mode;     /* AutoRepeatModeOff, AutoRepeatModeOn,
                                  AutoRepeatModeDefault */
} XKeyboardControl;
```

The key_click_percent member sets the volume for key clicks between 0 (off) and 100 (loud) inclusive, if possible. A setting of –1 restores the default. Other negative values generate a **BadValue** error.

The bell_percent sets the base volume for the bell between 0 (off) and 100 (loud) inclusive, if possible. A setting of –1 restores the default. Other negative values generate a **BadValue** error. The bell_pitch member sets the pitch (specified in Hz) of the bell, if possible. A setting of –1 restores the default. Other negative values generate a **BadValue** error. The bell_duration member sets the duration of the bell specified in milliseconds, if possible. A setting of –1 restores the default. Other negative values generate a **BadValue** error.

If both the led_mode and led members are specified, the state of that LED is changed, if possible. The led_mode member can be set to **LedModeOn** or **LedModeOff**. If only led_mode is specified, the state of all LEDs are changed, if possible. At most 32 LEDs numbered from one are supported. No standard interpretation of LEDs is defined. If led is specified without led_mode, a **BadMatch** error results.

If both the auto_repeat_mode and key members are specified, the auto_repeat_mode of that key is changed (according to **AutoRepeatModeOn**, **AutoRepeatModeOff**, or **AutoRepeatModeDefault**), if possible. If only auto_repeat_mode is specified, the global auto_repeat_mode for the entire keyboard is changed, if possible, and does not affect the per key settings. If a key is specified without an auto_repeat_mode, a **BadMatch** error results. Each key has an individual mode of whether or not it should auto-repeat and a default setting for the mode. In addition, there is a global mode of whether auto-repeat should be enabled or not and a default setting for that mode. When global mode is **AutoRepeatModeOn**, keys should obey their individual auto-repeat modes. When global mode is **AutoRepeatModeOff**, no keys should auto-repeat. An auto-repeating key generates alternating **KeyPress** and **KeyRelease** events. When a key is used as a modifier, it is desirable for the key not to auto-repeat, regardless of its auto-repeat setting.

A bell generator connected with the console but not directly on a keyboard is treated as if it were part of the keyboard. The order in which controls are verified and altered is server-dependent. If an error is generated, a subset of the controls may have been altered.

```
XChangeKeyboardControl(display, value_mask, values)
      Display *display;
      unsigned long value_mask;
      XKeyboardControl *values;
```

display Specifies the connection to the X server.

value_mask Specifies one value for each bit set to 1 in the mask.

values Specifies which controls to change. This mask is the bitwise inclusive OR of the valid control mask bits.

The **XChangeKeyboardControl** function controls the keyboard characteristics defined by the **XKeyboardControl** structure. The value_mask argument specifies which values are to be changed.

XChangeKeyboardControl can generate **BadMatch** and **BadValue** errors.

To obtain the current control values for the keyboard, use **XGetKeyboardControl**.

```
XGetKeyboardControl(display, values_return)
      Display *display;
      XKeyboardState *values_return;
```

display Specifies the connection to the X server.

values_return Returns the current keyboard controls in the specified **XKeyboardState** structure.

The **XGetKeyboardControl** function returns the current control values for the keyboard to the **XKeyboardState** structure.

```
typedef struct {
        int key_click_percent;
        int bell_percent;
        unsigned int bell_pitch, bell_duration;
        unsigned long led_mask;
        int global_auto_repeat;
        char auto_repeats[32];
} XKeyboardState;
```

For the LEDs, the least-significant bit of led_mask corresponds to LED one, and each bit set to 1 in led_mask indicates an LED that is lit. The global_auto_repeat member can be set to **AutoRepeatModeOn** or **AutoRepeatModeOff**. The auto_repeats member is a bit vector. Each bit set to 1 indicates that auto-repeat is enabled for the corresponding key. The vector is represented as 32 bytes. Byte N (from 0) contains the bits for keys 8N to 8N + 7 with the least-significant bit in the byte representing key 8N.

To turn on keyboard auto-repeat, use **XAutoRepeatOn**.

XAutoRepeatOn(*display*)
    Display **display*;

display Specifies the connection to the X server.

The **XAutoRepeatOn** function turns on auto-repeat for the keyboard on the specified display.

To turn off keyboard auto-repeat, use **XAutoRepeatOff**.

XAutoRepeatOff(*display*)
    Display **display*;

display Specifies the connection to the X server.

The **XAutoRepeatOff** function turns off auto-repeat for the keyboard on the specified display.

To ring the bell, use **XBell**.

XBell(*display*, *percent*)
    Display **display*;
    int *percent*;

display Specifies the connection to the X server.

percent Specifies the volume for the bell, which can range from –100 to 100 inclusive.

The **XBell** function rings the bell on the keyboard on the specified display, if possible. The specified volume is relative to the base volume for the keyboard. If the value for the percent argument is not in the range –100 to 100 inclusive, a **BadValue** error results. The volume at which the bell rings when the percent argument is nonnegative is:

    base – [(base * percent) / 100] + percent

The volume at which the bell rings when the percent argument is negative is:

    base + [(base * percent) / 100]

To change the base volume of the bell, use **XChangeKeyboardControl**.

XBell can generate a **BadValue** error.

To obtain a bit vector that describes the state of the keyboard, use **XQueryKeymap**.

XQueryKeymap(*display*, *keys_return*)
    Display **display*;
    char *keys_return*[32];

display Specifies the connection to the X server.

keys_return Returns an array of bytes that identifies which keys are pressed down. Each bit represents one key of the keyboard.

The **XQueryKeymap** function returns a bit vector for the logical state of the keyboard, where each bit set to 1 indicates that the corresponding key is currently pressed down. The vector is represented as 32 bytes. Byte N (from 0) contains the bits for keys 8N to 8N + 7 with the least-significant bit in the byte representing key 8N.

Note that the logical state of a device (as seen by client applications) may lag the physical state if device event processing is frozen.

To set the mapping of the pointer buttons, use **XSetPointerMapping**.

```
int XSetPointerMapping(display, map, nmap)
    Display *display;
    unsigned char map[];
    int nmap;
```

display Specifies the connection to the X server.

map Specifies the mapping list.

nmap Specifies the number of items in the mapping list.

The **XSetPointerMapping** function sets the mapping of the pointer. If it succeeds, the X server generates a **MappingNotify** event, and **XSetPointerMapping** returns **MappingSuccess**. Elements of the list are indexed starting from one. The length of the list must be the same as **XGetPointerMapping** would return, or a **BadValue** error results. The index is a core button number, and the element of the list defines the effective number. A zero element disables a button, and elements are not restricted in value by the number of physical buttons. However, no two elements can have the same nonzero value, or a **BadValue** error results. If any of the buttons to be altered are logically in the down state, **XSetPointerMapping** returns **MappingBusy**, and the mapping is not changed.

XSetPointerMapping can generate a **BadValue** error.

To get the pointer mapping, use **XGetPointerMapping**.

```
int XGetPointerMapping(display, map_return, nmap)
    Display *display;
    unsigned char map_return[];
    int nmap;
```

display Specifies the connection to the X server.

map_return Returns the mapping list.

nmap Specifies the number of items in the mapping list.

The **XGetPointerMapping** function returns the current mapping of the pointer. Elements of the list are indexed starting from one. **XGetPointerMapping** returns the number of physical buttons actually on the pointer. The nominal mapping for a pointer is the identity mapping: map[i]=i. The nmap argument specifies the length of the array where the pointer mapping is returned, and only the first nmap elements are returned in map_return.

To control the pointer's interactive feel, use **XChangePointerControl**.

```
XChangePointerControl(display, do_accel, do_threshold, accel_numerator,
                      accel_denominator, threshold)
    Display *display;
    Bool do_accel, do_threshold;
    int accel_numerator, accel_denominator;
    int threshold;
```

display Specifies the connection to the X server.

do_accel Specifies a Boolean value that controls whether the values for the accel_numerator or accel_denominator are used.

do_threshold Specifies a Boolean value that controls whether the value for the threshold is used.

accel_numerator
Specifies the numerator for the acceleration multiplier.

accel_denominator
Specifies the denominator for the acceleration multiplier.

threshold Specifies the acceleration threshold.

The **XChangePointerControl** function defines how the pointing device moves. The acceleration, expressed as a fraction, is a multiplier for movement. For example, specifying 3/1 means the pointer moves three times as fast as normal. The fraction may be rounded arbitrarily by the X server. Acceleration only takes effect if the pointer moves more than threshold pixels at once and only applies to the amount beyond the value in the threshold argument. Setting a value to –1 restores the default. The values of the do_accel and do_threshold arguments must be **True** for the pointer values to be set, or the parameters are unchanged. Negative values (other than –1) generate a **BadValue** error, as does a zero value for the accel_denominator argument.

XChangePointerControl can generate a **BadValue** error.

To get the current pointer parameters, use **XGetPointerControl**.

```
XGetPointerControl(display, accel_numerator_return, accel_denominator_return,
                   threshold_return)
    Display *display;
    int *accel_numerator_return, *accel_denominator_return;
    int *threshold_return;
```

display Specifies the connection to the X server.

accel_numerator_return
Returns the numerator for the acceleration multiplier.

accel_denominator_return
Returns the denominator for the acceleration multiplier.

threshold_return
Returns the acceleration threshold.

The **XGetPointerControl** function returns the pointer's current acceleration multiplier and acceleration threshold.

7.9. Keyboard Encoding

Most applications will find the simple interface **XLookupString**, which performs simple translation of a key event to an ASCII string, most useful. Keyboard-related utilities are discussed in chapter 10. The following section explains how to completely control the bindings of symbols to keys and modifiers.

A KeyCode represents a physical (or logical) key. KeyCodes lie in the inclusive range [8,255]. A KeyCode value carries no intrinsic information, although server implementors may attempt to encode geometry (for example, matrix) information in some fashion so that it can be interpreted in a server-dependent fashion. The mapping between keys and KeyCodes cannot be changed.

A KeySym is an encoding of a symbol on the cap of a key. The set of defined KeySyms include the ISO Latin character sets (1–4), Katakana, Arabic, Cyrillic, Greek, Technical, Special, Publishing, APL, Hebrew, and a special miscellany of keys found on keyboards (Return, Help, Tab, and so on). To the extent possible, these sets are derived from international standards. In areas where no standards exist, some of these sets are derived from Digital Equipment Corporation standards. The list of defined symbols can be found in <**X11/keysymdef.h**>. Unfortunately, some C preprocessors have limits on the number of defined symbols. If you must use KeySyms not in the Latin 1–4, Greek, and miscellaneous classes, you may have to define a symbol for those sets. Most applications usually only include <**X11/keysym.h**>, which defines symbols for ISO Latin 1–4, Greek, and miscellaneous.

A list of KeySyms is associated with each KeyCode. The length of the list can vary with each KeyCode. The list is intended to convey the set of symbols on the corresponding key. By convention, if the list contains a single KeySym and if that KeySym is alphabetic and case distinction is relevant for it, then it should be treated as equivalent to a two-element list of the lowercase and uppercase KeySyms. For example, if the list contains the single KeySym for uppercase *A*, the client should treat it as if it were a pair with lowercase *a* as the first KeySym and uppercase *A* as the second KeySym.

For any KeyCode, the first KeySym in the list should be chosen as the interpretation of a KeyPress when no modifier keys are down. The second KeySym in the list normally should be chosen when the Shift modifier is on or when the Lock modifier is on and Lock is interpreted as ShiftLock. When the Lock modifier is on and is interpreted as CapsLock, it is suggested that the Shift modifier first be applied to choose a KeySym. However, if that KeySym is lowercase alphabetic, the corresponding uppercase KeySym should be used instead. Other interpretations of CapsLock are possible; for example, it may be viewed as equivalent to ShiftLock, but only applying when the first KeySym is lowercase alphabetic and the second KeySym is the corresponding uppercase alphabetic. No interpretation of KeySyms beyond the first two in a list is suggested here. No spatial geometry of the symbols on the key is defined by their order in the KeySym list, although a geometry might be defined on a vendor-specific basis. The X server does not use the mapping between KeyCodes and KeySyms. Rather, it stores it merely for reading and writing by clients.

To obtain the legal KeyCodes for a display, use **XDisplayKeycodes**.

```
XDisplayKeycodes(display, min_keycodes_return, max_keycodes_return)
      Display *display;
      int *min_keycodes_return, max_keycodes_return;
```

display Specifies the connection to the X server.

min_keycodes_return
Returns the minimum number of KeyCodes.

max_keycodes_return
Returns the maximum number of KeyCodes.

The **XDisplayKeycodes** function returns the min-keycodes and max-keycodes supported by the specified display. The minimum number of KeyCodes returned is never less than 8, and the maximum number of KeyCodes returned is never greater than 255. Not all KeyCodes in this range are required to have corresponding keys.

To obtain the symbols for the specified KeyCodes, use **XGetKeyboardMapping**.

```
KeySym *XGetKeyboardMapping(display, first_keycode, keycode_count,
                            keysyms_per_keycode_return)
     Display *display;
     KeyCode first_keycode;
     int keycode_count;
     int *keysyms_per_keycode_return;
```

display Specifies the connection to the X server.

first_keycode Specifies the first KeyCode that is to be returned.

keycode_count Specifies the number of KeyCodes that are to be returned.

keysyms_per_keycode_return
Returns the number of KeySyms per KeyCode.

The **XGetKeyboardMapping** function returns the symbols for the specified number of KeyCodes starting with first_keycode. The value specified in first_keycode must be greater than or equal to min_keycode as returned by **XDisplayKeycodes**, or a **BadValue** error results. In addition, the following expression must be less than or equal to max_keycode as returned by **XDisplayKeycodes**:

first_keycode + keycode_count – 1

If this is not the case, a **BadValue** error results. The number of elements in the KeySyms list is:

keycode_count * keysyms_per_keycode_return

KeySym number N, counting from zero, for KeyCode K has the following index in the list, counting from zero:

(K – first_code) * keysyms_per_code_return + N

The X server arbitrarily chooses the keysyms_per_keycode_return value to be large enough to report all requested symbols. A special KeySym value of **NoSymbol** is used to fill in unused elements for individual KeyCodes. To free the storage returned by **XGetKeyboardMapping**, use **XFree**.

XGetKeyboardMapping can generate a **BadValue** error.

To change the keyboard mapping, use **XChangeKeyboardMapping**.

```
XChangeKeyboardMapping(display, first_keycode, keysyms_per_keycode, keysyms, num_codes)
      Display *display;
      int first_keycode;
      int keysyms_per_keycode;
      KeySym *keysyms;
      int num_codes;
```

display Specifies the connection to the X server.

first_keycode Specifies the first KeyCode that is to be changed.

keysyms_per_keycode
Specifies the number of KeySyms per KeyCode.

keysyms Specifies a pointer to an array of KeySyms.

num_codes Specifies the number of KeyCodes that are to be changed.

The **XChangeKeyboardMapping** function defines the symbols for the specified number of KeyCodes starting with first_keycode. The symbols for KeyCodes outside this range remain unchanged. The number of elements in keysyms must be:

num_codes * keysyms_per_keycode

The specified first_keycode must be greater than or equal to min_keycode returned by **XDisplayKeycodes**, or a **BadValue** error results. In addition, the following expression must be less than or equal to max_keycode as returned by **XDisplayKeycodes**, or a **BadValue** error results:

first_keycode + num_codes – 1

KeySym number N, counting from zero, for KeyCode K has the following index in keysyms, counting from zero:

(K – first_keycode) * keysyms_per_keycode + N

The specified keysyms_per_keycode can be chosen arbitrarily by the client to be large enough to hold all desired symbols. A special KeySym value of **NoSymbol** should be used to fill in unused elements for individual KeyCodes. It is legal for **NoSymbol** to appear in nontrailing positions of the effective list for a KeyCode. **XChangeKeyboardMapping** generates a **MappingNotify** event.

There is no requirement that the X server interpret this mapping. It is merely stored for reading and writing by clients.

XChangeKeyboardMapping can generate **BadAlloc** and **BadValue** errors.

The next four functions make use of the **XModifierKeymap** data structure, which contains:

```
typedef struct {
        int max_keypermod;          /* This server's max number of keys per modifier */
        KeyCode *modifiermap;       /* An 8 by max_keypermod array of the modifiers */
} XModifierKeymap;
```

To create an **XModifierKeymap** structure, use **XNewModifiermap**.

XModifierKeymap *XNewModifiermap(*max_keys_per_mod*)
    int *max_keys_per_mod*;

max_keys_per_mod
    Specifies the number of KeyCode entries preallocated to the modifiers in the map.

The **XNewModifiermap** function returns a pointer to **XModifierKeymap** structure for later use.

To add a new entry to an **XModifierKeymap** structure, use **XInsertModifiermapEntry**.

XModifierKeymap *XInsertModifiermapEntry(*modmap*, *keycode_entry*, *modifier*)
    XModifierKeymap **modmap*;
    KeyCode *keycode_entry*;
    int *modifier*;

modmap Specifies a pointer to the **XModifierKeymap** structure.

keycode_entry Specifies the KeyCode.

modifier Specifies the modifier.

The **XInsertModifiermapEntry** function adds the specified KeyCode to the set that controls the specified modifier and returns the resulting **XModifierKeymap** structure (expanded as needed).

To delete an entry from an **XModifierKeymap** structure, use **XDeleteModifiermapEntry**.

XModifierKeymap *XDeleteModifiermapEntry(*modmap*, *keycode_entry*, *modifier*)
    XModifierKeymap **modmap*;
    KeyCode *keycode_entry*;
    int *modifier*;

modmap Specifies a pointer to the **XModifierKeymap** structure.

keycode_entry Specifies the KeyCode.

modifier Specifies the modifier.

The **XDeleteModifiermapEntry** function deletes the specified KeyCode from the set that controls the specified modifier and returns a pointer to the resulting **XModifierKeymap** structure.

To destroy an **XModifierKeymap** structure, use **XFreeModifiermap**.

```
XFreeModifiermap(modmap)
      XModifierKeymap *modmap;
```

modmap Specifies a pointer to the **XModifierKeymap** structure.

The **XFreeModifiermap** function frees the specified **XModifierKeymap** structure.

To set the KeyCodes to be used as modifiers, use **XSetModifierMapping**.

```
int XSetModifierMapping(display, modmap)
      Display *display;
      XModifierKeymap *modmap;
```

display Specifies the connection to the X server.

modmap Specifies a pointer to the **XModifierKeymap** structure.

The **XSetModifierMapping** function specifies the KeyCodes of the keys (if any) that are to be used as modifiers. If it succeeds, the X server generates a **MappingNotify** event, and **XSetModifierMapping** returns **MappingSuccess**. X permits at most eight modifier keys. If more than eight are specified in the **XModifierKeymap** structure, a **BadLength** error results.

The modifiermap member of the **XModifierKeymap** structure contains eight sets of max_keypermod KeyCodes, one for each modifier in the order **Shift**, **Lock**, **Control**, **Mod1**, **Mod2**, **Mod3**, **Mod4**, and **Mod5**. Only nonzero KeyCodes have meaning in each set, and zero KeyCodes are ignored. In addition, all of the nonzero KeyCodes must be in the range specified by min_keycode and max_keycode in the **Display** structure, or a **BadValue** error results. No KeyCode may appear twice in the entire map, or a **BadValue** error results.

An X server can impose restrictions on how modifiers can be changed, for example, if certain keys do not generate up transitions in hardware, if auto-repeat cannot be disabled on certain keys, or if multiple modifier keys are not supported. If some such restriction is violated, the status reply is **MappingFailed**, and none of the modifiers are changed. If the new KeyCodes specified for a modifier differ from those currently defined and any (current or new) keys for that modifier are in the logically down state, **XSetModifierMapping** returns **MappingBusy**, and none of the modifiers is changed.

XSetModifierMapping can generate **BadAlloc** and **BadValue** errors.

To obtain the KeyCodes used as modifiers, use **XGetModifierMapping**.

```
XModifierKeymap *XGetModifierMapping(display)
      Display *display;
```

display Specifies the connection to the X server.

The **XGetModifierMapping** function returns a pointer to a newly created **XModifierKeymap** structure that contains the keys being used as modifiers. The structure should be freed after use by calling **XFreeModifiermap**. If only zero values appear in the set for any modifier, that modifier is disabled.

7.10. Screen Saver Control

Xlib provides functions that you can use to set, force, activate, or reset the screen saver and to obtain the current screen saver values.

To set the screen saver, use **XSetScreenSaver**.

```
XSetScreenSaver(display, timeout, interval, prefer_blanking, allow_exposures)
      Display *display;
      int timeout, interval;
      int prefer_blanking;
      int allow_exposures;
```

display Specifies the connection to the X server.

timeout Specifies the timeout, in seconds, until the screen saver turns on.

interval Specifies the interval between screen saver alterations.

prefer_blanking Specifies how to enable screen blanking. You can pass **DontPreferBlanking**, **PreferBlanking**, or **DefaultBlanking**.

allow_exposures Specifies the screen save control values. You can pass **DontAllowExposures**, **AllowExposures**, or **DefaultExposures**.

Timeout and interval are specified in seconds. A timeout of 0 disables the screen saver, and a timeout of –1 restores the default. Other negative values generate a **BadValue** error. If the timeout value is nonzero, **XSetScreenSaver** enables the screen saver. An interval of 0 disables the random-pattern motion. If no input from devices (keyboard, mouse, and so on) is generated for the specified number of timeout seconds once the screen saver is enabled, the screen saver is activated.

For each screen, if blanking is preferred and the hardware supports video blanking, the screen simply goes blank. Otherwise, if either exposures are allowed or the screen can be regenerated without sending **Expose** events to clients, the screen is tiled with the root window background tile randomly re-origined each interval minutes. Otherwise, the screens' state do not change, and the screen saver is not activated. The screen saver is deactivated, and all screen states are restored at the next keyboard or pointer input or at the next call to **XForceScreenSaver** with mode **ScreenSaverReset**.

If the server-dependent screen saver method supports periodic change, the interval argument serves as a hint about how long the change period should be, and zero hints that no periodic change should be made. Examples of ways to change the screen include scrambling the colormap periodically, moving an icon image around the screen periodically, or tiling the screen with the root window background tile, randomly re-origined periodically.

XSetScreenSaver can generate a **BadValue** error.

To force the screen saver on or off, use **XForceScreenSaver**.

```
XForceScreenSaver(display, mode)
      Display *display;
      int mode;
```

display Specifies the connection to the X server.

mode Specifies the mode that is to be applied. You can pass **ScreenSaverActive** or **ScreenSaverReset**.

If the specified mode is **ScreenSaverActive** and the screen saver currently is deactivated, **XForceScreenSaver** activates the screen saver even if the screen saver had been disabled with a timeout of zero. If the specified mode is **ScreenSaverReset** and the screen saver currently is enabled, **XForceScreenSaver** deactivates the screen saver if it was activated, and the activation timer is reset to its initial state (as if device input had been received).

XForceScreenSaver can generate a **BadValue** error.

To activate the screen saver, use **XActivateScreenSaver**.

```
XActivateScreenSaver(display)
      Display *display;
```

display Specifies the connection to the X server.

To reset the screen saver, use **XResetScreenSaver**.

```
XResetScreenSaver(display)
      Display *display;
```

display Specifies the connection to the X server.

To get the current screen saver values, use **XGetScreenSaver**.

```
XGetScreenSaver(display, timeout_return, interval_return, prefer_blanking_return,
                allow_exposures_return)
      Display *display;
      int *timeout_return, *interval_return;
      int *prefer_blanking_return;
      int *allow_exposures_return;
```

display Specifies the connection to the X server.

timeout_return Returns the timeout, in minutes, until the screen saver turns on.

interval_return Returns the interval between screen saver invocations.

prefer_blanking_return
Returns the current screen blanking preference (**DontPreferBlanking**, **PreferBlanking**, or **DefaultBlanking**).

allow_exposures_return
Returns the current screen save control value (**DontAllowExposures**, **AllowExposures**, or **DefaultExposures**).

7.11. Controlling Host Access

This section discusses how to:

- Add, get, or remove hosts from the access control list
- Change, enable, or disable access

X does not provide any protection on a per-window basis. If you find out the resource ID of a resource, you can manipulate it. To provide some minimal level of protection, however, connections are permitted only from machines you trust. This is adequate on single-user workstations but obviously breaks down on timesharing machines. Although provisions exist in the X protocol for proper connection authentication, the lack of a standard authentication server leaves host-level access control as the only common mechanism.

The initial set of hosts allowed to open connections typically consists of:

- The host the window system is running on.
- On UNIX-based systems, each host listed in the **/etc/X?.hosts** file. The ? indicates the number of the display. This file should consist of host names separated by newlines. DECnet nodes must terminate in :: to distinguish them from Internet

hosts.

If a host is not in the access control list when the access control mechanism is enabled and if the host attempts to establish a connection, the server refuses the connection. To change the access list, the client must reside on the same host as the server and/or must have been granted permission in the initial authorization at connection setup.

Servers also can implement other access control policies in addition to or in place of this host access facility. For further information about other access control implementations, see "X Window System Protocol."

7.11.1. Adding, Getting, or Removing Hosts

Xlib provides functions that you can use to add, get, or remove hosts from the access control list. All the host access control functions use the **XHostAddress** structure, which contains:

```
typedef struct {
	int family;		/* for example FamilyInternet */
	int length;		/* length of address, in bytes */
	char *address;		/* pointer to where to find the address */
} XHostAddress;
```

The family member specifies which protocol address family to use (for example, TCP/IP or DECnet) and can be **FamilyInternet**, **FamilyDECnet**, or **FamilyChaos**. The length member specifies the length of the address in bytes. The address member specifies a pointer to the address.

For TCP/IP, the address should be in network byte order. For the DECnet family, the server performs no automatic swapping on the address bytes. A Phase IV address is two bytes long. The first byte contains the least-significant eight bits of the node number. The second byte contains the most-significant two bits of the node number in the least-significant two bits of the byte and the area in the most-significant six bits of the byte.

To add a single host, use **XAddHost**.

XAddHost(*display*, *host*)
    Display **display*;
    XHostAddress **host*;

display Specifies the connection to the X server.

host Specifies the host that is to be added.

The **XAddHost** function adds the specified host to the access control list for that display. The server must be on the same host as the client issuing the command, or a **BadAccess** error results.

XAddHost can generate **BadAccess** and **BadValue** errors.

To add multiple hosts at one time, use **XAddHosts**.

XAddHosts(*display*, *hosts*, *num_hosts*)
    Display **display*;
    XHostAddress **hosts*;
    int *num_hosts*;

display Specifies the connection to the X server.

hosts Specifies each host that is to be added.

num_hosts Specifies the number of hosts.

The **XAddHosts** function adds each specified host to the access control list for that display. The server must be on the same host as the client issuing the command, or a **BadAccess** error results.

XAddHosts can generate **BadAccess** and **BadValue** errors.

To obtain a host list, use **XListHosts**.

XHostAddress *XListHosts(*display*, *nhosts_return*, *state_return*)
    Display **display*;
    int **nhosts_return*;
    Bool **state_return*;

display Specifies the connection to the X server.

nhosts_return Returns the number of hosts currently in the access control list.

state_return Returns the state of the access control.

The **XListHosts** function returns the current access control list as well as whether the use of the list at connection setup was enabled or disabled. **XListHosts** allows a program to find out what machines can make connections. It also returns a pointer to a list of host structures that were allocated by the function. When no longer needed, this memory should be freed by calling **XFree**.

To remove a single host, use **XRemoveHost**.

XRemoveHost(*display*, *host*)
    Display **display*;
    XHostAddress **host*;

display Specifies the connection to the X server.

host Specifies the host that is to be removed.

The **XRemoveHost** function removes the specified host from the access control list for that display. The server must be on the same host as the client process, or a **BadAccess** error results. If you remove your machine from the access list, you can no longer connect to that server, and this operation cannot be reversed unless you reset the server.

XRemoveHost can generate **BadAccess** and **BadValue** errors.

To remove multiple hosts at one time, use **XRemoveHosts**.

XRemoveHosts(*display*, *hosts*, *num_hosts*)
    Display **display*;
    XHostAddress **hosts*;
    int *num_hosts*;

display Specifies the connection to the X server.

hosts Specifies each host that is to be removed.

num_hosts Specifies the number of hosts.

The **XRemoveHosts** function removes each specified host from the access control list for that display. The X server must be on the same host as the client process, or a **BadAccess** error results. If you remove your machine from the access list, you can no longer connect to that server, and this operation cannot be reversed unless you reset the server.

XRemoveHosts can generate **BadAccess** and **BadValue** errors.

7.11.2. Changing, Enabling, or Disabling Access Control

Xlib provides functions that you can use to enable, disable, or change access control.

For these functions to execute successfully, the client application must reside on the same host as the X server and/or have been given permission in the initial authorization at connection setup.

To change access control, use **XSetAccessControl**.

XSetAccessControl(*display*, *mode*)
    Display **display*;
    int *mode*;

display Specifies the connection to the X server.

mode Specifies the mode. You can pass **EnableAccess** or **DisableAccess**.

The **XSetAccessControl** function either enables or disables the use of the access control list at each connection setup.

XSetAccessControl can generate **BadAccess** and **BadValue** errors.

To enable access control, use **XEnableAccessControl**.

XEnableAccessControl(*display*)
    Display **display*;

display Specifies the connection to the X server.

The **XEnableAccessControl** function enables the use of the access control list at each connection setup.

XEnableAccessControl can generate a **BadAccess** error.

To disable access control, use **XDisableAccessControl**.

XDisableAccessControl(*display*)
    Display **display*;

display Specifies the connection to the X server.

The **XDisableAccessControl** function disables the use of the access control list at each connection setup.

XDisableAccessControl can generate a **BadAccess** error.

Chapter 8

Events and Event-Handling Functions

A client application communicates with the X server through the connection you establish with the **XOpenDisplay** function. A client application sends requests to the X server over this connection. These requests are made by the Xlib functions that are called in the client application. Many Xlib functions cause the X server to generate events, and the user's typing or moving the pointer can generate events asynchronously. The X server returns events to the client on the same connection.

This chapter begins with a discussion of the following topics associated with events:

- Event types
- Event structures
- Event mask
- Event processing

It then discusses the Xlib functions you can use to:

- Select events
- Handle the output buffer and the event queue
- Select events from the event queue
- Send and get events
- Handle error events

Note

> Some toolkits use their own event-handling functions and do not allow you to interchange these event-handling functions with those in Xlib. For further information, see the documentation supplied with the toolkit.

Most applications simply are event loops: they wait for an event, decide what to do with it, execute some amount of code that results in changes to the display, and then wait for the next event.

8.1. Event Types

An event is data generated asynchronously by the X server as a result of some device activity or as side effects of a request sent by an Xlib function. Device-related events propagate from the source window to ancestor windows until some client application has selected that event type or until the event is explicitly discarded. The X server generally sends an event to a client application only if the client has specifically asked to be informed of that event type, typically by setting the event-mask attribute of the window. The mask can also be set when you create a window or by changing the window's event-mask. You can also mask out events that would propagate to ancestor windows by manipulating the do-not-propagate mask of the window's attributes. However, **MappingNotify** events are always sent to all clients.

An event type describes a specific event generated by the X server. For each event type, a corresponding constant name is defined in **<X11/X.h>**, which is used when referring to an event type. The following table lists the event category and its associated event type or types. The processing associated with these events is discussed in section 8.4.

Event Category	Event Type
Keyboard events	**KeyPress**, **KeyRelease**
Pointer events	**ButtonPress**, **ButtonRelease**, **MotionNotify**
Window crossing events	**EnterNotify**, **LeaveNotify**
Input focus events	**FocusIn**, **FocusOut**
Keymap state notification event	**KeymapNotify**
Exposure events	**Expose**, **GraphicsExpose**, **NoExpose**
Structure control events	**CirculateRequest**, **ConfigureRequest**, **MapRequest**, **ResizeRequest**
Window state notification events	**CirculateNotify**, **ConfigureNotify**, **CreateNotify**, **DestroyNotify**, **GravityNotify**, **MapNotify**, **MappingNotify**, **ReparentNotify**, **UnmapNotify**, **VisibilityNotify**
Colormap state notification event	**ColormapNotify**
Client communication events	**ClientMessage**, **PropertyNotify**, **SelectionClear**, **SelectionNotify**, **SelectionRequest**

8.2. Event Structures

For each event type, a corresponding structure is declared in **<X11/Xlib.h>**. All the event structures have the following common members:

```
typedef struct {
        int type;
        unsigned long serial;           /* # of last request processed by server */
        Bool send_event;                /* true if this came from a SendEvent request */
        Display *display;               /* Display the event was read from */
        Window window;
} XAnyEvent;
```

The type member is set to the event type constant name that uniquely identifies it. For example, when the X server reports a **GraphicsExpose** event to a client application, it sends an **XGraphicsExposeEvent** structure with the type member set to **GraphicsExpose**. The display member is set to a pointer to the display the event was read on. The send_event member is set to **True** if the event came from a **SendEvent** protocol request. The serial member is set from the serial number reported in the protocol but expanded from the 16-bit least-significant bits to a full 32-bit value. The window member is set to the window that is most useful to toolkit dispatchers.

The X server can send events at any time in the input stream. Xlib stores any events received while waiting for a reply in an event queue for later use. Xlib also provides functions that allow you to check events in the event queue (see section 8.7).

In addition to the individual structures declared for each event type, the **XEvent** structure is a union of the individual structures declared for each event type. Depending on the type, you should access members of each event by using the **XEvent** union.

```
typedef union _XEvent {
        int type;                       /* must not be changed */
        XAnyEvent xany;
```

```
        XKeyEvent xkey;
        XButtonEvent xbutton;
        XMotionEvent xmotion;
        XCrossingEvent xcrossing;
        XFocusChangeEvent xfocus;
        XExposeEvent xexpose;
        XGraphicsExposeEvent xgraphicsexpose;
        XNoExposeEvent xnoexpose;
        XVisibilityEvent xvisibility;
        XCreateWindowEvent xcreatewindow;
        XDestroyWindowEvent xdestroywindow;
        XUnmapEvent xunmap;
        XMapEvent xmap;
        XMapRequestEvent xmaprequest;
        XReparentEvent xreparent;
        XConfigureEvent xconfigure;
        XGravityEvent xgravity;
        XResizeRequestEvent xresizerequest;
        XConfigureRequestEvent xconfigurerequest;
        XCirculateEvent xcirculate;
        XCirculateRequestEvent xcirculaterequest;
        XPropertyEvent xproperty;
        XSelectionClearEvent xselectionclear;
        XSelectionRequestEvent xselectionrequest;
        XSelectionEvent xselection;
        XColormapEvent xcolormap;
        XClientMessageEvent xclient;
        XMappingEvent xmapping;
        XErrorEvent xerror;
        XKeymapEvent xkeymap;
        long pad[24];
} XEvent;
```

An **XEvent** structure's first entry always is the type member, which is set to the event type. The second member always is the serial number of the protocol request that generated the event. The third member always is send_event, which is a **Bool** that indicates if the event was sent by a different client. The fourth member always is a display, which is the display that the event was read from. Except for keymap events, the fifth member always is a window, which has been carefully selected to be useful to toolkit dispatchers. To avoid breaking toolkits, the order of these first five entries is not to change. Most events also contain a time member, which is the time at which an event occurred. In addition, a pointer to the generic event must be cast before it is used to access any other information in the structure.

8.3. Event Masks

Clients select event reporting of most events relative to a window. To do this, pass an event mask to an Xlib event-handling function that takes an event_mask argument. The bits of the event mask are defined in **<X11/X.h>**. Each bit in the event mask maps to an event mask name, which describes the event or events you want the X server to return to a client application.

Unless the client has specifically asked for them, most events are not reported to clients when they are generated. Unless the client suppresses them by setting graphics-exposures in the GC to **False**, **GraphicsExpose** and **NoExpose** are reported by default as a result of **XCopyPlane** and **XCopyArea**. **SelectionClear**, **SelectionRequest**,

SelectionNotify, or **ClientMessage** cannot be masked. Selection related events are only sent to clients cooperating with selections (see section 4.4). When the keyboard or pointer mapping is changed, **MappingNotify** is always sent to clients.

The following table lists the event mask constants you can pass to the event_mask argument and the circumstances in which you would want to specify the event mask:

Event Mask	Circumstances
NoEventMask	No events wanted
KeyPressMask	Keyboard down events wanted
KeyReleaseMask	Keyboard up events wanted
ButtonPressMask	Pointer button down events wanted
ButtonReleaseMask	Pointer button up events wanted
EnterWindowMask	Pointer window entry events wanted
LeaveWindowMask	Pointer window leave events wanted
PointerMotionMask	Pointer motion events wanted
PointerMotionHintMask	Pointer motion hints wanted
Button1MotionMask	Pointer motion while button 1 down
Button2MotionMask	Pointer motion while button 2 down
Button3MotionMask	Pointer motion while button 3 down
Button4MotionMask	Pointer motion while button 4 down
Button5MotionMask	Pointer motion while button 5 down
ButtonMotionMask	Pointer motion while any button down
KeymapStateMask	Keyboard state wanted at window entry and focus in
ExposureMask	Any exposure wanted
VisibilityChangeMask	Any change in visibility wanted
StructureNotifyMask	Any change in window structure wanted
ResizeRedirectMask	Redirect resize of this window
SubstructureNotifyMask	Substructure notification wanted
SubstructureRedirectMask	Redirect structure requests on children
FocusChangeMask	Any change in input focus wanted
PropertyChangeMask	Any change in property wanted
ColormapChangeMask	Any change in colormap wanted
OwnerGrabButtonMask	Automatic grabs should activate with owner_events set to **True**

8.4. Event Processing

The event reported to a client application during event processing depends on which event masks you provide as the event-mask attribute for a window. For some event masks, there is a one-to-one correspondence between the event mask constant and the event type constant. For example, if you pass the event mask **ButtonPressMask**, the X server sends back only **ButtonPress** events. Most events contain a time member, which is the time at which an event occurred.

In other cases, one event mask constant can map to several event type constants. For example, if you pass the event mask **SubstructureNotifyMask**, the X server can send back **CirculateNotify**, **ConfigureNotify**, **CreateNotify**, **DestroyNotify**, **GravityNotify**, **MapNotify**, **ReparentNotify**, or **UnmapNotify** events.

In another case, two event masks can map to one event type. For example, if you pass either **PointerMotionMask** or **ButtonMotionMask**, the X server sends back a

MotionNotify event.

The following table lists the event mask, its associated event type or types, and the structure name associated with the event type. Some of these structures actually are typedefs to a generic structure that is shared between two event types. Note that N.A. appears in columns for which the information is not applicable.

Event Mask	Event Type	Structure	Generic Structure
ButtonMotionMask Button1MotionMask Button2MotionMask Button3MotionMask Button4MotionMask Button5MotionMask	MotionNotify	XPointerMovedEvent	XMotionEvent
ButtonPressMask	ButtonPress	XButtonPressedEvent	XButtonEvent
ButtonReleaseMask	ButtonRelease	XButtonReleasedEvent	XButtonEvent
ColormapChangeMask	ColormapNotify	XColormapEvent	
EnterWindowMask	EnterNotify	XEnterWindowEvent	XCrossingEvent
LeaveWindowMask	LeaveNotify	XLeaveWindowEvent	XCrossingEvent
ExposureMask GCGraphicsExposures in GC	Expose GraphicsExpose NoExpose	XExposeEvent XGraphicsExposeEvent XNoExposeEvent	
FocusChangeMask	FocusIn FocusOut	XFocusInEvent XFocusOutEvent	XFocusChangeEvent XFocusChangeEvent
KeymapStateMask	KeymapNotify	XKeymapEvent	
KeyPressMask KeyReleaseMask	KeyPress KeyRelease	XKeyPressedEvent XKeyReleasedEvent	XKeyEvent XKeyEvent
OwnerGrabButtonMask	N.A.	N.A.	
PointerMotionMask PointerMotionHintMask	MotionNotify N.A.	XPointerMovedEvent N.A.	XMotionEvent
PropertyChangeMask	PropertyNotify	XPropertyEvent	
ResizeRedirectMask	ResizeRequest	XResizeRequestEvent	
StructureNotifyMask	CirculateNotify ConfigureNotify DestroyNotify GravityNotify MapNotify ReparentNotify UnmapNotify	XCirculateEvent XConfigureEvent XDestroyWindowEvent XGravityEvent XMapEvent XReparentEvent XUnmapEvent	
SubstructureNotifyMask	CirculateNotify ConfigureNotify CreateNotify DestroyNotify GravityNotify MapNotify ReparentNotify	XCirculateEvent XConfigureEvent XCreateWindowEvent XDestroyWindowEvent XGravityEvent XMapEvent XReparentEvent	

Event Mask	Event Type	Structure	Generic Structure
	UnmapNotify	XUnmapEvent	
SubstructureRedirectMask	CirculateRequest ConfigureRequest MapRequest	XCirculateRequestEvent XConfigureRequestEvent XMapRequestEvent	
N.A.	ClientMessage	XClientMessageEvent	
N.A.	MappingNotify	XMappingEvent	
N.A.	SelectionClear	XSelectionClearEvent	
N.A.	SelectionNotify	XSelectionEvent	
N.A.	SelectionRequest	XSelectionRequestEvent	
VisibilityChangeMask	VisibilityNotify	XVisibilityEvent	

The sections that follow describe the processing that occurs when you select the different event masks. The sections are organized according to these processing categories:

- Keyboard and pointer events
- Window crossing events
- Input focus events
- Keymap state notification events
- Exposure events
- Window state notification events
- Structure control events
- Colormap state notification events
- Client communication events

8.4.1. Keyboard and Pointer Events

This section discusses:

- Pointer button events
- Keyboard and pointer events

8.4.1.1. Pointer Button Events

The following describes the event processing that occurs when a pointer button press is processed with the pointer in some window w and when no active pointer grab is in progress.

The X server searches the ancestors of w from the root down, looking for a passive grab to activate. If no matching passive grab on the button exists, the X server automatically starts an active grab for the client receiving the event and sets the last-pointer-grab time to the current server time. The effect is essentially equivalent to an **XGrabButton** with these client passed arguments:

Argument	Value
w	The event window

Argument	Value
event_mask	The client's selected pointer events on the event window
pointer_mode	**GrabModeAsync**
keyboard_mode	**GrabModeAsync**
owner_events	**True**, if the client has selected **OwnerGrabButtonMask** on the event window, otherwise **False**
confine_to	**None**
cursor	**None**

The active grab is automatically terminated when the logical state of the pointer has all buttons released. Clients can modify the active grab by calling **XUngrabPointer** and **XChangeActivePointerGrab**.

8.4.1.2. Keyboard and Pointer Events

This section discusses the processing that occurs for the keyboard events **KeyPress** and **KeyRelease** and the pointer events **ButtonPress**, **ButtonRelease**, and **MotionNotify**. For information about the keyboard event-handling utilities, see chapter 10.

The X server reports **KeyPress** or **KeyRelease** events to clients wanting information about keys that logically change state. Note that these events are generated for all keys, even those mapped to modifier bits. The X server reports **ButtonPress** or **ButtonRelease** events to clients wanting information about buttons that logically change state.

The X server reports **MotionNotify** events to clients wanting information about when the pointer logically moves. The X server generates this event whenever the pointer is moved and the pointer motion begins and ends in the window. The granularity of **MotionNotify** events is not guaranteed, but a client that selects this event type is guaranteed to receive at least one event when the pointer moves and then rests.

The generation of the logical changes lags the physical changes if device event processing is frozen.

To receive **KeyPress**, **KeyRelease**, **ButtonPress**, and **ButtonRelease** events, set **KeyPressMask**, **KeyReleaseMask**, **ButtonPressMask**, and **ButtonReleaseMask** bits in the event-mask attribute of the window.

To receive **MotionNotify** events, set one or more of the following event masks bits in the event-mask attribute of the window.

- **Button1MotionMask–Button5MotionMask**

  The client application receives **MotionNotify** events only when one or more of the specified buttons is pressed.

- **ButtonMotionMask**

  The client application receives **MotionNotify** events only when at least one button is pressed.

- **PointerMotionMask**

  The client application receives **MotionNotify** events independent of the state of the pointer buttons.

- **PointerMotionHint**

  If **PointerMotionHintMask** is selected, the X server is free to send only one **MotionNotify** event (with the is_hint member of the **XPointerMovedEvent** structure set to **NotifyHint**) to the client for the event window, until either the key or button state changes, the pointer leaves the event window, or the client calls **XQueryPointer** or **XGetMotionEvents**. The server still may send **MotionNotify** events without is_hint set to **NotifyHint**.

The source of the event is the viewable window that the pointer is in. The window used by the X server to report these events depends on the window's position in the window hierarchy and whether any intervening window prohibits the generation of these events. Starting with the source window, the X server searches up the window hierarchy until it locates the first window specified by a client as having an interest in these events. If one of the intervening windows has its do-not-propagate-mask set to prohibit generation of the event type, the events of those types will be suppressed. Clients can modify the actual window used for reporting by performing active grabs and, in the case of keyboard events, by using the focus window.

The structures for these event types contain:

```
typedef struct {
	int type;			/* ButtonPress or ButtonRelease */
	unsigned long serial;		/* # of last request processed by server */
	Bool send_event;		/* true if this came from a SendEvent request */
	Display *display;		/* Display the event was read from */
	Window window;			/* "event" window it is reported relative to */
	Window root;			/* root window that the event occurred on */
	Window subwindow;		/* child window */
	Time time;			/* milliseconds */
	int x, y;			/* pointer x, y coordinates in event window */
	int x_root, y_root;		/* coordinates relative to root */
	unsigned int state;		/* key or button mask */
	unsigned int button;		/* detail */
	Bool same_screen;		/* same screen flag */
} XButtonEvent;
typedef XButtonEvent XButtonPressedEvent;
typedef XButtonEvent XButtonReleasedEvent;

typedef struct {
	int type;			/* KeyPress or KeyRelease */
	unsigned long serial;		/* # of last request processed by server */
	Bool send_event;		/* true if this came from a SendEvent request */
	Display *display;		/* Display the event was read from */
	Window window;			/* "event" window it is reported relative to */
	Window root;			/* root window that the event occurred on */
	Window subwindow;		/* child window */
	Time time;			/* milliseconds */
	int x, y;			/* pointer x, y coordinates in event window */
	int x_root, y_root;		/* coordinates relative to root */
	unsigned int state;		/* key or button mask */
	unsigned int keycode;		/* detail */
	Bool same_screen;		/* same screen flag */
} XKeyEvent;
typedef XKeyEvent XKeyPressedEvent;
typedef XKeyEvent XKeyReleasedEvent;

typedef struct {
	int type;			/* MotionNotify */
	unsigned long serial;		/* # of last request processed by server */
	Bool send_event;		/* true if this came from a SendEvent request */
	Display *display;		/* Display the event was read from */
	Window window;			/* "event" window reported relative to */
```

```
        Window root;                    /* root window that the event occurred on */
        Window subwindow;               /* child window */
        Time time;                      /* milliseconds */
        int x, y;                       /* pointer x, y coordinates in event window */
        int x_root, y_root;             /* coordinates relative to root */
        unsigned int state;             /* key or button mask */
        char is_hint;                   /* detail */
        Bool same_screen;               /* same screen flag */
} XMotionEvent;
typedef XMotionEvent XPointerMovedEvent;
```

These structures have the following common members: window, root, subwindow, time, x, y, x_root, y_root, state, and same_screen. The window member is set to the window on which the event was generated and is referred to as the event window. As long as the conditions previously discussed are met, this is the window used by the X server to report the event. The root member is set to the source window's root window. The x_root and y_root members are set to the pointer's coordinates relative to the root window's origin at the time of the event.

The same_screen member is set to indicate whether the event window is on the same screen as the root window and can be either **True** or **False**. If **True**, the event and root windows are on the same screen. If **False**, the event and root windows are not on the same screen.

If the source window is an inferior of the event window, the subwindow member of the structure is set to the child of the event window that is the source member or an ancestor of it. Otherwise, the X server sets the subwindow member to **None**. The time member is set to the time when the event was generated and is expressed in milliseconds.

If the event window is on the same screen as the root window, the x and y members are set to the coordinates relative to the event window's origin. Otherwise, these members are set to zero.

The state member is set to indicate the logical state of the pointer buttons and modifier keys just prior to the event, which is the bitwise inclusive OR of one or more of the button or modifier key masks: **Button1Mask**, **Button2Mask**, **Button3Mask**, **Button4Mask**, **Button5Mask**, **ShiftMask**, **LockMask**, **ControlMask**, **Mod1Mask**, **Mod2Mask**, **Mod3Mask**, **Mod4Mask**, and **Mod5Mask**.

Each of these structures also has a member that indicates the detail. For the **XKeyPressedEvent** and **XKeyReleasedEvent** structures, this member is called keycode. It is set to a number that represents a physical key on the keyboard. The keycode is an arbitrary representation for any key on the keyboard (see chapter 7).

For the **XButtonPressedEvent** and **XButtonReleasedEvent** structures, this member is called button. It represents the pointer button that changed state and can be the **Button1**, **Button2**, **Button3**, **Button4**, or **Button5** value. For the **XPointerMovedEvent** structure, this member is called is_hint. It can be set to **NotifyNormal** or **NotifyHint**.

8.4.2. Window Entry/Exit Events

This section describes the processing that occurs for the window crossing events **EnterNotify** and **LeaveNotify**. If a pointer motion or a window hierarchy change causes the pointer to be in a different window than before, the X server reports **EnterNotify** or **LeaveNotify** events to clients who have selected for these events. All **EnterNotify** and **LeaveNotify** events caused by a hierarchy change are generated after any hierarchy event (**UnmapNotify**, **MapNotify**, **ConfigureNotify**, **GravityNotify**, **CirculateNotify**) caused by that change; however, the X protocol does not constrain the ordering of **EnterNotify** and **LeaveNotify** events with respect to **FocusOut**,

VisibilityNotify, and **Expose** events.

This contrasts with **MotionNotify** events, which are also generated when the pointer moves but only when the pointer motion begins and ends in a single window. An **EnterNotify** or **LeaveNotify** event also can be generated when some client application calls **XGrabPointer** and **XUngrabPointer**.

To receive **EnterNotify** or **LeaveNotify** events, set the **EnterWindowMask** or **LeaveWindowMask** bits of the event-mask attribute of the window.

The structure for these event types contains:

```
typedef struct {
	int type;			/* EnterNotify or LeaveNotify */
	unsigned long serial;		/* # of last request processed by server */
	Bool send_event;		/* true if this came from a SendEvent request */
	Display *display;		/* Display the event was read from */
	Window window;			/* "event" window reported relative to */
	Window root;			/* root window that the event occurred on */
	Window subwindow;		/* child window */
	Time time;			/* milliseconds */
	int x, y;			/* pointer x, y coordinates in event window */
	int x_root, y_root;		/* coordinates relative to root */
	int mode;			/* NotifyNormal, NotifyGrab, NotifyUngrab */
	int detail;
					/*
					* NotifyAncestor, NotifyVirtual, NotifyInferior,
					* NotifyNonlinear,NotifyNonlinearVirtual
					*/
	Bool same_screen;		/* same screen flag */
	Bool focus;			/* boolean focus */
	unsigned int state;		/* key or button mask */
} XCrossingEvent;
typedef XCrossingEvent XEnterWindowEvent;
typedef XCrossingEvent XLeaveWindowEvent;
```

The window member is set to the window on which the **EnterNotify** or **LeaveNotify** event was generated and is referred to as the event window. This is the window used by the X server to report the event, and is relative to the root window on which the event occurred. The root member is set to the root window of the screen on which the event occurred.

For a **LeaveNotify** event, if a child of the event window contains the initial position of the pointer, the subwindow component is set to that child. Otherwise, the X server sets the subwindow member to **None**. For an **EnterNotify** event, if a child of the event window contains the final pointer position, the subwindow component is set to that child or **None**.

The time member is set to the time when the event was generated and is expressed in milliseconds. The x and y members are set to the coordinates of the pointer position in the event window. This position is always the pointer's final position, not its initial position. If the event window is on the same screen as the root window, x and y are the pointer coordinates relative to the event window's origin. Otherwise, x and y are set to zero. The x_root and y_root members are set to the pointer's coordinates relative to the root window's origin at the time of the event.

The same_screen member is set to indicate whether the event window is on the same screen as the root window and can be either **True** or **False**. If **True**, the event and root windows are on the same screen. If **False**, the event and root windows are not on the same screen.

The focus member is set to indicate whether the event window is the focus window or an inferior of the focus window. The X server can set this member to either **True** or **False**. If **True**, the event window is the focus window or an inferior of the focus window. If **False**, the event window is not the focus window or an inferior of the focus window.

The state member is set to indicate the state of the pointer buttons and modifier keys just prior to the event. The X server can set this member to the bitwise inclusive OR of one or more of the button or modifier key masks: **Button1Mask**, **Button2Mask**, **Button3Mask**, **Button4Mask**, **Button5Mask**, **ShiftMask**, **LockMask**, **ControlMask**, **Mod1Mask**, **Mod2Mask**, **Mod3Mask**, **Mod4Mask**, **Mod5Mask**.

The mode member is set to indicate whether the events are normal events, pseudo-motion events when a grab activates, or pseudo-motion events when a grab deactivates. The X server can set this member to **NotifyNormal**, **NotifyGrab**, or **NotifyUngrab**.

The detail member is set to indicate the notify detail and can be **NotifyAncestor**, **NotifyVirtual**, **NotifyInferior**, **NotifyNonlinear**, or **NotifyNonlinearVirtual**.

8.4.2.1. Normal Entry/Exit Events

EnterNotify and **LeaveNotify** events are generated when the pointer moves from one window to another window. Normal events are identified by **XEnterWindowEvent** or **XLeaveWindowEvent** structures whose mode member is set to **NotifyNormal**.

- When the pointer moves from window A to window B and A is an inferior of B, the X server does the following:
  - It generates a **LeaveNotify** event on window A, with the detail member of the **XLeaveWindowEvent** structure set to **NotifyAncestor**.
  - It generates a **LeaveNotify** event on each window between window A and window B, exclusive, with the detail member of each **XLeaveWindowEvent** structure set to **NotifyVirtual**.
  - It generates an **EnterNotify** event on window B, with the detail member of the **XEnterWindowEvent** structure set to **NotifyInferior**.
- When the pointer moves from window A to window B and B is an inferior of A, the X server does the following:
  - It generates a **LeaveNotify** event on window A, with the detail member of the **XLeaveWindowEvent** structure set to **NotifyInferior**.
  - It generates an **EnterNotify** event on each window between window A and window B, exclusive, with the detail member of each **XEnterWindowEvent** structure set to **NotifyVirtual**.
  - It generates an **EnterNotify** event on window B, with the detail member of the **XEnterWindowEvent** structure set to **NotifyAncestor**.
- When the pointer moves from window A to window B and window C is their least common ancestor, the X server does the following:
  - It generates a **LeaveNotify** event on window A, with the detail member of the **XLeaveWindowEvent** structure set to **NotifyNonlinear**.
  - It generates a **LeaveNotify** event on each window between window A and window C, exclusive, with the detail member of each **XLeaveWindowEvent** structure set to **NotifyNonlinearVirtual**.
  - It generates an **EnterNotify** event on each window between window C and window B, exclusive, with the detail member of each **XEnterWindowEvent** structure set to **NotifyNonlinearVirtual**.

- It generates an **EnterNotify** event on window B, with the detail member of the **XEnterWindowEvent** structure set to **NotifyNonlinear**.

- When the pointer moves from window A to window B on different screens, the X server does the following:
  - It generates a **LeaveNotify** event on window A, with the detail member of the **XLeaveWindowEvent** structure set to **NotifyNonlinear**.
  - If window A is not a root window, it generates a **LeaveNotify** event on each window above window A up to and including its root, with the detail member of each **XLeaveWindowEvent** structure set to **NotifyNonlinearVirtual**.
  - If window B is not a root window, it generates an **EnterNotify** event on each window from window B's root down to but not including window B, with the detail member of each **XEnterWindowEvent** structure set to **NotifyNonlinearVirtual**.
  - It generates an **EnterNotify** event on window B, with the detail member of the **XEnterWindowEvent** structure set to **NotifyNonlinear**.

8.4.2.2. Grab and Ungrab Entry/Exit Events

Pseudo-motion mode **EnterNotify** and **LeaveNotify** events are generated when a pointer grab activates or deactivates. Events in which the pointer grab activates are identified by **XEnterWindowEvent** or **XLeaveWindowEvent** structures whose mode member is set to **NotifyGrab**. Events in which the pointer grab deactivates are identified by **XEnterWindowEvent** or **XLeaveWindowEvent** structures whose mode member is set to **NotifyUngrab** (see **XGrabPointer**).

- When a pointer grab activates after any initial warp into a confine_to window and before generating any actual **ButtonPress** event that activates the grab, G is the grab_window for the grab, and P is the window the pointer is in, the X server does the following:
  - It generates **EnterNotify** and **LeaveNotify** events (see section 8.4.2.1) with the mode members of the **XEnterWindowEvent** and **XLeaveWindowEvent** structures set to **NotifyGrab**. These events are generated as if the pointer were to suddenly warp from its current position in P to some position in G. However, the pointer does not warp, and the X server uses the pointer position as both the initial and final positions for the events.

- When a pointer grab deactivates after generating any actual **ButtonRelease** event that deactivates the grab, G is the grab_window for the grab, and P is the window the pointer is in, the X server does the following:
  - It generates **EnterNotify** and **LeaveNotify** events (see section 8.4.2.1) with the mode members of the **XEnterWindowEvent** and **XLeaveWindowEvent** structures set to **NotifyUngrab**. These events are generated as if the pointer were to suddenly warp from some position in G to its current position in P. However, the pointer does not warp, and the X server uses the current pointer position as both the initial and final positions for the events.

8.4.3. Input Focus Events

This section describes the processing that occurs for the input focus events **FocusIn** and **FocusOut**. The X server can report **FocusIn** or **FocusOut** events to clients wanting information about when the input focus changes. The keyboard is always attached to some window (typically, the root window or a top-level window), which is called the focus window. The focus window and the position of the pointer determine the window that receives keyboard input. Clients may need to know when the input focus changes to control highlighting of areas on the screen.

To receive **FocusIn** or **FocusOut** events, set the **FocusChangeMask** bit in the event-mask attribute of the window.

The structure for these event types contains:

```
typedef struct {
	int type;			/* FocusIn or FocusOut */
	unsigned long serial;		/* # of last request processed by server */
	Bool send_event;		/* true if this came from a SendEvent request */
	Display *display;		/* Display the event was read from */
	Window window;			/* window of event */
	int mode;			/* NotifyNormal, NotifyGrab, NotifyUngrab */
	int detail;
					/*
					 * NotifyAncestor, NotifyVirtual, NotifyInferior,
					 * NotifyNonlinear,NotifyNonlinearVirtual, NotifyPointer,
					 * NotifyPointerRoot, NotifyDetailNone
					 */
} XFocusChangeEvent;
typedef XFocusChangeEvent XFocusInEvent;
typedef XFocusChangeEvent XFocusOutEvent;
```

The window member is set to the window on which the **FocusIn** or **FocusOut** event was generated. This is the window used by the X server to report the event. The mode member is set to indicate whether the focus events are normal focus events, focus events while grabbed, focus events when a grab activates, or focus events when a grab deactivates. The X server can set the mode member to **NotifyNormal**, **NotifyWhileGrabbed**, **NotifyGrab**, or **NotifyUngrab**.

All **FocusOut** events caused by a window unmap are generated after any **UnmapNotify** event; however, the X protocol does not constrain the ordering of **FocusOut** events with respect to generated **EnterNotify**, **LeaveNotify**, **VisibilityNotify**, and **Expose** events.

Depending on the event mode, the detail member is set to indicate the notify detail and can be **NotifyAncestor**, **NotifyVirtual**, **NotifyInferior**, **NotifyNonlinear**, **NotifyNonlinearVirtual**, **NotifyPointer**, **NotifyPointerRoot**, or **NotifyDetailNone**.

8.4.3.1. Normal Focus Events and Focus Events While Grabbed

Normal focus events are identified by **XFocusInEvent** or **XFocusOutEvent** structures whose mode member is set to **NotifyNormal**. Focus events while grabbed are identified by **XFocusInEvent** or **XFocusOutEvent** structures whose mode member is set to **NotifyWhileGrabbed**. The X server processes normal focus and focus events while grabbed according to the following:

- When the focus moves from window A to window B, A is an inferior of B, and the pointer is in window P, the X server does the following:
  - It generates a **FocusOut** event on window A, with the detail member of the **XFocusOutEvent** structure set to **NotifyAncestor**.
  - It generates a **FocusOut** event on each window between window A and window B, exclusive, with the detail member of each **XFocusOutEvent** structure set to **NotifyVirtual**.
  - It generates a **FocusIn** event on window B, with the detail member of the **XFocusOutEvent** structure set to **NotifyInferior**.

 - If window P is an inferior of window B but window P is not window A or an inferior or ancestor of window A, it generates a **FocusIn** event on each window below window B, down to and including window P, with the detail member of each **XFocusInEvent** structure set to **NotifyPointer**.
- When the focus moves from window A to window B, B is an inferior of A, and the pointer is in window P, the X server does the following:
  - If window P is an inferior of window A but P is not an inferior of window B or an ancestor of B, it generates a **FocusOut** event on each window from window P up to but not including window A, with the detail member of each **XFocusOutEvent** structure set to **NotifyPointer**.
  - It generates a **FocusOut** event on window A, with the detail member of the **XFocusOutEvent** structure set to **NotifyInferior**.
  - It generates a **FocusIn** event on each window between window A and window B, exclusive, with the detail member of each **XFocusInEvent** structure set to **NotifyVirtual**.
  - It generates a **FocusIn** event on window B, with the detail member of the **XFocusInEvent** structure set to **NotifyAncestor**.
- When the focus moves from window A to window B, window C is their least common ancestor, and the pointer is in window P, the X server does the following:
  - If window P is an inferior of window A, it generates a **FocusOut** event on each window from window P up to but not including window A, with the detail member of the **XFocusOutEvent** structure set to **NotifyPointer**.
  - It generates a **FocusOut** event on window A, with the detail member of the **XFocusOutEvent** structure set to **NotifyNonlinear**.
  - It generates a **FocusOut** event on each window between window A and window C, exclusive, with the detail member of each **XFocusOutEvent** structure set to **NotifyNonlinearVirtual**.
  - It generates a **FocusIn** event on each window between C and B, exclusive, with the detail member of each **XFocusInEvent** structure set to **NotifyNonlinearVirtual**.
  - It generates a **FocusIn** event on window B, with the detail member of the **XFocusInEvent** structure set to **NotifyNonlinear**.
  - If window P is an inferior of window B, it generates a **FocusIn** event on each window below window B down to and including window P, with the detail member of the **XFocusInEvent** structure set to **NotifyPointer**.
- When the focus moves from window A to window B on different screens and the pointer is in window P, the X server does the following:
  - If window P is an inferior of window A, it generates a **FocusOut** event on each window from window P up to but not including window A, with the detail member of each **XFocusOutEvent** structure set to **NotifyPointer**.
  - It generates a **FocusOut** event on window A, with the detail member of the **XFocusOutEvent** structure set to **NotifyNonlinear**.
  - If window A is not a root window, it generates a **FocusOut** event on each window above window A up to and including its root, with the detail member of each **XFocusOutEvent** structure set to **NotifyNonlinearVirtual**.
  - If window B is not a root window, it generates a **FocusIn** event on each window from window B's root down to but not including window B, with the detail member of each **XFocusInEvent** structure set to **NotifyNonlinearVirtual**.

- It generates a **FocusIn** event on window B, with the detail member of each **XFocusInEvent** structure set to **NotifyNonlinear**.
- If window P is an inferior of window B, it generates a **FocusIn** event on each window below window B down to and including window P, with the detail member of each **XFocusInEvent** structure set to **NotifyPointer**.

When the focus moves from window A to **PointerRoot** (events sent to the window under the pointer) or **None** (discard), and the pointer is in window P, the X server does the following:

- If window P is an inferior of window A, it generates a **FocusOut** event on each window from window P up to but not including window A, with the detail member of each **XFocusOutEvent** structure set to **NotifyPointer**.
- It generates a **FocusOut** event on window A, with the detail member of the **XFocusOutEvent** structure set to **NotifyNonlinear**.
- If window A is not a root window, it generates a **FocusOut** event on each window above window A up to and including its root, with the detail member of each **XFocusOutEvent** structure set to **NotifyNonlinearVirtual**.
- It generates a **FocusIn** event on the root window of all screens, with the detail member of each **XFocusInEvent** structure set to **NotifyPointerRoot** (or **NotifyDetailNone**).
- If the new focus is **PointerRoot**, it generates a **FocusIn** event on each window from window P's root down to and including window P, with the detail member of each **XFocusInEvent** structure set to **NotifyPointer**.

- When the focus moves from **PointerRoot** (events sent to the window under the pointer) or **None** to window A, and the pointer is in window P, the X server does the following:
  - If the old focus is **PointerRoot**, it generates a **FocusOut** event on each window from window P up to and including window P's root, with the detail member of each **XFocusOutEvent** structure set to **NotifyPointer**.
  - It generates a **FocusOut** event on all root windows, with the detail member of each **XFocusOutEvent** structure set to **NotifyPointerRoot** (or **NotifyDetailNone**).
  - If window A is not a root window, it generates a **FocusIn** event on each window from window A's root down to but not including window A, with the detail member of each **XFocusInEvent** structure set to **NotifyNonlinearVirtual**.
  - It generates a **FocusIn** event on window A, with the detail member of the **XFocusInEvent** structure set to **NotifyNonlinear**.
  - If window P is an inferior of window A, it generates a **FocusIn** event on each window below window A down to and including window P, with the detail member of each **XFocusInEvent** structure set to **NotifyPointer**.
- When the focus moves from **PointerRoot** (events sent to the window under the pointer) to **None** (or vice versa), and the pointer is in window P, the X server does the following:
  - If the old focus is **PointerRoot**, it generates a **FocusOut** event on each window from window P up to and including window P's root, with the detail member of each **XFocusOutEvent** structure set to **NotifyPointer**.
  - It generates a **FocusOut** event on all root windows, with the detail member of each **XFocusOutEvent** structure set to either **NotifyPointerRoot** or **NotifyDetailNone**.

  - It generates a **FocusIn** event on all root windows, with the detail member of each **XFocusInEvent** structure set to **NotifyDetailNone** or **NotifyPointerRoot**.
  - If the new focus is **PointerRoot**, it generates a **FocusIn** event on each window from window P's root down to and including window P, with the detail member of each **XFocusInEvent** structure set to **NotifyPointer**.

8.4.3.2. Focus Events Generated by Grabs

Focus events in which the keyboard grab activates are identified by **XFocusInEvent** or **XFocusOutEvent** structures whose mode member is set to **NotifyGrab**. Focus events in which the keyboard grab deactivates are identified by **XFocusInEvent** or **XFocusOutEvent** structures whose mode member is set to **NotifyUngrab** (see **XGrabKeyboard**).

- When a keyboard grab activates before generating any actual **KeyPress** event that activates the grab, G is the grab_window, and F is the current focus, the X server does the following:
  - It generates **FocusIn** and **FocusOut** events, with the mode members of the **XFocusInEvent** and **XFocusOutEvent** structures set to **NotifyGrab**. These events are generated as if the focus were to change from F to G.
- When a keyboard grab deactivates after generating any actual **KeyRelease** event that deactivates the grab, G is the grab_window, and F is the current focus, the X server does the following:
  - It generates **FocusIn** and **FocusOut** events, with the mode members of the **XFocusInEvent** and **XFocusOutEvent** structures set to **NotifyUngrab**. These events are generated as if the focus were to change from G to F.

8.4.4. Key Map State Notification Events

The X server can report **KeymapNotify** events to clients that want information about changes in their keyboard state.

To receive **KeymapNotify** events, set the **KeymapStateMask** bit in the event-mask attribute of the window. The X server generates this event immediately after every **EnterNotify** and **FocusIn** event.

The structure for this event type contains:

```
/* generated on EnterWindow and FocusIn when KeymapState selected */
typedef struct {
	int type;			/* KeymapNotify */
	unsigned long serial;		/* # of last request processed by server */
	Bool send_event;		/* true if this came from a SendEvent request */
	Display *display;		/* Display the event was read from */
	Window window;
	char key_vector[32];
} XKeymapEvent;
```

The window member is not used but is present to aid some toolkits. The key_vector member is set to the bit vector of the keyboard. Each bit set to 1 indicates that the corresponding key is currently pressed. The vector is represented as 32 bytes. Byte N (from 0) contains the bits for keys 8N to 8N + 7 with the least-significant bit in the byte representing key 8N.

8.4.5. Exposure Events

The X protocol does not guarantee to preserve the contents of window regions when the windows are obscured or reconfigured. Some implementations may preserve the contents of windows. Other implementations are free to destroy the contents of windows when exposed. X expects client applications to assume the responsibility for restoring the contents of an exposed window region. (An exposed window region describes a formerly obscured window whose region becomes visible.) Therefore, the X server sends **Expose** events describing the window and the region of the window that has been exposed. A naive client application usually redraws the entire window. A more sophisticated client application redraws only the exposed region.

8.4.5.1. Expose Events

The X server can report **Expose** events to clients wanting information about when the contents of window regions have been lost. The circumstances in which the X server generates **Expose** events are not as definite as those for other events. However, the X server never generates **Expose** events on windows whose class you specified as **InputOnly**. The X server can generate **Expose** events when no valid contents are available for regions of a window and either the regions are visible, the regions are viewable and the server is (perhaps newly) maintaining backing store on the window, or the window is not viewable but the server is (perhaps newly) honoring the window's backing-store attribute of **Always** or **WhenMapped**. The regions decompose into an (arbitrary) set of rectangles, and an **Expose** event is generated for each rectangle. For any given window, the X server guarantees to report contiguously all of the regions exposed by some action that causes **Expose** events, such as raising a window.

To receive **Expose** events, set the **ExposureMask** bit in the event-mask attribute of the window.

The structure for this event type contains:

```
typedef struct {
        int type;                        /* Expose */
        unsigned long serial;            /* # of last request processed by server */
        Bool send_event;                 /* true if this came from a SendEvent request */
        Display *display;                /* Display the event was read from */
        Window window;
        int x, y;
        int width, height;
        int count;                       /* if nonzero, at least this many more */
} XExposeEvent;
```

The window member is set to the exposed (damaged) window. The x and y members are set to the coordinates relative to the window's origin and indicate the upper-left corner of the rectangle. The width and height members are set to the size (extent) of the rectangle. The count member is set to the number of **Expose** events that are to follow. If count is zero, no more **Expose** events follow for this window. However, if count is nonzero, at least that number of **Expose** events (and possibly more) follow for this window. Simple applications that do not want to optimize redisplay by distinguishing between subareas of its window can just ignore all **Expose** events with nonzero counts and perform full redisplays on events with zero counts.

8.4.5.2. GraphicsExpose and NoExpose Events

The X server can report **GraphicsExpose** events to clients wanting information about when a destination region could not be computed during certain graphics requests: **XCopyArea** or **XCopyPlane**. The X server generates this event whenever a destination region could not be computed due to an obscured or out-of-bounds source region.

In addition, the X server guarantees to report contiguously all of the regions exposed by some graphics request (for example, copying an area of a drawable to a destination drawable).

The X server generates a **NoExpose** event whenever a graphics request that might produce a **GraphicsExpose** event does not produce any. In other words, the client is really asking for a **GraphicsExpose** event but instead receives a **NoExpose** event.

To receive **GraphicsExpose** or **NoExpose** events, you must first set the graphics-exposure attribute of the graphics context to **True**. You also can set the graphics-expose attribute when creating a graphics context using **XCreateGC** or by calling **XSetGraphicsExposures**.

The structures for these event types contain:

```
typedef struct {
	int type;			/* GraphicsExpose */
	unsigned long serial;		/* # of last request processed by server */
	Bool send_event;		/* true if this came from a SendEvent request */
	Display *display;		/* Display the event was read from */
	Drawable drawable;
	int x, y;
	int width, height;
	int count;			/* if nonzero, at least this many more */
	int major_code;			/* core is CopyArea or CopyPlane */
	int minor_code;			/* not defined in the core */
} XGraphicsExposeEvent;

typedef struct {
	int type;			/* NoExpose */
	unsigned long serial;		/* # of last request processed by server */
	Bool send_event;		/* true if this came from a SendEvent request */
	Display *display;		/* Display the event was read from */
	Drawable drawable;
	int major_code;			/* core is CopyArea or CopyPlane */
	int minor_code;			/* not defined in the core */
} XNoExposeEvent;
```

Both structures have these common members: drawable, major_code, and minor_code. The drawable member is set to the drawable of the destination region on which the graphics request was to be performed. The major_code member is set to the graphics request initiated by the client and can be either **X_CopyArea** or **X_CopyPlane**. If it is **X_CopyArea**, a call to **XCopyArea** initiated the request. If it is **X_CopyPlane**, a call to **XCopyPlane** initiated the request. These constants are defined in **<X11/Xproto.h>**. The minor_code member, like the major_code member, indicates which graphics request was initiated by the client. However, the minor_code member is not defined by the core X protocol and will be zero in these cases, although it may be used by an extension.

The **XGraphicsExposeEvent** structure has these additional members: x, y, width, height, and count. The x and y members are set to the coordinates relative to the drawable's origin and indicate the upper-left corner of the rectangle. The width and height members are set to the size (extent) of the rectangle. The count member is set to the number of **GraphicsExpose** events to follow. If count is zero, no more **GraphicsExpose** events follow for this window. However, if count is nonzero, at least that number of **GraphicsExpose** events (and possibly more) are to follow for this window.

8.4.6. Window State Change Events

The following sections discuss:

- **CirculateNotify** events
- **ConfigureNotify** events
- **CreateNotify** events
- **DestroyNotify** events
- **GravityNotify** events
- **MapNotify** events
- **MappingNotify** events
- **ReparentNotify** events
- **UnmapNotify** events
- **VisibilityNotify** events

8.4.6.1. CirculateNotify Events

The X server can report **CirculateNotify** events to clients wanting information about when a window changes its position in the stack. The X server generates this event type whenever a window is actually restacked as a result of a client application calling **XCirculateSubwindows**, **XCirculateSubwindowsUp**, or **XCirculateSubwindowsDown**.

To receive **CirculateNotify** events, set the **StructureNotifyMask** bit in the event-mask attribute of the window or the **SubstructureNotifyMask** bit in the event-mask attribute of the parent window (in which case, circulating any child generates an event).

The structure for this event type contains:

```
typedef struct {
        int type;                    /* CirculateNotify */
        unsigned long serial;        /* # of last request processed by server */
        Bool send_event;             /* true if this came from a SendEvent request */
        Display *display;            /* Display the event was read from */
        Window event;
        Window window;
        int place;                   /* PlaceOnTop, PlaceOnBottom */
} XCirculateEvent;
```

The event member is set either to the restacked window or to its parent, depending on whether **StructureNotify** or **SubstructureNotify** was selected. The window member is set to the window that was restacked. The place member is set to the window's position after the restack occurs and is either **PlaceOnTop** or **PlaceOnBottom**. If it is **PlaceOnTop**, the window is now on top of all siblings. If it is **PlaceOnBottom**, the window is now below all siblings.

8.4.6.2. ConfigureNotify Events

The X server can report **ConfigureNotify** events to clients wanting information about actual changes to a window's state, such as size, position, border, and stacking order. The X server generates this event type whenever one of the following configure window requests made by a client application actually completes:

- A window's size, position, border, and/or stacking order is reconfigured by calling **XConfigureWindow**.
- The window's position in the stacking order is changed by calling **XLowerWindow**, **XRaiseWindow**, or **XRestackWindows**.

- A window is moved by calling **XMoveWindow**.
- A window's size is changed by calling **XResizeWindow**.
- A window's size and location is changed by calling **XMoveResizeWindow**.
- A window is mapped and its position in the stacking order is changed by calling **XMapRaised**.
- A window's border width is changed by calling **XSetWindowBorderWidth**.

To receive **ConfigureNotify** events, set the **StructureNotifyMask** bit in the event-mask attribute of the window or the **SubstructureNotifyMask** bit in the event-mask attribute of the parent window (in which case, configuring any child generates an event).

The structure for this event type contains:

```
typedef struct {
	int type;                    /* ConfigureNotify */
	unsigned long serial;        /* # of last request processed by server */
	Bool send_event;             /* true if this came from a SendEvent request */
	Display *display;            /* Display the event was read from */
	Window event;
	Window window;
	int x, y;
	int width, height;
	int border_width;
	Window above;
	Bool override_redirect;
} XConfigureEvent;
```

The event member is set either to the reconfigured window or to its parent, depending on whether **StructureNotify** or **SubstructureNotify** was selected. The window member is set to the window whose size, position, border, and/or stacking order was changed.

The x and y members are set to the cöordinates relative to the parent window's origin and indicate the position of the upper-left outside corner of the window. The width and height members are set to the inside size of the window, not including the border. The border_width member is set to the width of the window's border, in pixels.

The above member is set to the sibling window and is used for stacking operations. If the X server sets this member to **None**, the window whose state was changed is on the bottom of the stack with respect to sibling windows. However, if this member is set to a sibling window, the window whose state was changed is placed on top of this sibling window.

The override_redirect member is set to the override-redirect attribute of the window. Window manager clients normally should ignore this window if the override_redirect member is **True**.

8.4.6.3. CreateNotify Events

The X server can report **CreateNotify** events to clients wanting information about creation of windows. The X server generates this event whenever a client application creates a window by calling **XCreateWindow** or **XCreateSimpleWindow**.

To receive **CreateNotify** events, set the **SubstructureNotifyMask** bit in the event-mask attribute of the window. Creating any children then generates an event.

The structure for the event type contains:

```
typedef struct {
	int type;                    /* CreateNotify */
	unsigned long serial;        /* # of last request processed by server */
```

```
        Bool send_event;            /* true if this came from a SendEvent request */
        Display *display;           /* Display the event was read from */
        Window parent;              /* parent of the window */
        Window window;              /* window id of window created */
        int x, y;                   /* window location */
        int width, height;          /* size of window */
        int border_width;           /* border width */
        Bool override_redirect;     /* creation should be overridden */
} XCreateWindowEvent;
```

The parent member is set to the created window's parent. The window member specifies the created window. The x and y members are set to the created window's coordinates relative to the parent window's origin and indicate the position of the upper-left outside corner of the created window. The width and height members are set to the inside size of the created window (not including the border) and are always nonzero. The border_width member is set to the width of the created window's border, in pixels. The override_redirect member is set to the override-redirect attribute of the window. Window manager clients normally should ignore this window if the override_redirect member is **True**.

8.4.6.4. DestroyNotify Events

The X server can report **DestroyNotify** events to clients wanting information about which windows are destroyed. The X server generates this event whenever a client application destroys a window by calling **XDestroyWindow** or **XDestroySubwindows**.

The ordering of the **DestroyNotify** events is such that for any given window, **DestroyNotify** is generated on all inferiors of the window before being generated on the window itself. The X protocol does not constrain the ordering among siblings and across subhierarchies.

To receive **DestroyNotify** events, set the **StructureNotifyMask** bit in the event-mask attribute of the window or the **SubstructureNotifyMask** bit in the event-mask attribute of the parent window (in which case, destroying any child generates an event).

The structure for this event type contains:

```
typedef struct {
        int type;                   /* DestroyNotify */
        unsigned long serial;       /* # of last request processed by server */
        Bool send_event;            /* true if this came from a SendEvent request */
        Display *display;           /* Display the event was read from */
        Window event;
        Window window;
} XDestroyWindowEvent;
```

The event member is set either to the destroyed window or to its parent, depending on whether **StructureNotify** or **SubstructureNotify** was selected. The window member is set to the window that is destroyed.

8.4.6.5. GravityNotify Events

The X server can report **GravityNotify** events to clients wanting information about when a window is moved because of a change in the size of its parent. The X server generates this event whenever a client application actually moves a child window as a result of resizing its parent by calling **XConfigureWindow**, **XMoveResizeWindow**, or **XResizeWindow**.

To receive **GravityNotify** events, set the **StructureNotifyMask** bit in the event-mask attribute of the window or the **SubstructureNotifyMask** bit in the event-mask attribute of the parent window (in which case, any child that is moved because its parent has been resized generates an event).

The structure for this event type contains:

```
typedef struct {
	int type;                       /* GravityNotify */
	unsigned long serial;           /* # of last request processed by server */
	Bool send_event;                /* true if this came from a SendEvent request */
	Display *display;               /* Display the event was read from */
	Window event;
	Window window;
	int x, y;
} XGravityEvent;
```

The event member is set either to the window that was moved or to its parent, depending on whether **StructureNotify** or **SubstructureNotify** was selected. The window member is set to the child window that was moved. The x and y members are set to the coordinates relative to the new parent window's origin and indicate the position of the upper-left outside corner of the window.

8.4.6.6. MapNotify Events

The X server can report **MapNotify** events to clients wanting information about which windows are mapped. The X server generates this event type whenever a client application changes the window's state from unmapped to mapped by calling **XMapWindow**, **XMapRaised**, **XMapSubwindows**, **XReparentWindow**, or as a result of save-set processing.

To receive **MapNotify** events, set the **StructureNotifyMask** bit in the event-mask attribute of the window or the **SubstructureNotifyMask** bit in the event-mask attribute of the parent window (in which case, mapping any child generates an event).

The structure for this event type contains:

```
typedef struct {
	int type;                       /* MapNotify */
	unsigned long serial;           /* # of last request processed by server */
	Bool send_event;                /* true if this came from a SendEvent request */
	Display *display;               /* Display the event was read from */
	Window event;
	Window window;
	Bool override_redirect;         /* boolean, is override set... */
} XMapEvent;
```

The event member is set either to the window that was mapped or to its parent, depending on whether **StructureNotify** or **SubstructureNotify** was selected. The window member is set to the window that was mapped. The override_redirect member is set to the override-redirect attribute of the window. Window manager clients normally should ignore this window if the override-redirect attribute is **True**, because these events usually are generated from pop-ups, which override structure control.

8.4.6.7. MappingNotify Events

The X server reports **MappingNotify** events to all clients. There is no mechanism to express disinterest in this event. The X server generates this event type whenever a client application successfully calls:

- **XSetModifierMapping** to indicate which KeyCodes are to be used as modifiers
- **XChangeKeyboardMapping** to change the keyboard mapping
- **XSetPointerMapping** to set the pointer mapping

The structure for this event type contains:

```
typedef struct {
        int type;                   /* MappingNotify */
        unsigned long serial;       /* # of last request processed by server */
        Bool send_event;            /* true if this came from a SendEvent request */
        Display *display;           /* Display the event was read from */
        Window window;              /* unused */
        int request;                /* one of MappingModifier, MappingKeyboard,
                                       MappingPointer */
        int first_keycode;          /* first keycode */
        int count;                  /* defines range of change w. first_keycode*/
} XMappingEvent;
```

The request member is set to indicate the kind of mapping change that occurred and can be **MappingModifier**, **MappingKeyboard**, **MappingPointer**. If it is **MappingModifier**, the modifier mapping was changed. If it is **MappingKeyboard**, the keyboard mapping was changed. If it is **MappingPointer**, the pointer button mapping was changed. The first_keycode and count members are set only if the request member was set to **MappingKeyboard**. The number in first_keycode represents the first number in the range of the altered mapping, and count represents the number of keycodes altered.

To update the client application's knowledge of the keyboard, you should call **XRefreshKeyboardMapping**.

8.4.6.8. ReparentNotify Events

The X server can report **ReparentNotify** events to clients wanting information about changing a window's parent. The X server generates this event whenever a client application calls **XReparentWindow** and the window is actually reparented.

To receive **ReparentNotify** events, set the **StructureNotifyMask** bit in the event-mask attribute of the window or the **SubstructureNotifyMask** bit in the event-mask attribute of either the old or the new parent window (in which case, reparenting any child generates an event).

The structure for this event type contains:

```
typedef struct {
        int type;                   /* ReparentNotify */
        unsigned long serial;       /* # of last request processed by server */
        Bool send_event;            /* true if this came from a SendEvent request */
        Display *display;           /* Display the event was read from */
        Window event;
        Window window;
        Window parent;
        int x, y;
        Bool override_redirect;
} XReparentEvent;
```

The event member is set either to the reparented window or to the old or the new parent, depending on whether **StructureNotify** or **SubstructureNotify** was selected. The window member is set to the window that was reparented. The parent member is set to the new parent window. The x and y members are set to the reparented window's coordinates relative to the new parent window's origin and define the upper-left outer corner of the reparented window. The override_redirect member is set to the override-redirect attribute of the window specified by the window member. Window manager clients normally should ignore this window if the override_redirect member is **True**.

8.4.6.9. UnmapNotify Events

The X server can report **UnmapNotify** events to clients wanting information about which windows are unmapped. The X server generates this event type whenever a client application changes the window's state from mapped to unmapped.

To receive **UnmapNotify** events, set the **StructureNotifyMask** bit in the event-mask attribute of the window or the **SubstructureNotifyMask** bit in the event-mask attribute of the parent window (in which case, unmapping any child window generates an event).

The structure for this event type contains:

```
typedef struct {
        int type;                       /* UnmapNotify */
        unsigned long serial;           /* # of last request processed by server */
        Bool send_event;                /* true if this came from a SendEvent request */
        Display *display;               /* Display the event was read from */
        Window event;
        Window window;
        Bool from_configure;
} XUnmapEvent;
```

The event member is set either to the unmapped window or to its parent, depending on whether **StructureNotify** or **SubstructureNotify** was selected. This is the window used by the X server to report the event. The window member is set to the window that was unmapped. The from_configure member is set to **True** if the event was generated as a result of a resizing of the window's parent when the window itself had a win_gravity of **UnmapGravity**.

8.4.6.10. VisibilityNotify Events

The X server can report **VisibilityNotify** events to clients wanting any change in the visibility of the specified window. A region of a window is visible if someone looking at the screen can actually see it. The X server generates this event whenever the visibility changes state. However, this event is never generated for windows whose class is **InputOnly**.

All **VisibilityNotify** events caused by a hierarchy change are generated after any hierarchy event (**UnmapNotify**, **MapNotify**, **ConfigureNotify**, **GravityNotify**, **CirculateNotify**) caused by that change. Any **VisibilityNotify** event on a given window is generated before any **Expose** events on that window, but it is not required that all **VisibilityNotify** events on all windows be generated before all **Expose** events on all windows. The X protocol does not constrain the ordering of **VisibilityNotify** events with respect to **FocusOut**, **EnterNotify**, and **LeaveNotify** events.

To receive **VisibilityNotify** events, set the **VisibilityChangeMask** bit in the event-mask attribute of the window.

The structure for this event type contains:

```
typedef struct {
        int type;                       /* VisibiltyNotify */
        unsigned long serial;           /* # of last request processed by server */
        Bool send_event;                /* true if this came from a SendEvent request */
        Display *display;               /* Display the event was read from */
```

```
        Window window;
        int state;
} XVisibilityEvent;
```

The window member is set to the window whose visibility state changes. The state member is set to the state of the window's visibility and can be **VisibilityUnobscured**, **VisibilityPartiallyObscured**, or **VisibilityFullyObscured**. The X server ignores all of a window's subwindows when determining the visibility state of the window and processes **VisibilityNotify** events according to the following:

- When the window changes state from partially obscured, fully obscured, or not viewable to viewable and completely unobscured, the X server generates the event with the state member of the **XVisibilityEvent** structure set to **VisibilityUnobscured**.
- When the window changes state from viewable and completely unobscured or not viewable to viewable and partially obscured, the X server generates the event with the state member of the **XVisibilityEvent** structure set to **VisibilityPartiallyObscured**.
- When the window changes state from viewable and completely unobscured, viewable and partially obscured, or not viewable to viewable and fully obscured, the X server generates the event with the state member of the **XVisibilityEvent** structure set to **VisibilityFullyObscured**.

8.4.7. Structure Control Events

This section discusses:

- **CirculateRequest** events
- **ConfigureRequest** events
- **MapRequest** events
- **ResizeRequest** events

8.4.7.1. CirculateRequest Events

The X server can report **CirculateRequest** events to clients wanting information about when another client initiates a circulate window request on a specified window. The X server generates this event type whenever a client initiates a circulate window request on a window and a subwindow actually needs to be restacked. The client initiates a circulate window request on the window by calling **XCirculateSubwindows**, **XCirculateSubwindowsUp**, or **XCirculateSubwindowsDown**.

To receive **CirculateRequest** events, set the **SubstructureRedirectMask** in the event-mask attribute of the window. Then, in the future, the circulate window request for the specified window is not executed, and thus, any subwindow's position in the stack is not changed. For example, suppose a client application calls **XCirculateSubwindowsUp** to raise a subwindow to the top of the stack. If you had selected **SubstructureRedirectMask** on the window, the X server reports to you a **CirculateRequest** event and does not raise the subwindow to the top of the stack.

The structure for this event type contains:

```
typedef struct {
        int type;                    /* CirculateRequest */
        unsigned long serial;        /* # of last request processed by server */
        Bool send_event;             /* true if this came from a SendEvent request */
        Display *display;            /* Display the event was read from */
        Window parent;
        Window window;
```

```
        int place;                      /* PlaceOnTop, PlaceOnBottom */
} XCirculateRequestEvent;
```

The parent member is set to the parent window. The window member is set to the subwindow to be restacked. The place member is set to what the new position in the stacking order should be and is either **PlaceOnTop** or **PlaceOnBottom**. If it is **PlaceOnTop**, the subwindow should be on top of all siblings. If it is **PlaceOnBottom**, the subwindow should be below all siblings.

8.4.7.2. ConfigureRequest Events

The X server can report **ConfigureRequest** events to clients wanting information about when a different client initiates a configure window request on any child of a specified window. The configure window request attempts to reconfigure a window's size, position, border, and stacking order. The X server generates this event whenever a different client initiates a configure window request on a window by calling **XConfigureWindow**, **XLowerWindow**, **XRaiseWindow**, **XMapRaised**, **XMoveResizeWindow**, **XMoveWindow**, **XResizeWindow**, **XRestackWindows**, or **XSetWindowBorderWidth**.

To receive **ConfigureRequest** events, set the **SubstructureRedirectMask** bit in the event-mask attribute of the window. **ConfigureRequest** events are generated when a **ConfigureWindow** protocol request is issued on a child window by another client. For example, suppose a client application calls **XLowerWindow** to lower a window. If you had selected **SubstructureRedirectMask** on the parent window and if the override-redirect attribute of the window is set to **False**, the X server reports a **ConfigureRequest** event to you and does not lower the specified window.

The structure for this event type contains:

```
typedef struct {
        int type;                       /* ConfigureRequest */
        unsigned long serial;           /* # of last request processed by server */
        Bool send_event;                /* true if this came from a SendEvent request */
        Display *display;               /* Display the event was read from */
        Window parent;
        Window window;
        int x, y;
        int width, height;
        int border_width;
        Window above;
        int detail;                     /* Above, Below, TopIf, BottomIf, Opposite */
        unsigned long value_mask;
} XConfigureRequestEvent;
```

The parent member is set to the parent window. The window member is set to the window whose size, position, border width, and/or stacking order is to be reconfigured. The value_mask member indicates which components were specified in the **ConfigureWindow** protocol request. The corresponding values are reported as given in the request. The remaining values are filled in from the current geometry of the window, except in the case of above (sibling) and detail (stack-mode), which are reported as **Above** and **None**, respectively, if they are not given in the request.

8.4.7.3. MapRequest Events

The X server can report **MapRequest** events to clients wanting information about a different client's desire to map windows. A window is considered mapped when a map window request completes. The X server generates this event whenever a different client initiates a map window request on an unmapped window whose override_redirect member is set to **False**. Clients initiate map window requests by calling **XMapWindow**, **XMapRaised**, or **XMapSubwindows**.

To receive **MapRequest** events, set the **SubstructureRedirectMask** bit in the event-mask attribute of the window. This means another client's attempts to map a child window by calling one of the map window request functions is intercepted, and you are sent a **MapRequest** instead. For example, suppose a client application calls **XMapWindow** to map a window. If you (usually a window manager) had selected **SubstructureRedirectMask** on the parent window and if the override-redirect attribute of the window is set to **False**, the X server reports a **MapRequest** event to you and does not map the specified window. Thus, this event gives your window manager client the ability to control the placement of subwindows.

The structure for this event type contains:

```
typedef struct {
        int type;                   /* MapRequest */
        unsigned long serial;       /* # of last request processed by server */
        Bool send_event;            /* true if this came from a SendEvent request */
        Display *display;           /* Display the event was read from */
        Window parent;
        Window window;
} XMapRequestEvent;
```

The parent member is set to the parent window. The window member is set to the window to be mapped.

8.4.7.4. ResizeRequest Events

The X server can report **ResizeRequest** events to clients wanting information about another client's attempts to change the size of a window. The X server generates this event whenever some other client attempts to change the size of the specified window by calling **XConfigureWindow**, **XResizeWindow**, or **XMoveResizeWindow**.

To receive **ResizeRequest** events, set the **ResizeRedirect** bit in the event-mask attribute of the window. Any attempts to change the size by other clients are then redirected.

The structure for this event type contains:

```
typedef struct {
        int type;                   /* ResizeRequest */
        unsigned long serial;       /* # of last request processed by server */
        Bool send_event;            /* true if this came from a SendEvent request */
        Display *display;           /* Display the event was read from */
        Window window;
        int width, height;
} XResizeRequestEvent;
```

The window member is set to the window whose size another client attempted to change. The width and height members are set to the inside size of the window, excluding the border.

8.4.8. Colormap State Change Events

The X server can report **ColormapNotify** events to clients wanting information about when the colormap changes and when a colormap is installed or uninstalled. The X server generates this event type whenever a client application:

- Changes the colormap member of the **XSetWindowAttributes** structure by calling **XChangeWindowAttributes**, **XFreeColormap**, or **XSetWindowColormap**
- Installs or uninstalls the colormap by calling **XInstallColormap** or **XUninstallColormap**

To receive **ColormapNotify** events, set the **ColormapChangeMask** bit in the event-mask attribute of the window.

The structure for this event type contains:

```
typedef struct {
	int type;			/* ColormapNotify */
	unsigned long serial;		/* # of last request processed by server */
	Bool send_event;		/* true if this came from a SendEvent request */
	Display *display;		/* Display the event was read from */
	Window window;
	Colormap colormap;		/* colormap or None */
	Bool new;
	int state;			/* ColormapInstalled, ColormapUninstalled */
} XColormapEvent;
```

The window member is set to the window whose associated colormap is changed, installed, or uninstalled. For a colormap that is changed, installed, or uninstalled, the colormap member is set to the colormap associated with the window. For a colormap that is changed by a call to **XFreeColormap**, the colormap member is set to **None**. The new member is set to indicate whether the colormap for the specified window was changed or installed or uninstalled and can be **True** or **False**. If it is **True**, the colormap was changed. If it is **False**, the colormap was installed or uninstalled. The state member is always set to indicate whether the colormap is installed or uninstalled and can be **ColormapInstalled** or **ColormapUninstalled**.

8.4.9. Client Communication Events

This section discusses:

- **ClientMessage** events
- **PropertyNotify** events
- **SelectionClear** events
- **SelectionNotify** events
- **SelectionRequest** events

8.4.9.1. ClientMessage Events

The X server generates **ClientMessage** events only when a client calls the function **XSendEvent**.

The structure for this event type contains:

```
typedef struct {
	int type;			/* ClientMessage */
	unsigned long serial;		/* # of last request processed by server */
	Bool send_event;		/* true if this came from a SendEvent request */
	Display *display;		/* Display the event was read from */
	Window window;
	Atom message_type;
	int format;
	union {
		char b[20];
```

```
                short s[10];
                long l[5];
            } data;
} XClientMessageEvent;
```

The window member is set to the window to which the event was sent. The message_type member is set to an atom that indicates how the data should be interpreted by the receiving client. The format member is set to 8, 16, or 32 and specifies whether the data should be viewed as a list of bytes, shorts, or longs. The data member is a union that contains the members b, s, and l. The b, s, and l members represent data of 20 8-bit values, 10 16-bit values, and 5 32-bit values. Particular message types might not make use of all these values. The X server places no interpretation on the values in the message_type or data members.

8.4.9.2. PropertyNotify Events

The X server can report **PropertyNotify** events to clients wanting information about property changes for a specified window.

To receive **PropertyNotify** events, set the **PropertyChangeMask** bit in the event-mask attribute of the window.

The structure for this event type contains:

```
typedef struct {
        int type;                       /* PropertyNotify */
        unsigned long serial;           /* # of last request processed by server */
        Bool send_event;                /* true if this came from a SendEvent request */
        Display *display;               /* Display the event was read from */
        Window window;
        Atom atom;
        Time time;
        int state;                      /* PropertyNewValue or PropertyDeleted */
} XPropertyEvent;
```

The window member is set to the window whose associated property was changed. The atom member is set to the property's atom and indicates which property was changed or desired. The time member is set to the server time when the property was changed. The state member is set to indicate whether the property was changed to a new value or deleted and can be **PropertyNewValue** or **PropertyDelete**. The state member is set to **PropertyNewValue** when a property of the window is changed using **XChangeProperty** or **XRotateWindowProperties** (even when adding zero-length data using **XChangeProperty**) and when replacing all or part of a property with identical data using **XChangeProperty** or **XRotateWindowProperties**. The state member is set to **PropertyDeleted** when a property of the window is deleted using **XDeleteProperty** or, if the delete argument is **True**, **XGetWindowProperty**.

8.4.9.3. SelectionClear Events

The X server reports **SelectionClear** events to the current owner of a selection. The X server generates this event type on the window losing ownership of the selection to a new owner. This sequence of events could occur whenever a client calls **XSetSelectionOwner**.

The structure for this event type contains:

```
typedef struct {
        int type;                       /* SelectionClear */
        unsigned long serial;           /* # of last request processed by server */
        Bool send_event;                /* true if this came from a SendEvent request */
```

```
        Display *display;            /* Display the event was read from */
        Window window;
        Atom selection;
        Time time;
} XSelectionClearEvent;
```

The window member is set to the window losing ownership of the selection. The selection member is set to the selection atom. The time member is set to the last change time recorded for the selection. The owner member is the window that was specified by the current owner in its **XSetSelectionOwner** call.

8.4.9.4. SelectionRequest Events

The X server reports **SelectionRequest** events to the owner of a selection. The X server generates this event whenever a client requests a selection conversion by calling **XConvertSelection** and the specified selection is owned by a window.

The structure for this event type contains:

```
typedef struct {
        int type;                    /* SelectionRequest */
        unsigned long serial;        /* # of last request processed by server */
        Bool send_event;             /* true if this came from a SendEvent request */
        Display *display;            /* Display the event was read from */
        Window owner;
        Window requestor;
        Atom selection;
        Atom target;
        Atom property;
        Time time;
} XSelectionRequestEvent;
```

The owner member is set to the window owning the selection and is the window that was specified by the current owner in its **XSetSelectionOwner** call. The requestor member is set to the window requesting the selection. The selection member is set to the atom that names the selection. For example, PRIMARY is used to indicate the primary selection. The target member is set to the atom that indicates the type the selection is desired in. The property member can be a property name or **None**. The time member is set to the time and is a timestamp or **CurrentTime** from the **ConvertSelection** request.

The client who owns the selection should do the following:

- The owner client should convert the selection based on the atom contained in the target member.
- If a property was specified (that is, the property member is set), the owner client should store the result as that property on the requestor window and then send a **SelectionNotify** event to the requestor by calling **XSendEvent** with an empty event-mask; that is, the event should be sent to the creator of the requestor window.
- If **None** is specified as the property, the owner client should choose a property name on the requestor window and then send a **SelectionNotify** event giving the actual name.
- If the selection cannot be converted as requested, the owner client should send a **SelectionNotify** event with the property set to **None**.

8.4.9.5. SelectionNotify Events

This event is generated by the X server in response to a **ConvertSelection** protocol request when there is no owner for the selection. When there is an owner, it should be generated by the owner of the selection by using **XSendEvent**. The owner of a selection should send this event to a requestor when a selection has been converted and stored as a property or when a selection conversion could not be performed (which is indicated by setting the property member to **None**).

If **None** is specified as the property in the **ConvertSelection** protocol request, the owner should choose a property name, store the result as that property on the requestor window, and then send a **SelectionNotify** giving that actual property name.

The structure for this event type contains:

```
typedef struct {
	int type;			/* SelectionNotify */
	unsigned long serial;		/* # of last request processed by server */
	Bool send_event;		/* true if this came from a SendEvent request */
	Display *display;		/* Display the event was read from */
	Window requestor;
	Atom selection;
	Atom target;
	Atom property;			/* atom or None */
	Time time;
} XSelectionEvent;
```

The requestor member is set to the window associated with the requestor of the selection. The selection member is set to the atom that indicates the selection. For example, PRIMARY is used for the primary selection. The target member is set to the atom that indicates the converted type. For example, PIXMAP is used for a pixmap. The property member is set to the atom that indicates which property the result was stored on. If the conversion failed, the property member is set to **None**. The time member is set to the time the conversion took place and can be a timestamp or **CurrentTime**.

8.5. Selecting Events

There are two ways to select the events you want reported to your client application. One way is to set the event_mask member of the **XSetWindowAttributes** structure when you call **XCreateWindow** and **XChangeWindowAttributes**. Another way is to use **XSelectInput**.

XSelectInput(*display, w, event_mask*)
    Display **display*;
    Window *w*;
    long *event_mask*;

display Specifies the connection to the X server.

w Specifies the window whose events you are interested in.

event_mask Specifies the event mask.

The **XSelectInput** function requests that the X server report the events associated with the specified event mask. Initially, X will not report any of these events. Events are reported relative to a window. If a window is not interested in a device event, it usually propagates to the closest ancestor that is interested, unless the do_not_propagate mask prohibits it.

Setting the event-mask attribute of a window overrides any previous call for the same window but not for other clients. Multiple clients can select for the same events on the same window with the following restrictions:

- Multiple clients can select events on the same window because their event masks are disjoint. When the X server generates an event, it reports it to all interested clients.
- Only one client at a time can select **CirculateRequest**, **ConfigureRequest**, or **MapRequest** events, which are associated with the event mask **SubstructureRedirectMask**.
- Only one client at a time can select a **ResizeRequest** event, which is associated with the event mask **ResizeRedirectMask**.
- Only one client at a time can select a **ButtonPress** event, which is associated with the event mask **ButtonPressMask**.

The server reports the event to all interested clients.

XSelectInput can generate a **BadWindow** error.

8.6. Handling the Output Buffer

The output buffer is an area used by Xlib to store requests. The functions described in this section flush the output buffer if the function would block or not return an event. That is, all requests residing in the output buffer that have not yet been sent are transmitted to the X server. These functions differ in the additional tasks they might perform.

To flush the output buffer, use **XFlush**.

XFlush(*display*)
    Display **display*;

display Specifies the connection to the X server.

The **XFlush** function flushes the output buffer. Most client applications need not use this function because the output buffer is automatically flushed as needed by calls to **XPending**, **XNextEvent**, and **XWindowEvent**. Events generated by the server may be enqueued into the library's event queue.

To flush the output buffer and then wait until all requests have been processed, use **XSync**.

XSync(*display, discard*)
    Display **display*;
    Bool *discard*;

display Specifies the connection to the X server.

discard Specifies a Boolean value that indicates whether **XSync** discards all events on the event queue.

The **XSync** function flushes the output buffer and then waits until all requests have been received and processed by the X server. Any errors generated must be handled by the error handler. For each error event received by Xlib, **XSync** calls the client application's error handling routine (see section 8.12.2). Any events generated by the server are enqueued into the library's event queue.

Finally, if you passed **False**, **XSync** does not discard the events in the queue. If you passed **True**, **XSync** discards all events in the queue, including those events that were on the queue before **XSync** was called. Client applications seldom need to call **XSync**.

8.7. Event Queue Management

Xlib maintains an event queue. However, the operating system also may be buffering data in its network connection that is not yet read into the event queue.

To check the number of events in the event queue, use **XEventsQueued**.

```
int XEventsQueued(display, mode)
    Display *display;
    int mode;
```

display Specifies the connection to the X server.

mode Specifies the mode. You can pass **QueuedAlready**, **QueuedAfterFlush**, or **QueuedAfterReading**.

If mode is **QueuedAlready**, **XEventsQueued** returns the number of events already in the event queue (and never performs a system call). If mode is **QueuedAfterFlush**, **XEventsQueued** returns the number of events already in the queue if the number is nonzero. If there are no events in the queue, **XEventsQueued** flushes the output buffer, attempts to read more events out of the application's connection, and returns the number read. If mode is **QueuedAfterReading**, **XEventsQueued** returns the number of events already in the queue if the number is nonzero. If there are no events in the queue, **XEventsQueued** attempts to read more events out of the application's connection without flushing the output buffer and returns the number read.

XEventsQueued always returns immediately without I/O if there are events already in the queue. **XEventsQueued** with mode **QueuedAfterFlush** is identical in behavior to **XPending**. **XEventsQueued** with mode **QueuedAlready** is identical to the **XQLength** function.

To return the number of events that are pending, use **XPending**.

```
int XPending(display)
    Display *display;
```

display Specifies the connection to the X server.

The **XPending** function returns the number of events that have been received from the X server but have not been removed from the event queue. **XPending** is identical to **XEventsQueued** with the mode **QueuedAfterFlush** specified.

8.8. Manipulating the Event Queue

Xlib provides functions that let you manipulate the event queue. The next three sections discuss how to:

- Obtain events, in order, and remove them from the queue
- Peek at events in the queue without removing them
- Obtain events that match the event mask or the arbitrary predicate procedures that you provide

8.8.1. Returning the Next Event

To get the next event and remove it from the queue, use **XNextEvent**.

```
XNextEvent(display, event_return)
    Display *display;
    XEvent *event_return;
```

display Specifies the connection to the X server.

event_return Returns the next event in the queue.

The **XNextEvent** function copies the first event from the event queue into the specified **XEvent** structure and then removes it from the queue. If the event queue is empty, **XNextEvent** flushes the output buffer and blocks until an event is received.

To peek at the event queue, use **XPeekEvent**.

```
XPeekEvent(display, event_return)
      Display *display;
      XEvent *event_return;
```

display Specifies the connection to the X server.

event_return Returns a copy of the matched event's associated structure.

The **XPeekEvent** function returns the first event from the event queue, but it does not remove the event from the queue. If the queue is empty, **XPeekEvent** flushes the output buffer and blocks until an event is received. It then copies the event into the client-supplied **XEvent** structure without removing it from the event queue.

8.8.2. Selecting Events Using a Predicate Procedure

Each of the functions discussed in this section requires you to pass a predicate procedure that determines if an event matches what you want. Your predicate procedure must decide only if the event is useful and must not call Xlib functions. In particular, a predicate is called from inside the event routine, which must lock data structures so that the event queue is consistent in a multi-threaded environment.

The predicate procedure and its associated arguments are:

```
Bool (*predicate)(display, event, arg)
     Display *display;
     XEvent *event;
     char *arg;
```

display Specifies the connection to the X server.

event Specifies a pointer to the **XEvent** structure.

arg Specifies the argument passed in from the **XIfEvent**, **XCheckIfEvent**, or **XPeekIfEvent** function.

The predicate procedure is called once for each event in the queue until it finds a match. After finding a match, the predicate procedure must return **True**. If it did not find a match, it must return **False**.

To check the event queue for a matching event and, if found, remove the event from the queue, use **XIfEvent**.

```
XIfEvent(display, event_return, predicate, arg)
      Display *display;
      XEvent *event_return;
      Bool (*predicate)();
      char *arg;
```

display Specifies the connection to the X server.

event_return Returns the matched event's associated structure.

predicate Specifies the procedure that is to be called to determine if the next event in the queue matches what you want.

arg Specifies the user-supplied argument that will be passed to the predicate procedure.

The **XIfEvent** function completes only when the specified predicate procedure returns **True** for an event, which indicates an event in the queue matches. **XIfEvent** flushes the output buffer if it blocks waiting for additional events. **XIfEvent** removes the matching event from the queue and copies the structure into the client-supplied **XEvent** structure.

To check the event queue for a matching event without blocking, use **XCheckIfEvent**.

```
Bool XCheckIfEvent(display, event_return, predicate, arg)
      Display *display;
      XEvent *event_return;
      Bool (*predicate)();
      char *arg;
```

display	Specifies the connection to the X server.
event_return	Returns a copy of the matched event's associated structure.
predicate	Specifies the procedure that is to be called to determine if the next event in the queue matches what you want.
arg	Specifies the user-supplied argument that will be passed to the predicate procedure.

When the predicate procedure finds a match, **XCheckIfEvent** copies the matched event into the client-supplied **XEvent** structure and returns **True**. (This event is removed from the queue.) If the predicate procedure finds no match, **XCheckIfEvent** returns **False**, and the output buffer will have been flushed. All earlier events stored in the queue are not discarded.

To check the event queue for a matching event without removing the event from the queue, use **XPeekIfEvent**.

```
XPeekIfEvent(display, event_return, predicate, arg)
      Display *display;
      XEvent *event_return;
      Bool (*predicate)();
      char *arg;
```

display	Specifies the connection to the X server.
event_return	Returns a copy of the matched event's associated structure.
predicate	Specifies the procedure that is to be called to determine if the next event in the queue matches what you want.
arg	Specifies the user-supplied argument that will be passed to the predicate procedure.

The **XPeekIfEvent** function returns only when the specified predicate procedure returns **True** for an event. After the predicate procedure finds a match, **XPeekIfEvent** copies the matched event into the client-supplied **XEvent** structure without removing the event from the queue. **XPeekIfEvent** flushes the output buffer if it blocks waiting for additional events.

8.8.3. Selecting Events Using a Window or Event Mask

The functions discussed in this section let you select events by window or event types, allowing you to process events out of order.

To remove the next event that matches both a window and an event mask, use **XWindowEvent**.

```
XWindowEvent(display, w, event_mask, event_return)
      Display *display;
      Window w;
      long event_mask;
      XEvent *event_return;
```

display Specifies the connection to the X server.

w Specifies the window whose events you are interested in.

event_mask Specifies the event mask.

event_return Returns the matched event's associated structure.

The **XWindowEvent** function searches the event queue for an event that matches both the specified window and event mask. When it finds a match, **XWindowEvent** removes that event from the queue and copies it into the specified **XEvent** structure. The other events stored in the queue are not discarded. If a matching event is not in the queue, **XWindowEvent** flushes the output buffer and blocks until one is received.

To remove the next event that matches both a window and an event mask (if any), use **XCheckWindowEvent**. This function is similar to **XWindowEvent** except that it never blocks and it returns a **Bool** indicating if the event was returned.

```
Bool XCheckWindowEvent(display, w, event_mask, event_return)
      Display *display;
      Window w;
      long event_mask;
      XEvent *event_return;
```

display Specifies the connection to the X server.

w Specifies the window whose events you are interested in.

event_mask Specifies the event mask.

event_return Returns the matched event's associated structure.

The **XCheckWindowEvent** function searches the event queue and then the events available on the server connection for the first event that matches the specified window and event mask. If it finds a match, **XCheckWindowEvent** removes that event, copies it into the specified **XEvent** structure, and returns **True**. The other events stored in the queue are not discarded. If the event you requested is not available, **XCheckWindowEvent** returns **False**, and the output buffer will have been flushed.

To remove the next event that matches an event mask, use **XMaskEvent**.

```
XMaskEvent(display, event_mask, event_return)
      Display *display;
      long event_mask;
      XEvent *event_return;
```

display Specifies the connection to the X server.

event_mask Specifies the event mask.

event_return Returns the matched event's associated structure.

The **XMaskEvent** function searches the event queue for the events associated with the specified mask. When it finds a match, **XMaskEvent** removes that event and copies it into the specified **XEvent** structure. The other events stored in the queue are not discarded. If the event you requested is not in the queue, **XMaskEvent** flushes the output buffer and blocks until one is received.

To return and remove the next event that matches an event mask (if any), use **XCheckMaskEvent**. This function is similar to **XMaskEvent** except that it never blocks and it returns a **Bool** indicating if the event was returned.

```
Bool XCheckMaskEvent(display, event_mask, event_return)
      Display *display;
      long event_mask;
      XEvent *event_return;
```

display Specifies the connection to the X server.

event_mask Specifies the event mask.

event_return Returns the matched event's associated structure.

The **XCheckMaskEvent** function searches the event queue and then any events available on the server connection for the first event that matches the specified mask. If it finds a match, **XCheckMaskEvent** removes that event, copies it into the specified **XEvent** structure, and returns **True**. The other events stored in the queue are not discarded. If the event you requested is not available, **XCheckMaskEvent** returns **False**, and the output buffer will have been flushed.

To return and remove the next event in the queue that matches an event type, use **XCheckTypedEvent**.

```
Bool XCheckTypedEvent(display, event_type, event_return)
      Display *display;
      int event_type;
      XEvent *event_return;
```

display Specifies the connection to the X server.

event_type Specifies the event type to be compared.

event_return Returns the matched event's associated structure.

The **XCheckTypedEvent** function searches the event queue and then any events available on the server connection for the first event that matches the specified type. If it finds a match, **XCheckTypedEvent** removes that event, copies it into the specified **XEvent** structure, and returns **True**. The other events in the queue are not discarded. If the event is not available, **XCheckTypedEvent** returns **False**, and the output buffer will have been flushed.

To return and remove the next event in the queue that matches an event type and a window, use **XCheckTypedWindowEvent**.

```
Bool XCheckTypedWindowEvent(display, w, event_type, event_return)
      Display *display;
      Window w;
      int event_type;
      XEvent *event_return;
```

display Specifies the connection to the X server.

w Specifies the window.

event_type Specifies the event type to be compared.

event_return Returns the matched event's associated structure.

The **XCheckTypedWindowEvent** function searches the event queue and then any events available on the server connection for the first event that matches the specified type and window. If it finds a match, **XCheckTypedWindowEvent** removes the event from the queue, copies it into the specified **XEvent** structure, and returns **True**. The other events in the queue are not discarded. If the event is not available, **XCheckTypedWindowEvent** returns **False**, and the output buffer will have been flushed.

8.9. Putting an Event Back into the Queue

To push an event back into the event queue, use **XPutBackEvent**.

```
XPutBackEvent(display, event)
      Display *display;
      XEvent *event;
```

display Specifies the connection to the X server.

event Specifies a pointer to the event.

The **XPutBackEvent** function pushes an event back onto the head of the display's event queue by copying the event into the queue. This can be useful if you read an event and then decide that you would rather deal with it later. There is no limit to the number of times in succession that you can call **XPutBackEvent**.

8.10. Sending Events to Other Applications

To send an event to a specified window, use **XSendEvent**. This function is often used in selection processing. For example, the owner of a selection should use **XSendEvent** to send a **SelectionNotify** event to a requestor when a selection has been converted and stored as a property.

```
Status XSendEvent(display, w, propagate, event_mask, event_send)
      Display *display;
      Window w;
      Bool propagate;
      long event_mask;
      XEvent *event_send;
```

display Specifies the connection to the X server.

w Specifies the window the event is to be sent to, **PointerWindow**, or **InputFocus**.

propagate Specifies a Boolean value.

event_mask Specifies the event mask.

event_send Specifies a pointer to the event that is to be sent.

The **XSendEvent** function identifies the destination window, determines which clients should receive the specified events, and ignores any active grabs. This function requires you to pass an event mask. For a discussion of the valid event mask names, see section 8.3. This function uses the w argument to identify the destination window as follows:

- If w is **PointerWindow**, the destination window is the window that contains the pointer.
- If w is **InputFocus** and if the focus window contains the pointer, the destination window is the window that contains the pointer; otherwise, the destination window is the focus window.

To determine which clients should receive the specified events, **XSendEvent** uses the propagate argument as follows:

- If event_mask is the empty set, the event is sent to the client that created the destination window. If that client no longer exists, no event is sent.
- If propagate is **False**, the event is sent to every client selecting on destination any of the event types in the event_mask argument.

> If propagate is **True** and no clients have selected on destination any of the event types in event-mask, the destination is replaced with the closest ancestor of destination for which some client has selected a type in event-mask and for which no intervening window has that type in its do-not-propagate-mask. If no such window exists or if the window is an ancestor of the focus window and **InputFocus** was originally specified as the destination, the event is not sent to any clients. Otherwise, the event is reported to every client selecting on the final destination any of the types specified in event_mask.

The event in the **XEvent** structure must be one of the core events or one of the events defined by an extension (or a **BadValue** error results) so that the X server can correctly byte-swap the contents as necessary. The contents of the event are otherwise unaltered and unchecked by the X server except to force send_event to **True** in the forwarded event and to set the serial number in the event correctly.

XSendEvent returns zero if the conversion to wire protocol format failed and returns nonzero otherwise.

XSendEvent can generate **BadValue** and **BadWindow** errors.

8.11. Getting Pointer Motion History

Some X server implementations will maintain a more complete history of pointer motion than is reported by event notification. The pointer position at each pointer hardware interrupt may be stored in a buffer for later retrieval. This buffer is called the motion history buffer. For example, a few applications, such as paint programs, want to have a precise history of where the pointer traveled. However, this historical information is highly excessive for most applications.

To determine the size of the motion buffer, use **XDisplayMotionBufferSize**.

```
unsigned long XDisplayMotionBufferSize(display)
      Display *display;
```

display Specifies the connection to the X server.

The server may retain the recent history of the pointer motion and do so to a finer granularity than is reported by **MotionNotify** events. The **XGetMotionEvents** function makes this history available.

To get the motion history for a specified window and time, use **XGetMotionEvents**.

```
XTimeCoord *XGetMotionEvents(display, w, start, stop, nevents_return)
      Display *display;
      Window w;
      Time start, stop;
      int *nevents_return;
```

display Specifies the connection to the X server.

w Specifies the window.

start
stop Specify the time interval in which the events are returned from the motion history buffer. You can pass a timestamp or **CurrentTime**.

nevents_return Returns the number of events from the motion history buffer.

The **XGetMotionEvents** function returns all events in the motion history buffer that fall between the specified start and stop times, inclusive, and that have coordinates that lie within the specified window (including its borders) at its present placement. If the start time is later than the stop time or if the start time is in the future, no events are returned. If the stop time is in the future, it is equivalent to specifying **CurrentTime**.

The return type for this function is a structure defined as follows:

```
typedef struct {
        Time time;
        short x, y;
} XTimeCoord;
```

The time member is set to the time, in milliseconds. The x and y members are set to the coordinates of the pointer and are reported relative to the origin of the specified window. To free the data returned from this call, use **XFree**.

XGetMotionEvents can generate a **BadWindow** error.

8.12. Handling Error Events

Xlib provides functions that you can use to enable or disable synchronization and to use the default error handlers.

8.12.1. Enabling or Disabling Synchronization

When debugging X applications, it often is very convenient to require Xlib to behave synchronously so that errors are reported as they occur. The following function lets you disable or enable synchronous behavior. Note that graphics may occur 30 or more times more slowly when synchronization is enabled. On UNIX-based systems, there is also a global variable **_Xdebug** that, if set to nonzero before starting a program under a debugger, will force synchronous library behavior.

After completing their work, all Xlib functions that generate protocol requests call what is known as an after function. **XSetAfterFunction** sets which function is to be called.

int (*XSetAfterFunction(*display*, *procedure*))()
    Display **display*;
    int (**procedure*)();

display Specifies the connection to the X server.

procedure Specifies the function to be called after an Xlib function that generates a protocol request completes its work.

The specified procedure is called with only a display pointer. **XSetAfterFunction** returns the previous after function.

To enable or disable synchronization, use **XSynchronize**.

int (*XSynchronize(*display*, *onoff*))()
    Display **display*;
    Bool *onoff*;

display Specifies the connection to the X server.

onoff Specifies a Boolean value that indicates whether to enable or disable synchronization.

The **XSynchronize** function returns the previous after function. If onoff is **True**, **XSynchronize** turns on synchronous behavior. If onoff is **False**, **XSynchronize** turns off synchronous behavior.

8.12.2. Using the Default Error Handlers

There are two default error handlers in Xlib: one to handle typically fatal conditions (for example, the connection to a display server dying because a machine crashed) and one to handle error events from the X server. These error handlers can be changed to user-supplied routines if you prefer your own error handling and can be changed as often as you like. If either function is passed a NULL pointer, it will reinvoke the default handler. The action of the default handlers is to print an explanatory message and exit.

To set the error handler, use **XSetErrorHandler**.

XSetErrorHandler(*handler*)
    int (**handler*)(Display *, XErrorEvent *)

handler Specifies the program's supplied error handler.

Xlib generally calls the program's supplied error handler whenever an error is received. It is not called on **BadName** errors from **OpenFont**, **LookupColor**, or **AllocNamedColor** protocol requests or on **BadFont** errors from a **QueryFont** protocol request. These errors generally are reflected back to the program through the procedural interface. Because this condition is not assumed to be fatal, it is acceptable for your error handler to return. However, the error handler should not call any functions (directly or indirectly) on the display that will generate protocol requests or that will look for input events.

The **XErrorEvent** structure contains:

```
typedef struct {
        int type;
        Display *display;            /* Display the event was read from */
        unsigned long serial;        /* serial number of failed request */
        unsigned char error_code;    /* error code of failed request */
        unsigned char request_code;  /* Major op-code of failed request */
        unsigned char minor_code;    /* Minor op-code of failed request */
        XID resourceid;              /* resource id */
} XErrorEvent;
```

The serial member is the number of requests, starting from one, sent over the network connection since it was opened. It is the number that was the value of **NextRequest** immediately before the failing call was made. The request_code member is a protocol request of the procedure that failed, as defined in <**X11/Xproto.h**>. The following error codes can be returned by the functions described in this chapter:

Error Code	Description
BadAccess	A client attempts to grab a key/button combination already grabbed by another client. A client attempts to free a colormap entry that it had not already allocated. A client attempts to store into a read-only or unallocated colormap entry. A client attempts to modify the access control list from other than the local (or otherwise authorized) host. A client attempts to select an event type that another client has already selected.

Error Code	Description
BadAlloc	The server fails to allocate the requested resource. Note that the explicit listing of **BadAlloc** errors in requests only covers allocation errors at a very coarse level and is not intended to (nor can it in practice hope to) cover all cases of a server running out of allocation space in the middle of service. The semantics when a server runs out of allocation space are left unspecified, but a server may generate a **BadAlloc** error on any request for this reason, and clients should be prepared to receive such errors and handle or discard them.
BadAtom	A value for an atom argument does not name a defined atom.
BadColor	A value for a colormap argument does not name a defined colormap.
BadCursor	A value for a cursor argument does not name a defined cursor.
BadDrawable	A value for a drawable argument does not name a defined window or pixmap.
BadFont	A value for a font argument does not name a defined font (or, in some cases, **GContext**).
BadGC	A value for a **GContext** argument does not name a defined **GContext**.
BadIDChoice	The value chosen for a resource identifier either is not included in the range assigned to the client or is already in use. Under normal circumstances, this cannot occur and should be considered a server or Xlib error.
BadImplementation	The server does not implement some aspect of the request. A server that generates this error for a core request is deficient. As such, this error is not listed for any of the requests, but clients should be prepared to receive such errors and handle or discard them.
BadLength	The length of a request is shorter or longer than that required to contain the arguments. This is an internal Xlib or server error. The length of a request exceeds the maximum length accepted by the server.
BadMatch	In a graphics request, the root and depth of the graphics context does not match that of the drawable. An **InputOnly** window is used as a drawable. Some argument or pair of arguments has the correct type and range, but it fails to match in some other way required by the request. An **InputOnly** window lacks this attribute.

Error Code	Description
BadName	A font or color of the specified name does not exist.
BadPixmap	A value for a pixmap argument does not name a defined pixmap.
BadRequest	The major or minor opcode does not specify a valid request. This usually is an Xlib or server error.
BadValue	Some numeric value falls outside of the range of values accepted by the request. Unless a specific range is specified for an argument, the full range defined by the argument's type is accepted. Any argument defined as a set of alternatives typically can generate this error (due to the encoding).
BadWindow	A value for a window argument does not name a defined window.

Note

The **BadAtom**, **BadColor**, **BadCursor**, **BadDrawable**, **BadFont**, **BadGC**, **BadPixmap**, and **BadWindow** errors are also used when the argument type is extended by a set of fixed alternatives.

To obtain textual descriptions of the specified error code, use **XGetErrorText**.

XGetErrorText(*display*, *code*, *buffer_return*, *length*)
    Display **display*;
    int *code*;
    char **buffer_return*;
    int *length*;

display Specifies the connection to the X server.

code Specifies the error code for which you want to obtain a description.

buffer_return Returns the error description.

length Specifies the size of the buffer.

The **XGetErrorText** function copies a null-terminated string describing the specified error code into the specified buffer. It is recommended that you use this function to obtain an error description because extensions to Xlib may define their own error codes and error strings.

To obtain error messages from the error database, use **XGetErrorDatabaseText**.

XGetErrorDatabaseText(*display*, *name*, *message*, *default_string*, *buffer_return*, *length*)
    Display **display*;
    char **name*, **message*;
    char **default_string*;
    char **buffer_return*;
    int *length*;

display Specifies the connection to the X server.

name Specifies the name of the application.

message Specifies the type of the error message.

default_string Specifies the default error message if none is found in the database.

buffer_return Returns the error description.

length Specifies the size of the buffer.

The **XGetErrorDatabaseText** function returns a message (or the default message) from the error message database. Xlib uses this function internally to look up its error messages. On a UNIX-based system, the error message database is **/usr/lib/X11/XErrorDB**.

The name argument should generally be the name of your application. The message argument should indicate which type of error message you want. Xlib uses three predefined message types to report errors (uppercase and lowercase matter):

XProtoError The protocol error number is used as a string for the message argument.

XlibMessage These are the message strings that are used internally by the library.

XRequest The major request protocol number is used for the message argument. If no string is found in the error database, the default_string is returned to the buffer argument.

To report an error to the user when the requested display does not exist, use **XDisplay-Name**.

```
char *XDisplayName(string)
     char *string;
```

string Specifies the character string.

The **XDisplayName** function returns the name of the display that **XOpenDisplay** would attempt to use. If a NULL string is specified, **XDisplayName** looks in the environment for the display and returns the display name that **XOpenDisplay** would attempt to use. This makes it easier to report to the user precisely which display the program attempted to open when the initial connection attempt failed.

To handle fatal I/O errors, use **XSetIOErrorHandler**.

```
XSetIOErrorHandler(handler)
     int (*handler)(Display *);
```

handler Specifies the program's supplied error handler.

The **XSetIOErrorHandler** sets the fatal I/O error handler. Xlib calls the program's supplied error handler if any sort of system call error occurs (for example, the connection to the server was lost). This is assumed to be a fatal condition, and the called routine should not return. If the I/O error handler does return, the client process exits.

Chapter 9

Predefined Property Functions

There are a number of predefined properties for information commonly associated with windows. The atoms for these predefined properties can be found in <**X11/Xatom.h**>, where the prefix XA_ is added to each atom name.

Xlib provides functions that you can use to perform operations on predefined properties. This chapter discusses how to:

- Communicate with window managers
- Manipulate standard colormaps

9.1. Communicating with Window Managers

This section discusses a set of properties and functions that are necessary for clients to communicate effectively with window managers. Some of these properties have complex structures. Because all the data in a single property on the server has to be of the same format (8-bit, 16-bit, or 32-bit) and because the C structures representing property types cannot be guaranteed to be uniform in the same way, Set and Get functions are provided for properties with complex structures.

These functions define but do not enforce minimal policy among window managers. Writers of window managers are urged to use the information in these properties rather than invent their own properties and types. A window manager writer, however, can define additional properties beyond this least common denominator.

In addition to Set and Get functions for individual properties, Xlib includes one function, **XSetStandardProperties**, that sets all or portions of several properties. Applications are encouraged to provide the window manager more information than is possible with **XSetStandardProperties**. To do so, they should call the Set functions for the additional or specific properties that they need.

To work well with most window managers, every application should specify the following information:

- Name of the application
- Name to be used in the icon
- Command used to invoke the application
- Size and window manager hints

Xlib does not set defaults for the properties described in this section. Thus, the default behavior is determined by the window manager and may be based on the presence or absence of certain properties. All the properties are considered to be hints to a window manager. When implementing window management policy, a window manager determines what to do with this information and can ignore it.

The supplied properties are:

Name	Type	Format	Description
WM_NAME	STRING	8	Name of the application.
WM_ICON_NAME	STRING	8	Name to be used in icon.
WM_NORMAL_HINTS	WM_SIZE_HINTS	32	Size hints for a window in its normal state. The C type of this property is **XSizeHints**.
WM_ZOOM_HINTS	WM_SIZE_HINTS	32	Size hints for a zoomed window. The C type of this property is **XSizeHints**.
WM_HINTS	WM_HINTS	32	Additional hints set by client for use by the window manager. The C type of this property is **XWMHints**.
WM_COMMAND	STRING	8	The command and arguments, separated by ASCII nulls, used to invoke the application.
WM_ICON_SIZE	WM_ICON_SIZE	32	The window manager may set this property on the root window to specify the icon sizes it supports. The C type of this property is **XIconSize**.
WM_CLASS	STRING	32	Set by application programs to allow window and session managers to obtain the application's resources from the resource database.
WM_TRANSIENT_FOR	WINDOW	32	Set by application programs to indicate to the window manager that a transient top-level window, such as a dialog box, is not really a normal application window.

The atom names stored in <**X11/Xatom.h**> are named XA_*PROPERTY_NAME.*

Xlib provides functions that you can use to set and get predefined properties. Note that calling the Set function for a property with complex structure redefines all members in that property, even though only some of those members may have a specified new value. Simple properties for which Xlib does not provide a Set or Get function can be set by using **XChangeProperty**, and their values can be retrieved using **XGetWindowProperty**. The remainder of this section discusses how to:

- Set standard properties
- Set and get the name of a window
- Set and get the icon name of a window
- Set the command and arguments of the application

- Set and get window manager hints
- Set and get window size hints
- Set and get icon size hints
- Set and get the class of a window
- Set and get the transient property for a window

9.1.1. Setting Standard Properties

To specify a minimum set of properties describing the "quickie" application, use **XSetStandardProperties**. This function sets all or portions of the WM_NAME, WM_ICON_NAME, WM_HINTS, WM_COMMAND, and WM_NORMAL_HINTS properties.

```
XSetStandardProperties(display, w, window_name, icon_name, icon_pixmap, argv, argc, hints)
      Display *display;
      Window w;
      char *window_name;
      char *icon_name;
      Pixmap icon_pixmap;
      char **argv;
      int argc;
      XSizeHints *hints;
```

display	Specifies the connection to the X server.
w	Specifies the window.
window_name	Specifies the window name, which should be a null-terminated string.
icon_name	Specifies the icon name, which should be a null-terminated string.
icon_pixmap	Specifies the bitmap that is to be used for the icon or **None**.
argv	Specifies the application's argument list.
argc	Specifies the number of arguments.
hints	Specifies a pointer to the size hints for the window in its normal state.

The **XSetStandardProperties** function provides a means by which simple applications set the most essential properties with a single call. **XSetStandardProperties** should be used to give a window manager some information about your program's preferences. It should not be used by applications that need to communicate more information than is possible with **XSetStandardProperties**. (Typically, argv is the argv array of your main program.)

XSetStandardProperties can generate **BadAlloc** and **BadWindow** errors.

9.1.2. Setting and Getting Window Names

Xlib provides functions that you can use to set and read the name of a window. These functions set and read the WM_NAME property.

To assign a name to a window, use **XStoreName**.

```
XStoreName(display, w, window_name)
      Display *display;
      Window w;
      char *window_name;
```

display	Specifies the connection to the X server.

w Specifies the window.

window_name Specifies the window name, which should be a null-terminated string.

The **XStoreName** function assigns the name passed to window_name to the specified window. A window manager can display the window name in some prominent place, such as the title bar, to allow users to identify windows easily. Some window managers may display a window's name in the window's icon, although they are encouraged to use the window's icon name if one is provided by the application.

XStoreName can generate **BadAlloc** and **BadWindow** errors.

To get the name of a window, use **XFetchName**.

```
Status XFetchName(display, w, window_name_return)
      Display *display;
      Window w;
      char **window_name_return;
```

display Specifies the connection to the X server.

w Specifies the window.

window_name_return
Returns a pointer to the window name, which is a null-terminated string.

The **XFetchName** function returns the name of the specified window. If it succeeds, it returns nonzero; otherwise, if no name has been set for the window, it returns zero. If the WM_NAME property has not been set for this window, **XFetchName** sets window_name_return to NULL. When finished with it, a client must free the window name string using **XFree**.

XFetchName can generate a **BadWindow** error.

9.1.3. Setting and Getting Icon Names

Xlib provides functions that you can use to set and read the name to be displayed in a window's icon. These functions set and read the WM_ICON_NAME property.

To set the name to be displayed in a window's icon, use **XSetIconName**.

```
XSetIconName(display, w, icon_name)
      Display *display;
      Window w;
      char *icon_name;
```

display Specifies the connection to the X server.

w Specifies the window.

icon_name Specifies the icon name, which should be a null-terminated string.

XSetIconName can generate **BadAlloc** and **BadWindow** errors.

To get the name a window wants displayed in its icon, use **XGetIconName**.

```
Status XGetIconName(display, w, icon_name_return)
      Display *display;
      Window w;
      char **icon_name_return;
```

display Specifies the connection to the X server.

w Specifies the window.

icon_name_return
Returns a pointer to the window's icon name, which is a null-terminated string.

The **XGetIconName** function returns the name to be displayed in the specified window's icon. If it succeeds, it returns nonzero; otherwise, if no icon name has been set for the window, it returns zero. If you never assigned a name to the window, **XGetIconName** sets icon_name_return to NULL. When finished with it, a client must free the icon name string using **XFree**.

XGetIconName can generate a **BadWindow** error.

9.1.4. Setting the Command

To set the command property, use **XSetCommand**. This function sets the WM_COMMAND property.

```
XSetCommand(display, w, argv, argc)
      Display *display;
      Window w;
      char **argv;
      int argc;
```

display	Specifies the connection to the X server.
w	Specifies the window.
argv	Specifies the application's argument list.
argc	Specifies the number of arguments.

The **XSetCommand** function sets the command and arguments used to invoke the application. (Typically, argv is the argv array of your main program.)

XSetCommand can generate **BadAlloc** and **BadWindow** errors.

9.1.5. Setting and Getting Window Manager Hints

The functions discussed in this section set and read the WM_HINTS property and use the flags and the **XWMHints** structure, as defined in the <**X11/Xutil.h**> header file:

```
/* Window manager hints mask bits */

#define   InputHint              (1L << 0)
#define   StateHint              (1L << 1)
#define   IconPixmapHint         (1L << 2)
#define   IconWindowHint         (1L << 3)
#define   IconPositionHint       (1L << 4)
#define   IconMaskHint           (1L << 5)
#define   WindowGroupHint        (1L << 6)
#define   AllHints               (InputHint|StateHint|IconPixmapHint|
                                 IconWindowHint|IconPositionHint|
                                 IconMaskHint|WindowGroupHint)

/* Values */

typedef struct {
        long flags;              /* marks which fields in this structure are defined */
        Bool input;              /* does this application rely on the window manager to
                                 get keyboard input? */
        int initial_state;       /* see below */
        Pixmap icon_pixmap;      /* pixmap to be used as icon */
        Window icon_window;      /* window to be used as icon */
```

```
        int icon_x, icon_y;           /* initial position of icon */
        Pixmap icon_mask;             /* pixmap to be used as mask for icon_pixmap */
        XID window_group;             /* id of related window group */
        /* this structure may be extended in the future */
} XWMHints;
```

The input member is used to communicate to the window manager the input focus model used by the application. Applications that expect input but never explicitly set focus to any of their subwindows (that is, use the push model of focus management), such as X10-style applications that use real-estate driven focus, should set this member to **True**. Similarly, applications that set input focus to their subwindows only when it is given to their top-level window by a window manager should also set this member to **True**. Applications that manage their own input focus by explicitly setting focus to one of their subwindows whenever they want keyboard input (that is, use the pull model of focus management) should set this member to **False**. Applications that never expect any keyboard input also should set this member to **False**.

Pull model window managers should make it possible for push model applications to get input by setting input focus to the top-level windows of applications whose input member is **True**. Push model window managers should make sure that pull model applications do not break them by resetting input focus to **PointerRoot** when it is appropriate (for example, whenever an application whose input member is **False** sets input focus to one of its subwindows).

The definitions for the initial_state flag are:

#define	**DontCareState**	0	/* don't know or care */
#define	**NormalState**	1	/* most applications start this way */
#define	**ZoomState**	2	/* application wants to start zoomed */
#define	**IconicState**	3	/* application wants to start as an icon */
#define	**InactiveState**	4	/* application believes it is seldom used; some wm's may put it on inactive menu */

The icon_mask specifies which pixels of the icon_pixmap should be used as the icon. This allows for nonrectangular icons. Both the icon_pixmap and icon_mask must be bitmaps. The icon_window lets an application provide a window for use as an icon for window managers that support such use. The window_group lets you specify that this window belongs to a group of other windows. For example, if a single application manipulates multiple top-level windows, this allows you to provide enough information that a window manager can iconify all of the windows rather than just the one window.

To set the window manager hints for a window, use **XSetWMHints**.

XSetWMHints(*display*, *w*, *wmhints*)
    Display **display*;
    Window *w*;
    XWMHints **wmhints*;

display Specifies the connection to the X server.

w Specifies the window.

wmhints Specifies a pointer to the window manager hints.

The **XSetWMHints** function sets the window manager hints that include icon information and location, the initial state of the window, and whether the application relies on the window manager to get keyboard input.

XSetWMHints can generate **BadAlloc** and **BadWindow** errors.

To read the window manager hints for a window, use **XGetWMHints**.

```
XWMHints *XGetWMHints(display, w)
      Display *display;
      Window w;
```

display Specifies the connection to the X server.

w Specifies the window.

The **XGetWMHints** function reads the window manager hints and returns NULL if no WM_HINTS property was set on the window or a pointer to a **XWMHints** structure if it succeeds. When finished with the data, free the space used for it by calling **XFree**.

XGetWMHints can generate a **BadWindow** error.

9.1.6. Setting and Getting Window Sizing Hints

Xlib provides functions that you can use to set or get window sizing hints.

The functions discussed in this section use the flags and the **XSizeHints** structure, as defined in the <**X11/Xutil.h**> header file:

```
/* Size hints mask bits */
#define   USPosition    (1L << 0)   /* user specified x, y */
#define   USSize        (1L << 1)   /* user specified width, height */
#define   PPosition     (1L << 2)   /* program specified position */
#define   PSize         (1L << 3)   /* program specified size */
#define   PMinSize      (1L << 4)   /* program specified minimum size */
#define   PMaxSize      (1L << 5)   /* program specified maximum size */
#define   PResizeInc    (1L << 6)   /* program specified resize increments */
#define   PAspect       (1L << 7)   /* program specified min and max aspect ratios */
#define   PAllHints                 (PPosition|PSize|PMinSize|PMaxSize|
                                    PResizeInc|PAspect)

/* Values */

typedef struct {
        long flags;             /* marks which fields in this structure are defined */
        int x, y;
        int width, height;
        int min_width, min_height;
        int max_width, max_height;
        int width_inc, height_inc;
        struct {
               int x;           /* numerator */
               int y;           /* denominator */
        } min_aspect, max_aspect;
} XSizeHints;
```

The x, y, width, and height members describe a desired position and size for the window. To indicate that this information was specified by the user, set the **USPosition** and **USSize** flags. To indicate that it was specified by the application without any user involvement, set **PPosition** and **PSize**. This lets a window manager know that the user specifically asked where the window should be placed or how the window should be sized and that the window manager does not have to rely on the program's opinion.

The min_width and min_height members specify the minimum window size that still allows the application to be useful. The max_width and max_height members specify the maximum window size. The width_inc and height_inc members define an arithmetic progression of sizes (minimum to maximum) into which the window prefers to be resized. The min_aspect and max_aspect members are expressed as ratios of x and y, and they allow an application to specify the range of aspect ratios it prefers.

The next two functions set and read the WM_NORMAL_HINTS property.

To set the size hints for a given window in its normal state, use **XSetNormalHints**.

XSetNormalHints(*display*, *w*, *hints*)
    Display **display*;
    Window *w*;
    XSizeHints **hints*;

display Specifies the connection to the X server.

w Specifies the window.

hints Specifies a pointer to the size hints for the window in its normal state.

The **XSetNormalHints** function sets the size hints structure for the specified window. Applications use **XSetNormalHints** to inform the window manager of the size or position desirable for that window. In addition, an application that wants to move or resize itself should call **XSetNormalHints** and specify its new desired location and size as well as making direct Xlib calls to move or resize. This is because window managers may ignore redirected configure requests, but they pay attention to property changes.

To set size hints, an application not only must assign values to the appropriate members in the hints structure but also must set the flags member of the structure to indicate which information is present and where it came from. A call to **XSetNormalHints** is meaningless, unless the flags member is set to indicate which members of the structure have been assigned values.

XSetNormalHints can generate **BadAlloc** and **BadWindow** errors.

To return the size hints for a window in its normal state, use **XGetNormalHints**.

Status XGetNormalHints(*display*, *w*, *hints_return*)
    Display **display*;
    Window *w*;
    XSizeHints **hints_return*;

display Specifies the connection to the X server.

w Specifies the window.

hints_return Returns the size hints for the window in its normal state.

The **XGetNormalHints** function returns the size hints for a window in its normal state. It returns a nonzero status if it succeeds or zero if the application specified no normal size hints for this window.

XGetNormalHints can generate a **BadWindow** error.

The next two functions set and read the WM_ZOOM_HINTS property.

To set the zoom hints for a window, use **XSetZoomHints**.

```
XSetZoomHints(display, w, zhints)
      Display *display;
      Window w;
      XSizeHints *zhints;
```

display	Specifies the connection to the X server.
w	Specifies the window.
zhints	Specifies a pointer to the zoom hints.

Many window managers think of windows in one of three states: iconic, normal, or zoomed. The **XSetZoomHints** function provides the window manager with information for the window in the zoomed state.

XSetZoomHints can generate **BadAlloc** and **BadWindow** errors.

To read the zoom hints for a window, use **XGetZoomHints**.

```
Status XGetZoomHints(display, w, zhints_return)
      Display *display;
      Window w;
      XSizeHints *zhints_return;
```

display	Specifies the connection to the X server.
w	Specifies the window.
zhints_return	Returns the zoom hints.

The **XGetZoomHints** function returns the size hints for a window in its zoomed state. It returns a nonzero status if it succeeds or zero if the application specified no zoom size hints for this window.

XGetZoomHints can generate a **BadWindow** error.

To set the value of any property of type WM_SIZE_HINTS, use **XSetSizeHints**.

```
XSetSizeHints(display, w, hints, property)
      Display *display;
      Window w;
      XSizeHints *hints;
      Atom property;
```

display	Specifies the connection to the X server.
w	Specifies the window.
hints	Specifies a pointer to the size hints.
property	Specifies the property name.

The **XSetSizeHints** function sets the **XSizeHints** structure for the named property and the specified window. This is used by **XSetNormalHints** and **XSetZoomHints**, and can be used to set the value of any property of type WM_SIZE_HINTS. Thus, it may be useful if other properties of that type get defined.

XSetSizeHints can generate **BadAlloc**, **BadAtom**, and **BadWindow** errors.

To read the value of any property of type WM_SIZE_HINTS, use **XGetSizeHints**.

Status XGetSizeHints(*display, w, hints_return, property*)
    Display **display*;
    Window *w*;
    XSizeHints **hints_return*;
    Atom *property*;

display Specifies the connection to the X server.

w Specifies the window.

hints_return Returns the size hints.

property Specifies the property name.

XGetSizeHints returns the **XSizeHints** structure for the named property and the specified window. This is used by **XGetNormalHints** and **XGetZoomHints**. It also can be used to retrieve the value of any property of type WM_SIZE_HINTS. Thus, it may be useful if other properties of that type get defined. **XGetSizeHints** returns a nonzero status if a size hint was defined or zero otherwise.

XGetSizeHints can generate **BadAtom** and **BadWindow** errors.

9.1.7. Setting and Getting Icon Size Hints

Applications can cooperate with window managers by providing icons in sizes supported by a window manager. To communicate the supported icon sizes to the applications, a window manager should set the icon size property on the root window of the screen. To find out what icon sizes a window manager supports, applications should read the icon size property from the root window of the screen.

The functions discussed in this section set or read the WM_ICON_SIZE property. In addition, they use the **XIconSize** structure, which is defined in **<X11/Xutil.h>** and contains:

```
typedef struct
        int min_width, min_height;
        int max_width, max_height;
        int width_inc, height_inc;
} XIconSize;
```

The width_inc and height_inc members define an arithmetic progression of sizes (minimum to maximum) that represent the supported icon sizes.

To set the icon size hints for a window, use **XSetIconSizes**.

XSetIconSizes(*display, w, size_list, count*)
    Display **display*;
    Window *w*;
    XIconSize **size_list*;
    int *count*;

display Specifies the connection to the X server.

w Specifies the window.

size_list Specifies a pointer to the size list.

count Specifies the number of items in the size list.

The **XSetIconSizes** function is used only by window managers to set the supported icon sizes.

XSetIconSizes can generate **BadAlloc** and **BadWindow** errors.

To return the icon sizes hints for a window, use **XGetIconSizes**.

```
Status XGetIconSizes(display, w, size_list_return, count_return)
      Display *display;
      Window w;
      XIconSize **size_list_return;
      int *count_return;
```

display Specifies the connection to the X server.

w Specifies the window.

size_list_return Returns a pointer to the size list.

count_return Returns the number of items in the size list.

The **XGetIconSizes** function returns zero if a window manager has not set icon sizes or nonzero otherwise. **XGetIconSizes** should be called by an application that wants to find out what icon sizes would be most appreciated by the window manager under which the application is running. The application should then use **XSetWMHints** to supply the window manager with an icon pixmap or window in one of the supported sizes. To free the data allocated in size_list_return, use **XFree**.

XGetIconSizes can generate a **BadWindow** error.

9.1.8. Setting and Getting the Class of a Window

Xlib provides functions to set and get the class of a window. These functions set and read the WM_CLASS property. In addition, they use the **XClassHint** structure, which is defined in <**X11/Xutil.h**> and contains:

```
typedef struct {
        char *res_name;
        char *res_class;
} XClassHint;
```

The res_name member contains the application name, and the res_class member contains the application class. Note that the name set in this property may differ from the name set as WM_NAME. That is, WM_NAME specifies what should be displayed in the title bar and, therefore, can contain temporal information (for example, the name of a file currently in an editor's buffer). On the other hand, the name specified as part of WM_CLASS is the formal name of the application that should be used when retrieving the application's resources from the resource database.

To set the class of a window, use **XSetClassHint**.

```
XSetClassHint(display, w, class_hints)
      Display *display;
      Window w;
      XClassHint *class_hints;
```

display Specifies the connection to the X server.

w Specifies the window.

class_hints Specifies a pointer to a **XClassHint** structure that is to be used.

The **XSetClassHint** function sets the class hint for the specified window.

XSetClassHint can generate **BadAlloc** and **BadWindow** errors.

To get the class of a window, use **XGetClassHint**.

```
Status XGetClassHint(display, w, class_hints_return)
      Display *display;
      Window w;
      XClassHint *class_hints_return;
```

display Specifies the connection to the X server.

w Specifies the window.

class_hints_return
Returns the **XClassHint** structure.

The **XGetClassHint** function returns the class of the specified window. To free res_name and res_class when finished with the strings, use **XFree**.

XGetClassHint can generate a **BadWindow** error.

9.1.9. Setting and Getting the Transient Property

An application may want to indicate to the window manager that a transient, top-level window (for example, a dialog box) is operating on behalf of (or is transient for) another window. To do so, the application would set the WM_TRANSIENT_FOR property of the dialog box to be the window ID of its main window. Some window managers use this information to unmap an application's dialog boxes (for example, when the main application window gets iconified).

The functions discussed in this section set and read the WM_TRANSIENT_FOR property.

To set the WM_TRANSIENT_FOR property for a window, use **XSetTransientForHint**.

```
XSetTransientForHint(display, w, prop_window)
      Display *display;
      Window w;
      Window prop_window;
```

display Specifies the connection to the X server.

w Specifies the window.

prop_window Specifies the window that the WM_TRANSIENT_FOR property is to be set to.

The **XSetTransientForHint** function sets the WM_TRANSIENT_FOR property of the specified window to the specified prop_window.

XSetTransientForHint can generate **BadAlloc** and **BadWindow** errors.

To get the WM_TRANSIENT_FOR value for a window, use **XGetTransientForHint**.

```
Status XGetTransientForHint(display, w, prop_window_return)
      Display *display;
      Window w;
      Window *prop_window_return;
```

display Specifies the connection to the X server.

w Specifies the window.

prop_window_return
Returns the WM_TRANSIENT_FOR property of the specified window.

The **XGetTransientForHint** function returns the WM_TRANSIENT_FOR property for the specified window.

XGetTransientForHint can generate a **BadWindow** error.

9.2. Manipulating Standard Colormaps

Applications with color palettes, smooth-shaded drawings, or digitized images demand large numbers of colors. In addition, these applications often require an efficient mapping from color triples to pixel values that display the appropriate colors.

As an example, consider a 3D display program that wants to draw a smoothly shaded sphere. At each pixel in the image of the sphere, the program computes the intensity and color of light reflected back to the viewer. The result of each computation is a triple of RGB coefficients in the range 0.0 to 1.0. To draw the sphere, the program needs a colormap that provides a large range of uniformly distributed colors. The colormap should be arranged so that the program can convert its RGB triples into pixel values very quickly, because drawing the entire sphere requires many such conversions.

On many current workstations, the display is limited to 256 or fewer colors. Applications must allocate colors carefully, not only to make sure they cover the entire range they need but also to make use of as many of the available colors as possible. On a typical X display, many applications are active at once. Most workstations have only one hardware look-up table for colors, so only one application colormap can be installed at a given time. The application using the installed colormap is displayed correctly, and the other applications "go technicolor" and are displayed with false colors.

As another example, consider a user who is running an image processing program to display earth-resources data. The image processing program needs a colormap set up with 8 reds, 8 greens, and 4 blues (a total of 256 colors). Because some colors are already in use in the default colormap, the image processing program allocates and installs a new colormap.

The user decides to alter some of the colors in the image. He invokes a color palette program to mix and choose colors. The color palette program also needs a colormap with 8 reds, 8 greens, and 4 blues, so just as the image-processing program, it must allocate and install a new colormap.

Because only one colormap can be installed at a time, the color palette may be displayed incorrectly whenever the image-processing program is active. Conversely, whenever the palette program is active, the image may be displayed incorrectly. The user can never match or compare colors in the palette and image. Contention for colormap resources can be reduced if applications with similar color needs share colormaps.

As another example, the image processing program and the color palette program could share the same colormap if there existed a convention that described how the colormap was set up. Whenever either program was active, both would be displayed correctly.

The standard colormap properties define a set of commonly used colormaps. Applications that share these colormaps and conventions display true colors more often and provide a better interface to the user.

9.2.1. Standard Colormaps

Standard colormaps allow applications to share commonly used color resources. This allows many applications to be displayed in true colors simultaneously, even when each application needs an entirely filled colormap.

Several standard colormaps are described in this section. Usually, a window manager creates these colormaps. Applications should use the standard colormaps if they already exist. If the standard colormaps do not exist, you should create them by opening a new connection, creating the properties, and setting the close-down mode of the connection to **RetainPermanent**.

The **XStandardColormap** structure contains:

```
typedef struct {
	Colormap colormap;
	unsigned long red_max;
	unsigned long red_mult;
	unsigned long green_max;
	unsigned long green_mult;
	unsigned long blue_max;
	unsigned long blue_mult;
	unsigned long base_pixel;
} XStandardColormap;
```

The colormap member is the colormap created by the **XCreateColormap** function. The red_max, green_max, and blue_max members give the maximum red, green, and blue values, respectively. Each color coefficient ranges from zero to its max, inclusive. For example, a common colormap allocation is 3/3/2 (3 planes for red, 3 planes for green, and 2 planes for blue). This colormap would have red_max = 7, green_max = 7, and blue_max = 3. An alternate allocation that uses only 216 colors is red_max = 5, green_max = 5, and blue_max = 5.

The red_mult, green_mult, and blue_mult members give the scale factors used to compose a full pixel value. (See the discussion of the base_pixel members for further information.) For a 3/3/2 allocation, red_mult might be 32, green_mult might be 4, and blue_mult might be 1. For a 6-colors-each allocation, red_mult might be 36, green_mult might be 6, and blue_mult might be 1.

The base_pixel member gives the base pixel value used to compose a full pixel value. Usually, the base_pixel is obtained from a call to the **XAllocColorPlanes** function. Given integer red, green, and blue coefficients in their appropriate ranges, one then can compute a corresponding pixel value by using the following expression:

```
r * red_mult + g * green_mult + b * blue_mult + base_pixel
```

For **GrayScale** colormaps, only the colormap, red_max, red_mult, and base_pixel members are defined. The other members are ignored.

To compute a **GrayScale** pixel value, use the following expression:

```
gray * red_mult + base_pixel
```

The properties containing the **XStandardColormap** information have the type RGB_COLOR_MAP.

9.2.2. Standard Colormap Properties and Atoms

Several standard colormaps are available. Each standard colormap is defined by a property, and each such property is identified by an atom. The following list names the atoms and describes the colormap associated with each one. The **<X11/Xatom.h>** header file contains the definitions for each of the following atoms, which are prefixed with XA_.

RGB_DEFAULT_MAP

This atom names a property. The value of the property is an **XStandardColormap**.

The property defines an RGB subset of the default colormap of the screen. Some applications only need a few RGB colors and may be able to allocate them from the system default colormap. This is the ideal situation because the fewer colormaps that are active in the system the more applications are displayed with correct colors at all times.

A typical allocation for the RGB_DEFAULT_MAP on 8-plane displays is 6 reds, 6 greens, and 6 blues. This gives 216 uniformly distributed colors (6 intensities of 36 different hues) and still leaves 40 elements of a 256-element colormap available for special-purpose colors for text, borders, and so on.

RGB_BEST_MAP

This atom names a property. The value of the property is an **XStandardColormap**.

The property defines the best RGB colormap available on the screen. (Of course, this is a subjective evaluation.) Many image processing and 3D applications need to use all available colormap cells and to distribute as many perceptually distinct colors as possible over those cells. This implies that there may be more green values available than red, as well as more green or red than blue.

On an 8-plane **PseudoColor** display, RGB_BEST_MAP should be a 3/3/2 allocation. On a 24-plane **DirectColor** display, RGB_BEST_MAP should be an 8/8/8 allocation. On other displays, the RGB_BEST_MAP allocation is purely up to the implementor of the display.

RGB_RED_MAP
RGB_GREEN_MAP
RGB_BLUE_MAP

These atoms name properties. The value of each property is an **XStandardColormap**.

The properties define all-red, all-green, and all-blue colormaps, respectively. These maps are used by applications that want to make color-separated images. For example, a user might generate a full-color image on an 8-plane display both by rendering an image three times (once with high color resolution in red, once with green, and once with blue) and by multiply-exposing a single frame in a camera.

RGB_GRAY_MAP

This atom names a property. The value of the property is an **XStandardColormap**.

The property describes the best **GrayScale** colormap available on the screen. As previously mentioned, only the colormap, red_max, red_mult, and base_pixel members of the **XStandardColormap** structure are used for **GrayScale** colormaps.

9.2.3. Getting and Setting an XStandardColormap Structure

To get the **XStandardColormap** structure associated with one of the described atoms, use **XGetStandardColormap**.

```
Status XGetStandardColormap(display, w, colormap_return, property)
      Display *display;
      Window w;
      XStandardColormap *colormap_return;
      Atom property;                    /* RGB_BEST_MAP, etc. */
```

display Specifies the connection to the X server.

w Specifies the window.

colormap_return Returns the colormap associated with the specified atom.

property Specifies the property name.

The **XGetStandardColormap** function returns the colormap definition associated with the atom supplied as the property argument. For example, to fetch the standard **GrayScale** colormap for a display, you use **XGetStandardColormap** with the following syntax:

```
XGetStandardColormap(dpy, DefaultRootWindow(dpy), &cmap, XA_RGB_GRAY_MAP);
```

Once you have fetched a standard colormap, you can use it to convert RGB values into pixel values. For example, given an **XStandardColormap** structure and floating-point RGB coefficients in the range 0.0 to 1.0, you can compose pixel values with the following C expression:

```
pixel = base_pixel
        + ((unsigned long) (0.5 + r * red_max)) * red_mult
        + ((unsigned long) (0.5 + g * green_max)) * green_mult
        + ((unsigned long) (0.5 + b * blue_max)) * blue_mult;
```

The use of addition rather than logical OR for composing pixel values permits allocations where the RGB value is not aligned to bit boundaries.

XGetStandardColormap can generate **BadAtom** and **BadWindow** errors.

To set a standard colormap, use **XSetStandardColormap**.

XSetStandardColormap(*display*, *w*, *colormap*, *property*)
    Display **display*;
    Window *w*;
    XStandardColormap **colormap*;
    Atom *property*;   /* RGB_BEST_MAP, etc. */

display Specifies the connection to the X server.

w Specifies the window.

colormap Specifies the colormap.

property Specifies the property name.

The **XSetStandardColormap** function usually is only used by window managers. To create a standard colormap, follow this procedure:

1. Open a new connection to the same server.
2. Grab the server.
3. See if the property is on the property list of the root window for the screen.
4. If the desired property is not present:
   - Create a colormap (not required for RGB_DEFAULT_MAP)
   - Determine the color capabilities of the display.
   - Call **XAllocColorPlanes** or **XAllocColorCells** to allocate cells in the colormap.
   - Call **XStoreColors** to store appropriate color values in the colormap.
   - Fill in the descriptive members in the **XStandardColormap** structure.
   - Attach the property to the root window.
   - Use **XSetCloseDownMode** to make the resource permanent.
5. Ungrab the server.

XSetStandardColormap can generate **BadAlloc**, **BadAtom**, and **BadWindow** errors.

Chapter 10

Application Utility Functions

Once you have initialized the X system, you can use the Xlib utility functions to:

- Handle keyboard events
- Obtain the X environment defaults
- Parse window geometry strings
- Parse hardware colors strings
- Generate regions
- Manipulate regions
- Use cut and paste buffers
- Determine the appropriate visual
- Manipulate images
- Manipulate bitmaps
- Use the resource manager
- Use the context manager

As a group, the functions discussed in this chapter provide the functionality that is frequently needed and that spans toolkits. Many of these functions do not generate actual protocol requests to the server.

10.1. Keyboard Utility Functions

This section discusses keyboard event functions and KeySym classification macros.

10.1.1. Keyboard Event Functions

The X server does not predefine the keyboard to be ASCII characters. It is often useful to know that the *a* key was just pressed or that it was just released. When a key is pressed or released, the X server sends keyboard events to client programs. The structures associated with keyboard events contain a keycode member that assigns a number to each physical key on the keyboard. For a discussion of keyboard event processing, see section 8.4.1. For information on how to manipulate the keyboard encoding, see section 7.9.

Because KeyCodes are completely arbitrary and may differ from server to server, client programs wanting to deal with ASCII text, for example, must explicitly convert the KeyCode value into ASCII. Therefore, Xlib provides functions to help you customize the keyboard layout. Keyboards differ dramatically, so writing code that presumes the existence of a particular key on the main keyboard creates portability problems.

Keyboard events are usually sent to the deepest viewable window underneath the pointer's position that is interested in that type of event. It is also possible to assign the keyboard input focus to a specific window. When the input focus is attached to a window, keyboard events go to the client that has selected input on that window rather than the window under the pointer.

The functions in this section handle the shift modifier computations suggested by the protocol. The KeySym table is internally modified to define the lowercase transformation of a–z by adding the lowercase KeySym to the first element of the KeySym list (used internally) defined for the KeyCode, when the list is of length 1. If you want the untransformed KeySyms defined for a key, you should only use the functions described in section 7.9.

To look up the KeySyms, use **XLookupKeysym**.

```
KeySym XLookupKeysym(key_event, index)
    XKeyEvent *key_event;
    int index;
```

key_event Specifies the **KeyPress** or **KeyRelease** event.

index Specifies the index into the KeySyms list for the event's KeyCode.

The **XLookupKeysym** function uses a given keyboard event and the index you specified to return the KeySym from the list that corresponds to the KeyCode member in the **XKeyPressedEvent** or **XKeyReleasedEvent** structure. If no KeySym is defined for the KeyCode of the event, **XLookupKeysym** returns **NoSymbol**.

To refresh the stored modifier and keymap information, use **XRefreshKeyboardMapping**.

```
XRefreshKeyboardMapping(event_map)
    XMappingEvent *event_map;
```

event_map Specifies the mapping event that is to be used.

The **XRefreshKeyboardMapping** function refreshes the stored modifier and keymap information. You usually call this function when a **MappingNotify** event with a request member of **MappingKeyboard** or **MappingModifier** occurs. The result is to update Xlib's knowledge of the keyboard.

To map a key event to an ISO Latin-1 string, use **XLookupString**.

```
int XLookupString(event_struct, buffer_return, bytes_buffer, keysym_return, status_in_out)
    XKeyEvent *event_struct;
    char *buffer_return;
    int bytes_buffer;
    KeySym *keysym_return;
    XComposeStatus *status_in_out;
```

event_struct Specifies the key event structure to be used. You can pass **XKeyPressedEvent** or **XKeyReleasedEvent**.

buffer_return Returns the translated characters.

bytes_buffer Specifies the length of the buffer. No more than bytes_buffer of translation are returned.

keysym_return Returns the KeySym computed from the event if this argument is not NULL.

status_in_out Specifies or returns the **XComposeStatus** structure or NULL.

The **XLookupString** function is a convenience routine that maps a key event to an ISO Latin-1 string, using the modifier bits in the key event to deal with shift, lock, and control. It returns the translated string into the user's buffer. It also detects any rebound KeySyms (see **XRebindKeysym**) and returns the specified bytes. **XLookupString** returns the length of the string stored in the tag buffer. If the lock modifier has the caps lock KeySym associated with it, **XLookupString** interprets the lock modifier to perform caps lock processing.

If present (non-NULL), the **XComposeStatus** structure records the state, which is private to Xlib, that needs preservation across calls to **XLookupString** to implement compose processing.

To rebind the meaning of a KeySym for a client, use **XRebindKeysym**.

```
XRebindKeysym( display, keysym, list, mod_count, string, bytes_string)
      Display *display;
      KeySym keysym;
      KeySym list[];
      int mod_count;
      unsigned char *string;
      int bytes_string;
```

display	Specifies the connection to the X server.
keysym	Specifies the KeySym that is to be rebound.
list	Specifies the KeySyms to be used as modifiers.
mod_count	Specifies the number of modifiers in the modifier list.
string	Specifies a pointer to the string that is copied and will be returned by **XLookupString**.
bytes_string	Specifies the length of the string.

The **XRebindKeysym** function can be used to rebind the meaning of a KeySym for the client. It does not redefine any key in the X server but merely provides an easy way for long strings to be attached to keys. **XLookupString** returns this string when the appropriate set of modifier keys are pressed and when the KeySym would have been used for the translation. Note that you can rebind a KeySym that may not exist.

To convert the name of the KeySym to the KeySym code, use **XStringToKeysym**.

```
KeySym XStringToKeysym(string)
      char *string;
```

string	Specifies the name of the KeySym that is to be converted.

Valid KeySym names are listed in <**X11/keysymdef.h**> by removing the XK_ prefix from each name. If the specified string does not match a valid KeySym, **XStringToKeysym** returns **NoSymbol**.

To convert a KeySym code to the name of the KeySym, use **XKeysymToString**.

```
char *XKeysymToString(keysym)
      KeySym keysym;
```

keysym	Specifies the KeySym that is to be converted.

The returned string is in a static area and must not be modified. If the specified KeySym is not defined, **XKeysymToString** returns a NULL.

To convert a key code to a defined KeySym, use **XKeycodeToKeysym**.

```
KeySym XKeycodeToKeysym(display, keycode, index)
      Display *display;
      KeyCode keycode;
      int index;
```

display	Specifies the connection to the X server.
keycode	Specifies the KeyCode.
index	Specifies the element of KeyCode vector.

The **XKeycodeToKeysym** function uses internal Xlib tables and returns the KeySym defined for the specified KeyCode and the element of the KeyCode vector. If no symbol is defined, **XKeycodeToKeysym** returns **NoSymbol**.

To convert a KeySym to the appropriate KeyCode, use **XKeysymToKeycode**.

```
KeyCode XKeysymToKeycode(display, keysym)
      Display *display;
      KeySym keysym;
```

display Specifies the connection to the X server.

keysym Specifies the KeySym that is to be searched for.

If the specified KeySym is not defined for any KeyCode, **XKeysymToKeycode** returns zero.

10.1.2. Keysym Classification Macros

You may want to test if a KeySym is, for example, on the keypad or on one of the function keys. You can use the KeySym macros to perform the following tests.

IsCursorKey(*keysym*)

Returns **True** if the specified KeySym is a cursor key.

IsFunctionKey(*keysym*)

Returns **True** if the specified KeySym is a function key.

IsKeypadKey(*keysym*)

Returns **True** if the specified KeySym is a keypad key.

IsMiscFunctionKey(*keysym*)

Returns **True** if the specified KeySym is a miscellaneous function key.

IsModifierKey(*keysym*)

Returns **True** if the specified KeySym is a modifier key.

IsPFKey(*keysym*)

Returns **True** if the specified KeySym is a PF key.

10.2. Obtaining the X Environment Defaults

A program often needs a variety of options in the X environment (for example, fonts, colors, mouse, background, text, and cursor). Specifying these options on the command line is inefficient and unmanageable because individual users have a variety of tastes with regard to window appearance. **XGetDefault** makes it easy to find out the fonts, colors, and other environment defaults favored by a particular user. Defaults are usually loaded into the RESOURCE_MANAGER property on the root window at login. If no such property exists, a resource file in the user's home directory is loaded. On a UNIX-based system, this file is **$HOME/.Xdefaults**. After loading these defaults, **XGetDefault** merges additional defaults specified by the XENVIRONMENT environment variable. If XENVIRONMENT is defined, it contains a full path name for the additional resource file. If XENVIRONMENT is not defined, **XGetDefault** looks for

$HOME/.Xdefaults-*name*, where *name* specifies the name of the machine on which the application is running. For details of the format of these files, see section 10.11.

The **XGetDefault** function provides a simple interface for clients not wishing to use the X toolkit or the more elaborate interfaces provided by the resource manager discussed in section 10.11.

```
char *XGetDefault(display, program, option)
      Display *display;
      char *program;
      char *option;
```

display Specifies the connection to the X server.

program Specifies the program name for the Xlib defaults (usually argv[0] of the main program).

option Specifies the option name.

The **XGetDefault** function returns the value NULL if the option name specified in this argument does not exist for the program. The strings returned by **XGetDefault** are owned by Xlib and should not be modified or freed by the client.

To obtain a pointer to the resource manager string of a display, use **XResourceManagerString**.

```
char *XResourceManagerString(display)
       Display *display;
```

display Specifies the connection to the X server.

The **XResourceManagerString** returns the RESOURCE_MANAGER property from the server's root window of screen zero, which was returned when the connection was opened using **XOpenDisplay**.

10.3. Parsing the Window Geometry

To parse standard window geometry strings, use **XParseGeometry**.

```
int XParseGeometry(parsestring, x_return, y_return, width_return, height_return)
      char *parsestring;
      int *x_return, *y_return;
      int *width_return, *height_return;
```

parsestring Specifies the string you want to parse.

x_return
y_return Return the x and y offsets.

width_return
height_return Return the width and height determined.

By convention, X applications use a standard string to indicate window size and placement. **XParseGeometry** makes it easier to conform to this standard because it allows you to parse the standard window geometry. Specifically, this function lets you parse strings of the form:

[=][<*width*>x<*height*>][{+-}<*xoffset*>{+-}<*yoffset*>]

The items in this form map into the arguments associated with this function. (Items enclosed in < > are integers, items in [] are optional, and items enclosed in { } indicate "choose one of". Note that the brackets should not appear in the actual string.)

The **XParseGeometry** function returns a bitmask that indicates which of the four values (width, height, xoffset, and yoffset) were actually found in the string and whether the x and y values are negative. By convention, –0 is not equal to +0, because the user needs to be able to say "position the window relative to the right or bottom edge." For each value found, the corresponding argument is updated. For each value not found, the argument is left unchanged. The bits are represented by **XValue**, **YValue**, **WidthValue**, **HeightValue**, **XNegative**, or **YNegative** and are defined in <**X11/Xutil.h**>. They will be set whenever one of the values is defined or one of the signs is set.

If the function returns either the **XValue** or **YValue** flag, you should place the window at the requested position.

To parse window geometry given a user-specified position and a default position, use **XGeometry**.

```
int XGeometry(display, screen, position, default_position, bwidth, fwidth, fheight, xadder,
              yadder, x_return, y_return, width_return, height_return)
     Display *display;
     int screen;
     char *position, *default_position;
     unsigned int bwidth;
     unsigned int fwidth, fheight;
     int xadder, yadder;
     int *x_return, *y_return;
     int *width_return, *height_return;
```

display Specifies the connection to the X server.

screen Specifies the screen.

position
default_position Specify the geometry specifications.

bwidth Specifies the border width.

fheight
fwidth Specify the font height and width in pixels (increment size).

xadder
yadder Specify additional interior padding needed in the window.

x_return
y_return Return the x and y offsets.

width_return
height_return Return the width and height determined.

You pass in the border width (bwidth), size of the increments fwidth and fheight (typically font width and height), and any additional interior space (xadder and yadder) to make it easy to compute the resulting size. The **XGeometry** function returns the position the window should be placed given a position and a default position. **XGeometry** determines the placement of a window using a geometry specification as specified by **XParseGeometry** and the additional information about the window. Given a fully qualified default geometry specification and an incomplete geometry specification, **XParseGeometry** returns a bitmask value as defined above in the **XParseGeometry** call, by using the position argument.

The returned width and height will be the width and height specified by default_position as overridden by any user-specified position. They are not affected by fwidth, fheight, xadder, or yadder. The x and y coordinates are computed by using the border width, the screen width and height, padding as specified by xadder and yadder, and the fheight and fwidth times the width and height from the geometry specifications.

10.4. Parsing the Color Specifications

To parse color values, use **XParseColor**.

```
Status XParseColor(display, colormap, spec, exact_def_return)
      Display *display;
      Colormap colormap;
      char *spec;
      XColor *exact_def_return;
```

display Specifies the connection to the X server.

colormap Specifies the colormap.

spec Specifies the color name string; case is ignored.

exact_def_return
Returns the exact color value for later use and sets the **DoRed**, **DoGreen**, and **DoBlue** flags.

The **XParseColor** function provides a simple way to create a standard user interface to color. It takes a string specification of a color, typically from a command line or **XGetDefault** option, and returns the corresponding red, green, and blue values that are suitable for a subsequent call to **XAllocColor** or **XStoreColor**. The color can be specified either as a color name (as in **XAllocNamedColor**) or as an initial sharp sign character followed by a numeric specification, in one of the following formats:

#RGB	(4 bits each)
#RRGGBB	(8 bits each)
#RRRGGGBBB	(12 bits each)
#RRRRGGGGBBBB	(16 bits each)

The R, G, and B represent single hexadecimal digits (both uppercase and lowercase). When fewer than 16 bits each are specified, they represent the most-significant bits of the value. For example, #3a7 is the same as #3000a0007000. The colormap is used only to determine which screen to look up the color on. For example, you can use the screen's default colormap.

If the initial character is a sharp sign but the string otherwise fails to fit the above formats or if the initial character is not a sharp sign and the named color does not exist in the server's database, **XParseColor** fails and returns zero.

XParseColor can generate a **BadColor** error.

10.5. Generating Regions

Regions are arbitrary sets of pixel locations. Xlib provides functions for manipulating regions. The opaque type **Region** is defined in <**X11/Xutil.h**>.

To generate a region from a polygon, use **XPolygonRegion**.

```
Region XPolygonRegion(points, n, fill_rule)
    XPoint points[];
    int n;
    int fill_rule;
```

points Specifies an array of points.

n Specifies the number of points in the polygon.

fill_rule Specifies the fill-rule you want to set for the specified GC. You can pass **EvenOddRule** or **WindingRule**.

The **XPolygonRegion** function returns a region for the polygon defined by the points array. For an explanation of fill_rule, see **XCreateGC**.

To generate the smallest rectangle enclosing the region, use **XClipBox**.

```
XClipBox(r, rect_return)
      Region r;
      XRectangle *rect_return;
```

r Specifies the region.

rect_return Returns the smallest enclosing rectangle.

The **XClipBox** function returns the smallest rectangle enclosing the specified region.

10.6. Manipulating Regions

Xlib provides functions that you can use to manipulate regions. This section discusses how to:

- Create, copy, or destroy regions
- Move or shrink regions
- Compute with regions
- Determine if regions are empty or equal
- Locate a point or rectangle in a region

10.6.1. Creating, Copying, or Destroying Regions

To create a new empty region, use **XCreateRegion**.

```
Region XCreateRegion()
```

To set the clip-mask of a GC to a region, use **XSetRegion**.

```
XSetRegion(display, gc, r)
      Display *display;
      GC gc;
      Region r;
```

display Specifies the connection to the X server.

gc Specifies the GC.

r Specifies the region.

The **XSetRegion** function sets the clip-mask in the GC to the specified region. Once it is set in the GC, the region can be destroyed.

To deallocate the storage associated with a specified region, use **XDestroyRegion**.

```
XDestroyRegion(r)
      Region r;
```

r Specifies the region.

10.6.2. Moving or Shrinking Regions

To move a region by a specified amount, use **XOffsetRegion**.

```
XOffsetRegion(r, dx, dy)
      Region r;
      int dx, dy;
```

r Specifies the region.

dx
dy Specify the x and y coordinates, which define the amount you want to move the specified region.

To reduce a region by a specified amount, use **XShrinkRegion**.

XShrinkRegion(*r*, *dx*, *dy*)
    Region *r*;
    int *dx*, *dy*;

r Specifies the region.

dx
dy Specify the x and y coordinates, which define the amount you want to shrink the specified region.

Positive values shrink the size of the region, and negative values expand the region.

10.6.3. Computing with Regions

To compute the intersection of two regions, use **XIntersectRegion**.

XIntersectRegion(*sra*, *srb*, *dr_return*)
    Region *sra*, *srb*, *dr_return*;

sra
srb Specify the two regions with which you want to perform the computation.

dr_return Returns the result of the computation.

To compute the union of two regions, use **XUnionRegion**.

XUnionRegion(*sra*, *srb*, *dr_return*)
    Region *sra*, *srb*, *dr_return*;

sra
srb Specify the two regions with which you want to perform the computation.

dr_return Returns the result of the computation.

To create a union of a source region and a rectangle, use **XUnionRectWithRegion**.

XUnionRectWithRegion(*rectangle*, *src_region*, *dest_region_return*)
    XRectangle **rectangle*;
    Region *src_region*;
    Region *dest_region_return*;

rectangle Specifies the rectangle.

src_region Specifies the source region to be used.

dest_region_return
    Returns the destination region.

The **XUnionRectWithRegion** function updates the destination region from a union of the specified rectangle and the specified source region.

To subtract two regions, use **XSubtractRegion**.

XSubtractRegion(*sra*, *srb*, *dr_return*)
    Region *sra*, *srb*, *dr_return*;

sra
srb Specify the two regions with which you want to perform the computation.

dr_return Returns the result of the computation.

The **XSubtractRegion** function subtracts srb from sra and stores the results in dr_return.

To calculate the difference between the union and intersection of two regions, use **XXorRegion**.

XXorRegion(*sra*, *srb*, *dr_return*)
    Region *sra*, *srb*, *dr_return*;

sra
srb Specify the two regions with which you want to perform the computation.

dr_return Returns the result of the computation.

10.6.4. Determining if Regions Are Empty or Equal

To determine if the specified region is empty, use **XEmptyRegion**.

Bool XEmptyRegion(*r*)
    Region *r*;

r Specifies the region.

The **XEmptyRegion** function returns **True** if the region is empty.

To determine if two regions have the same offset, size, and shape, use **XEqualRegion**.

Bool XEqualRegion(*r1*, *r2*)
    Region *r1*, *r2*;

r1
r2 Specify the two regions.

The **XEqualRegion** function returns **True** if the two regions have the same offset, size, and shape.

10.6.5. Locating a Point or a Rectangle in a Region

To determine if a specified point resides in a specified region, use **XPointInRegion**.

Bool XPointInRegion(*r*, *x*, *y*)
    Region *r*;
    int *x*, *y*;

r Specifies the region.

x
y Specify the x and y coordinates, which define the point.

The **XPointInRegion** function returns **True** if the point (x, y) is contained in the region r.

To determine if a specified rectangle is inside a region, use **XRectInRegion**.

int XRectInRegion(*r*, *x*, *y*, *width*, *height*)
    Region *r*;
    int *x*, *y*;
    unsigned int *width*, *height*;

r Specifies the region.

x
y Specify the x and y coordinates, which define the coordinates of the upper-left corner of the rectangle.

width
height Specify the width and height, which define the rectangle .

The **XRectInRegion** function returns **RectangleIn** if the rectangle is entirely in the specified region, **RectangleOut** if the rectangle is entirely out of the specified region, and **RectanglePart** if the rectangle is partially in the specified region.

10.7. Using the Cut and Paste Buffers

Xlib provides functions that you can use to cut and paste buffers for programs using this form of communications. Selections are a more useful mechanism for interchanging data between clients because typed information can be exchanged. X provides property names for properties in which bytes can be stored for implementing cut and paste between windows (implemented by use of properties on the first root window of the display). It is up to applications to agree on how to represent the data in the buffers. The data is most often ISO Latin-1 text. The atoms for eight such buffer names are provided and can be accessed as a ring or as explicit buffers (numbered 0 through 7). New applications are encouraged to share data by using selections (see section 4.4).

To store data in cut buffer 0, use **XStoreBytes**.

```
XStoreBytes(display, bytes, nbytes)
      Display *display;
      char *bytes;
      int nbytes;
```

display Specifies the connection to the X server.

bytes Specifies the bytes, which are not necessarily ASCII or null-terminated.

nbytes Specifies the number of bytes to be stored.

Note that the cut buffer's contents need not be text, so zero bytes are not special. The cut buffer's contents can be retrieved later by any client calling **XFetchBytes**.

XStoreBytes can generate a **BadAlloc** error.

To store data in a specified cut buffer, use **XStoreBuffer**.

```
XStoreBuffer(display, bytes, nbytes, buffer)
      Display *display;
      char *bytes;
      int nbytes;
      int buffer;
```

display Specifies the connection to the X server.

bytes Specifies the bytes, which are not necessarily ASCII or null-terminated.

nbytes Specifies the number of bytes to be stored.

buffer Specifies the buffer in which you want to store the bytes.

If the property for the buffer has never been created, a **BadAtom** error results.

XStoreBuffer can generate **BadAlloc** and **BadAtom** errors.

To return data from cut buffer 0, use **XFetchBytes**.

```
char *XFetchBytes(display, nbytes_return)
      Display *display;
      int *nbytes_return;
```

display Specifies the connection to the X server.

nbytes_return Returns the number of bytes in the buffer.

The **XFetchBytes** function returns the number of bytes in the nbytes_return argument, if the buffer contains data. Otherwise, the function returns NULL and sets nbytes to 0. The appropriate amount of storage is allocated and the pointer returned. The client must free this storage when finished with it by calling **XFree**. Note that the cut buffer does not necessarily contain text, so it may contain embedded zero bytes and may not terminate with a null byte.

To return data from a specified cut buffer, use **XFetchBuffer**.

```
char *XFetchBuffer(display, nbytes_return, buffer)
      Display *display;
      int *nbytes_return;
      int buffer;
```

display Specifies the connection to the X server.

nbytes_return Returns the number of bytes in the buffer.

buffer Specifies the buffer from which you want the stored data returned.

The **XFetchBuffer** function returns zero to the nbytes_return argument if there is no data in the buffer.

XFetchBuffer can generate a **BadValue** error.

To rotate the cut buffers, use **XRotateBuffers**.

```
XRotateBuffers(display, rotate)
      Display *display;
      int rotate;
```

display Specifies the connection to the X server.

rotate Specifies how much to rotate the cut buffers.

The **XRotateBuffers** function rotates the cut buffers, such that buffer 0 becomes buffer n, buffer 1 becomes n + 1 mod 8, and so on. This cut buffer numbering is global to the display. Note that **XRotateBuffers** generates **BadMatch** errors if any of the eight buffers have not been created.

10.8. Determining the Appropriate Visual Type

A single display can support multiple screens. Each screen can have several different visual types supported at different depths. You can use the functions described in this section to determine which visual to use for your application.

The functions in this section use the visual information masks and the **XVisualInfo** structure, which is defined in **<X11/Xutil.h>** and contains:

```
/* Visual information mask bits */

#define    VisualNoMask              0x0
#define    VisualIDMask              0x1
#define    VisualScreenMask          0x2
#define    VisualDepthMask           0x4
#define    VisualClassMask           0x8
#define    VisualRedMaskMask         0x10
#define    VisualGreenMaskMask       0x20
#define    VisualBlueMaskMask        0x40
#define    VisualColormapSizeMask    0x80
#define    VisualBitsPerRGBMask      0x100
#define    VisualAllMask             0x1FF

/* Values */

typedef struct {
        Visual *visual;
```

```
        VisualID visualid;
        int screen;
        unsigned int depth;
        int class;
        unsigned long red_mask;
        unsigned long green_mask;
        unsigned long blue_mask;
        int colormap_size;
        int bits_per_rgb;
} XVisualInfo;
```

To obtain a list of visual information structures that match a specified template, use **XGetVisualInfo**.

XVisualInfo *XGetVisualInfo(*display*, *vinfo_mask*, *vinfo_template*, *nitems_return*)
    Display **display*;
    long *vinfo_mask*;
    XVisualInfo **vinfo_template*;
    int **nitems_return*;

display	Specifies the connection to the X server.
vinfo_mask	Specifies the visual mask value.
vinfo_template	Specifies the visual attributes that are to be used in matching the visual structures.
nitems_return	Returns the number of matching visual structures.

The **XGetVisualInfo** function returns a list of visual structures that match the attributes specified by vinfo_template. If no visual structures match the template using the specified vinfo_mask, **XGetVisualInfo** returns a NULL. To free the data returned by this function, use **XFree**.

To obtain the visual information that matches the specified depth and class of the screen, use **XMatchVisualInfo**.

Status XMatchVisualInfo(*display*, *screen*, *depth*, *class*, *vinfo_return*)
    Display **display*;
    int *screen*;
    int *depth*;
    int *class*;
    XVisualInfo **vinfo_return*;

display	Specifies the connection to the X server.
screen	Specifies the screen.
depth	Specifies the depth of the screen.
class	Specifies the class of the screen.
vinfo_return	Returns the matched visual information.

The **XMatchVisualInfo** function returns the visual information for a visual that matches the specified depth and class for a screen. Because multiple visuals that match the specified depth and class can exist, the exact visual chosen is undefined. If a visual is found, **XMatchVisualInfo** returns nonzero and the information on the visual to vinfo_return. Otherwise, when a visual is not found, **XMatchVisualInfo** returns zero.

10.9. Manipulating Images

Xlib provides several functions that perform basic operations on images. All operations on images are defined using an **XImage** structure, as defined in <**X11/Xlib.h**>. Because the number of different types of image formats can be very large, this hides details of image storage properly from applications.

This section describes the functions for generic operations on images. Manufacturers can provide very fast implementations of these for the formats frequently encountered on their hardware. These functions are neither sufficient nor desirable to use for general image processing. Rather, they are here to provide minimal functions on screen format images. The basic operations for getting and putting images are **XGetImage** and **XPutImage**.

Note that no functions have been defined, as yet, to read and write images to and from disk files.

The **XImage** structure describes an image as it exists in the client's memory. The user can request that some of the members such as height, width, and xoffset be changed when the image is sent to the server. Note that bytes_per_line in concert with offset can be used to extract a subset of the image. Other members (for example, byte order, bitmap_unit, and so forth) are characteristics of both the image and the server. If these members differ between the image and the server, **XPutImage** makes the appropriate conversions. The first byte of the first line of plane n must be located at the address (data + (n * height * bytes_per_line)). For a description of the **XImage** structure, see section 6.7.

To allocate sufficient memory for an **XImage** structure, use **XCreateImage**.

```
XImage *XCreateImage(display, visual, depth, format, offset, data, width, height, bitmap_pad,
                    bytes_per_line)
    Display *display;
    Visual *visual;
    unsigned int depth;
    int format;
    int offset;
    char *data;
    unsigned int width;
    unsigned int height;
    int bitmap_pad;
    int bytes_per_line;
```

display Specifies the connection to the X server.

visual Specifies a pointer to the visual.

depth Specifies the depth of the image.

format Specifies the format for the image. You can pass **XYBitmap**, **XYPixmap**, or **ZPixmap**.

offset Specifies the number of pixels to ignore at the beginning of the scanline.

data Specifies a pointer to the image data.

width Specifies the width of the image, in pixels.

height Specifies the height of the image, in pixels.

bitmap_pad Specifies the quantum of a scanline (8, 16, or 32). In other words, the start of one scanline is separated in client memory from the start of the next scanline by an integer multiple of this many bits.

bytes_per_line Specifies the number of bytes in the client image between the start of one scanline and the start of the next.

The **XCreateImage** function allocates the memory needed for an **XImage** structure for the specified display but does not allocate space for the image itself. Rather, it initializes the structure byte-order, bit-order, and bitmap-unit values from the display and returns a pointer to the **XImage** structure. The red, green, and blue mask values are defined for Z format images only and are derived from the **Visual** structure passed in. Other values also are passed in. The offset permits the rapid displaying of the image without requiring each scanline to be shifted into position. If you pass a zero value in bytes_per_line, Xlib assumes that the scanlines are contiguous in memory and calculates the value of bytes_per_line itself.

Note that when the image is created using **XCreateImage**, **XGetImage**, or **XSubImage**, the destroy procedure that the **XDestroyImage** function calls frees both the image structure and the data pointed to by the image structure.

The basic functions used to get a pixel, set a pixel, create a subimage, and add a constant offset to a Z format image are defined in the image object. The functions in this section are really macro invocations of the functions in the image object and are defined in <**X11/Xutil.h**>.

To obtain a pixel value in an image, use **XGetPixel**.

```
unsigned long XGetPixel(ximage, x, y)
      XImage *ximage;
      int x;
      int y;
```

ximage Specifies a pointer to the image.

x
y Specify the x and y coordinates.

The **XGetPixel** function returns the specified pixel from the named image. The pixel value is returned in normalized format (that is, the least-significant byte of the long is the least-significant byte of the pixel). The image must contain the x and y coordinates.

To set a pixel value in an image, use **XPutPixel**.

```
int XPutPixel(ximage, x, y, pixel)
      XImage *ximage;
      int x;
      int y;
      unsigned long pixel;
```

ximage Specifies a pointer to the image.

x
y Specify the x and y coordinates.

pixel Specifies the new pixel value.

The **XPutPixel** function overwrites the pixel in the named image with the specified pixel value. The input pixel value must be in normalized format (that is, the least-significant byte of the long is the least-significant byte of the pixel). The image must contain the x and y coordinates.

To create a subimage, use **XSubImage**.

```
XImage *XSubImage(ximage, x, y, subimage_width, subimage_height)
      XImage *ximage;
      int x;
      int y;
      unsigned int subimage_width;
      unsigned int subimage_height;
```

ximage Specifies a pointer to the image.

x
y Specify the x and y coordinates.

subimage_width Specifies the width of the new subimage, in pixels.

subimage_height Specifies the height of the new subimage, in pixels.

The **XSubImage** function creates a new image that is a subsection of an existing one. It allocates the memory necessary for the new **XImage** structure and returns a pointer to the new image. The data is copied from the source image, and the image must contain the rectangle defined by x, y, subimage_width, and subimage_height.

To increment each pixel in the pixmap by a constant value, use **XAddPixel**.

```
XAddPixel(ximage, value)
      XImage *ximage;
      long value;
```

ximage Specifies a pointer to the image.

value Specifies the constant value that is to be added.

The **XAddPixel** function adds a constant value to every pixel in an image. It is useful when you have a base pixel value from allocating color resources and need to manipulate the image to that form.

To deallocate the memory allocated in a previous call to **XCreateImage**, use **XDestroyImage**.

```
int XDestroyImage(ximage)
      XImage *ximage;
```

ximage Specifies a pointer to the image.

The **XDestroyImage** function deallocates the memory associated with the **XImage** structure.

Note that when the image is created using **XCreateImage**, **XGetImage**, or **XSubImage**, the destroy procedure that this macro calls frees both the image structure and the data pointed to by the image structure.

10.10. Manipulating Bitmaps

Xlib provides functions that you can use to read a bitmap from a file, save a bitmap to a file, or create a bitmap. This section describes those functions that transfer bitmaps to and from the client's file system, thus allowing their reuse in a later connection (for example, from an entirely different client or to a different display or server).

The X version 11 bitmap file format is:

```
#define name_width width
#define name_height height
#define name_x_hot x
#define name_y_hot y
static char name_bits[] = { 0xNN,... }
```

The variables ending with _x_hot and _y_hot suffixes are optional because they are present only if a hotspot has been defined for this bitmap. The other variables are required. The _bits array must be large enough to contain the size bitmap. The bitmap unit is eight. The name is derived from the name of the file that you specified on the original command line by deleting the directory path and extension.

To read a bitmap from a file, use **XReadBitmapFile**.

int XReadBitmapFile(*display, d, filename, width_return, height_return, bitmap_return, x_hot_return*
    y_hot_return)
  Display **display*;
  Drawable *d*;
  char **filename*;
  unsigned int **width_return*, **height_return*;
  Pixmap **bitmap_return*;
  int **x_hot_return*, **y_hot_return*;

display Specifies the connection to the X server.

d Specifies the drawable that indicates the screen.

filename Specifies the file name to use. The format of the file name is operating-system dependent.

width_return
height_return Return the width and height values of the read in bitmap file.

bitmap_return Returns the bitmap that is created.

x_hot_return
y_hot_return Return the hotspot coordinates.

The **XReadBitmapFile** function reads in a file containing a bitmap. The file can be either in the standard X version 10 format (that is, the format used by X version 10 bitmap program) or in the X version 11 bitmap format. If the file cannot be opened, **XReadBitmapFile** returns **BitmapOpenFailed**. If the file can be opened but does not contain valid bitmap data, it returns **BitmapFileInvalid**. If insufficient working storage is allocated, it returns **BitmapNoMemory**. If the file is readable and valid, it returns **BitmapSuccess**.

XReadBitmapFile returns the bitmap's height and width, as read from the file, to width_return and height_return. It then creates a pixmap of the appropriate size, reads the bitmap data from the file into the pixmap, and assigns the pixmap to the caller's variable bitmap. The caller must free the bitmap using **XFreePixmap** when finished. If *name*_x_hot and *name*_y_hot exist, **XReadBitmapFile** returns them to x_hot_return and y_hot_return; otherwise, it returns –1,–1.

XReadBitmapFile can generate **BadAlloc** and **BadDrawable** errors.

To write out a bitmap to a file, use **XWriteBitmapFile**.

int XWriteBitmapFile(*display, filename, bitmap, width, height, x_hot, y_hot*)
  Display **display*;
  char **filename*;
  Pixmap *bitmap*;
  unsigned int *width, height*;
  int *x_hot, y_hot*;

display Specifies the connection to the X server.

filename Specifies the file name to use. The format of the file name is operating-system dependent.

bitmap Specifies the bitmap.

width
height Specify the width and height.

x_hot
y_hot Specify where to place the hotspot coordinates (or -1,-1 if none are present) in the file.

The **XWriteBitmapFile** function writes a bitmap out to a file. While **XReadBitmapFile** can read in either X version 10 format or X version 11 format, **XWriteBitmapFile** always writes out X version 11 format. If the file cannot be opened for writing, it returns **BitmapOpenFailed**. If insufficient memory is allocated, **XWriteBitmapFile** returns **BitmapNoMemory**; otherwise, on no error, it returns **BitmapSuccess**. If x_hot and y_hot are not –1, –1, **XWriteBitmapFile** writes them out as the hotspot coordinates for the bitmap.

XWriteBitmapFile can generate **BadDrawable** and **BadMatch** errors.

To create a pixmap and then store bitmap-format data into it, use **XCreatePixmapFromBitmapData**.

Pixmap XCreatePixmapFromBitmapData(*display*, *d*, *data*, *width*, *height*, *fg*, *bg*, *depth*)
  Display **display*;
  Drawable *d*;
  char **data*;
  unsigned int *width*, *height*;
  unsigned long *fg*, *bg*;
  unsigned int *depth*;

display Specifies the connection to the X server.

d Specifies the drawable that indicates the screen.

data Specifies the data in bitmap format.

width
height Specify the width and height.

fg
bg Specify the foreground and background pixel values to use.

depth Specifies the depth of the pixmap.

The **XCreatePixmapFromBitmapData** function creates a pixmap of the given depth and then does a bitmap-format **XPutImage** of the data into it. The depth must be supported by the screen of the specified drawable, or a **BadMatch** error results.

XCreatePixmapFromBitmapData can generate **BadAlloc** and **BadMatch** errors.

To include a bitmap written out by **XWriteBitmapFile** in a program directly, as opposed to reading it in every time at run time, use **XCreateBitmapFromData**.

Pixmap XCreateBitmapFromData(*display*, *d*, *data*, *width*, *height*)
  Display **display*;
  Drawable *d*;
  char **data*;
  unsigned int *width*, *height*;

display Specifies the connection to the X server.

d Specifies the drawable that indicates the screen.

data Specifies the location of the bitmap data.

width
height Specify the width and height.

The **XCreateBitmapFromData** function allows you to include in your C program (using #include) a bitmap file that was written out by **XWriteBitmapFile** (X version 11 format only) without reading in the bitmap file. The following example creates a gray bitmap:

```
#include "gray.bitmap"

Pixmap bitmap;
bitmap = XCreateBitmapFromData(display, window, gray_bits, gray_width, gray_height);
```

If insufficient working storage was allocated, **XCreateBitmapFromData** returns **None**. It is your responsibility to free the bitmap using **XFreePixmap** when finished.

XCreateBitmapFromData can generate a **BadAlloc** error.

10.11. Using the Resource Manager

The resource manager is a database manager with a twist. In most database systems, you perform a query using an imprecise specification, and you get back a set of records. The resource manager, however, allows you to specify a large set of values with an imprecise specification, to query the database with a precise specification, and to get back only a single value. This should be used by applications that need to know what the user prefers for colors, fonts, and other resources. It is this use as a database for dealing with X resources that inspired the name "Resource Manager," although the resource manager can be and is used in other ways.

For example, a user of your application may want to specify that all windows should have a blue background but that all mail-reading windows should have a red background. Presuming that all applications use the resource manager, a user can define this information using only two lines of specifications. Your personal resource database usually is stored in a file and is loaded onto a server property when you log in. This database is retrieved automatically by Xlib when a connection is opened.

As an example of how the resource manager works, consider a mail-reading application called **xmh**. Assume that it is designed so that it uses a complex window hierarchy all the way down to individual command buttons, which may be actual small subwindows in some toolkits. These are often called objects or widgets. In such toolkit systems, each user interface object can be composed of other objects and can be assigned a name and a class. Fully qualified names or classes can have arbitrary numbers of component names, but a fully qualified name always has the same number of component names as a fully qualified class. This generally reflects the structure of the application as composed of these objects, starting with the application itself.

For example, the xmh mail program has a name "xmh" and is one of a class of "Mail" programs. By convention, the first character of class components is capitalized, and the first letter of name components is in lowercase. Each name and class finally has an attribute (for example "foreground" or "font"). If each window is properly assigned a name and class, it is easy for the user to specify attributes of any portion of the application.

At the top level, the application might consist of a paned window (that is, a window divided into several sections) named "toc". One pane of the paned window is a button box window named "buttons" and is filled with command buttons. One of these command buttons is used to retrieve (include) new mail and has the name "include". This window has a fully qualified name, "xmh.toc.buttons.include", and a fully qualified class, "Xmh.VPaned.Box.Command". Its fully qualified name is the name of its parent, "xmh.toc.buttons", followed by its name, "include". Its class is the class of its parent, "Xmh.VPaned.Box", followed by its particular class, "Command". The fully qualified name of a resource is the attribute's name appended to the object's fully qualified name, and the fully qualified class is its class appended to the object's class.

This include button needs the following resources:

- Title string
- Font
- Foreground color for its inactive state
- Background color for its inactive state
- Foreground color for its active state
- Background color for its active state

Each of the resources that this button needs are considered to be attributes of the button and, as such, have a name and a class. For example, the foreground color for the button in its active state might be named "activeForeground", and its class would be "Foreground."

When an application looks up a resource (for example, a color), it passes the complete name and complete class of the resource to a look-up routine. After look up, the resource manager returns the resource value and the representation type.

The resource manager allows applications to store resources by an incomplete specification of name, class, and a representation type, as well as to retrieve them given a fully qualified name and class.

10.11.1. Resource Manager Matching Rules

The algorithm for determining which resource name or names match a given query is the heart of the database. Resources are stored with only partially specified names and classes, using pattern matching constructs. An asterisk (*) is used to represent any number of intervening components (including none). A period (.) is used to separate immediately adjacent components. All queries fully specify the name and class of the resource needed. A trailing period and asterisk are not removed. The library supports 100 components in a name or class. The look-up algorithm then searches the database for the name that most closely matches (is most specific) this full name and class. The rules for a match in order of precedence are:

1. The attribute of the name and class must match. For example, queries for:

   ```
   xterm.scrollbar.background      (name)
   XTerm.Scrollbar.Background      (class)
   ```

   will not match the following database entry:

   ```
   xterm.scrollbar:on
   ```

2. Database entries with name or class prefixed by a period (.) are more specific than those prefixed by an asterisk (*). For example, the entry xterm.geometry is more specific than the entry xterm*geometry.
3. Names are more specific than classes. For example, the entry "*scrollbar.background" is more specific than the entry "*Scrollbar.Background".
4. Specifying a name or class is more specific than omitting either. For example, the entry "Scrollbar*Background" is more specific than the entry "*Background".
5. Left components are more specific than right components. For example, "*vt100*background" is more specific than the entry "*scrollbar*background" for the query ".vt100.scrollbar.background".
6. If neither a period (.) nor an asterisk (*) is specified at the beginning, a period (.) is implicit. For example, "xterm.background" is identical to ".xterm.background".

Names and classes can be mixed. As an example of these rules, assume the following user preference specification:

```
xmh*background:                    red
*command.font:                     8x13
*command.background:               blue
*Command.Foreground:               green
xmh.toc*Command.activeForeground:black
```

A query for the name "xmh.toc.messagefunctions.include.activeForeground" and class "Xmh.VPaned.Box.Command.Foreground" would match "xmh.toc*Command.activeForeground" and return "black". However, it also matches "*Command.Foreground".

Using the precedence algorithm described above, the resource manager would return the value specified by "xmh.toc*Command.activeForeground".

10.11.2. Basic Resource Manager Definitions

The definitions for the resource manager's use are contained in **<X11/Xresource.h>**. Xlib also uses the resource manager internally to allow for non-English language error messages.

Database values consist of a size, an address, and a representation type. The size is specified in bytes. The representation type is a way for you to store data tagged by some application-defined type (for example, "font" or "color"). It has nothing to do with the C data type or with its class. The **XrmValue** structure contains:

```
typedef struct {
        unsigned int size;
        caddr_t addr;
} XrmValue, *XrmValuePtr;
```

A resource database is an opaque type used by the look-up functions.

```
typedef struct _XrmHashBucketRec *XrmDatabase;
```

To initialize the resource manager, use **XrmInitialize**.

```
void XrmInitialize( );
```

Most uses of the resource manager involve defining names, classes, and representation types as string constants. However, always referring to strings in the resource manager can be slow, because it is so heavily used in some toolkits. To solve this problem, a shorthand for a string is used in place of the string in many of the resource manager functions. Simple comparisons can be performed rather than string comparisons. The shorthand name for a string is called a quark and is the type **XrmQuark**. On some occasions, you may want to allocate a quark that has no string equivalent.

A quark is to a string what an atom is to a string in the server, but its use is entirely local to your application.

To allocate a new quark, use **XrmUniqueQuark**.

```
XrmQuark XrmUniqueQuark( )
```

The **XrmUniqueQuark** function allocates a quark that is guaranteed not to represent any string that is known to the resource manager.

To allocate some memory you will never give back, use **Xpermalloc**.

```
char *Xpermalloc(size)
    unsigned int size;
```

The **Xpermalloc** function is used by some toolkits for permanently allocated storage and allows some performance and space savings over the completely general memory allocator.

Each name, class, and representation type is typedef'd as an **XrmQuark**.

```
typedef int XrmQuark, *XrmQuarkList;
typedef XrmQuark XrmName;
typedef XrmQuark XrmClass;
typedef XrmQuark XrmRepresentation;
```

Lists are represented as null-terminated arrays of quarks. The size of the array must be large enough for the number of components used.

```
typedef XrmQuarkList XrmNameList;
typedef XrmQuarkList XrmClassList;
```

To convert a string to a quark, use **XrmStringToQuark**.

```
#define XrmStringToName(string) XrmStringToQuark(string)
#define XrmStringToClass(string) XrmStringToQuark(string)
#define XrmStringToRepresentation(string) XrmStringToQuark(string)
```

```
XrmQuark XrmStringToQuark(string)
    char *string;
```

string Specifies the string for which a quark is to be allocated.

To convert a quark to a string, use **XrmQuarkToString**.

```
#define XrmNameToString(name) XrmQuarkToString(name)
#define XrmClassToString(class) XrmQuarkToString(class)
#define XrmRepresentationToString(type) XrmQuarkToString(type)
```

```
char *XrmQuarkToString(quark)
    XrmQuark quark;
```

quark Specifies the quark for which the equivalent string is desired.

These functions can be used to convert to and from quark representations. The string pointed to by the return value must not be modified or freed. If no string exists for that quark, **XrmQuarkToString** returns NULL.

To convert a string with one or more components to a quark list, use **XrmStringToQuarkList**.

```
#define XrmStringToNameList(str, name)  XrmStringToQuarkList((str), (name))
#define XrmStringToClassList(str,class) XrmStringToQuarkList((str), (class))
```

```
void XrmStringToQuarkList(string, quarks_return)
    char *string;
    XrmQuarkList quarks_return;
```

string Specifies the string for which a quark is to be allocated.

quarks_return Returns the list of quarks.

The **XrmStringToQuarkList** function converts the null-terminated string (generally a fully qualified name) to a list of quarks. The components of the string are separated by a period or asterisk character.

A binding list is a list of type **XrmBindingList** and indicates if components of name or class lists are bound tightly or loosely (that is, if wildcarding of intermediate components is specified).

```
typedef enum {XrmBindTightly, XrmBindLoosely} XrmBinding, *XrmBindingList;
```

XrmBindTightly indicates that a period separates the components, and **XrmBindLoosely** indicates that an asterisk separates the components.

To convert a string with one or more components to a binding list and a quark list, use **XrmStringToBindingQuarkList**.

XrmStringToBindingQuarkList(*string*, *bindings_return*, *quarks_return*)
    char **string*;
    XrmBindingList *bindings_return*;
    XrmQuarkList *quarks_return*;

string Specifies the string for which a quark is to be allocated.

bindings_return Returns the binding list. The caller must allocate sufficient space for the binding list before calling **XrmStringToBindingQuarkList**.

quarks_return Returns the list of quarks. The caller must allocate sufficient space for the quarks list before calling **XrmStringToBindingQuarkList**.

Component names in the list are separated by a period or an asterisk character. If the string does not start with a period or an asterisk, a period is assumed. For example, "*a.b*c" becomes:

quarks	a	b	c
bindings	loose	tight	loose

10.11.3. Resource Database Access

Xlib provides resource management functions that you can use to manipulate resource databases. The next sections discuss how to:

- Store and get resources
- Get database levels
- Merge two databases
- Retrieve and store databases

10.11.3.1. Storing Into a Resource Database

To store resources into the database, use **XrmPutResource** or **XrmQPutResource**. Both functions take a partial resource specification, a representation type, and a value. This value is copied into the specified database.

void XrmPutResource(*database*, *specifier*, *type*, *value*)
    XrmDatabase **database*;
    char **specifier*;
    char **type*;
    XrmValue **value*;

database Specifies a pointer to the resource database.

specifier Specifies a complete or partial specification of the resource.

type Specifies the type of the resource.

value Specifies the value of the resource, which is specified as a string.

If database contains NULL, **XrmPutResource** creates a new database and returns a pointer to it. **XrmPutResource** is a convenience function that calls **XrmStringToBindingQuarkList** followed by:

```
XrmQPutResource(database, bindings, quarks, XrmStringToQuark(type), value)
```

```
void XrmQPutResource(database, bindings, quarks, type, value)
    XrmDatabase *database;
    XrmBindingList bindings;
    XrmQuarkList quarks;
    XrmRepresentation type;
    XrmValue *value;
```

database Specifies a pointer to the resource database.

bindings Specifies a list of bindings.

quarks Specifies the complete or partial name or the class list of the resource.

type Specifies the type of the resource.

value Specifies the value of the resource, which is specified as a string.

If database contains NULL, **XrmQPutResource** creates a new database and returns a pointer to it.

To add a resource that is specified as a string, use **XrmPutStringResource**.

```
void XrmPutStringResource(database, specifier, value)
    XrmDatabase *database;
    char *specifier;
    char *value;
```

database Specifies a pointer to the resource database.

specifier Specifies a complete or partial specification of the resource.

value Specifies the value of the resource, which is specified as a string.

If database contains NULL, **XrmPutStringResource** creates a new database and returns a pointer to it. **XrmPutStringResource** adds a resource with the specified value to the specified database. **XrmPutStringResource** is a convenience routine that takes both the resource and value as null-terminated strings, converts them to quarks, and then calls **XrmQPutResource**, using a "String" representation type.

To add a string resource using quarks as a specification, use **XrmQPutStringResource**.

```
void XrmQPutStringResource(database, bindings, quarks, value)
    XrmDatabase *database;
    XrmBindingList bindings;
    XrmQuarkList quarks;
    char *value;
```

database Specifies a pointer to the resource database.

bindings Specifies a list of bindings.

quarks Specifies the complete or partial name or the class list of the resource.

value Specifies the value of the resource, which is specified as a string.

If database contains NULL, **XrmQPutStringResource** creates a new database and returns a pointer to it. **XrmQPutStringResource** is a convenience routine that constructs an **XrmValue** for the value string (by calling **strlen** to compute the size) and then calls **XrmQPutResource**, using a "String" representation type.

To add a single resource entry that is specified as a string that contains both a name and a value, use **XrmPutLineResource**.

```
void XrmPutLineResource(database, line)
    XrmDatabase *database;
    char *line;
```

database Specifies a pointer to the resource database.

line Specifies the resource value pair as a single string. A single colon (:) separates the name from the value.

If database contains NULL, **XrmPutLineResource** creates a new database and returns a pointer to it. **XrmPutLineResource** adds a single resource entry to the specified database. Any white space before or after the name or colon in the line argument is ignored. The value is terminated by a new-line or a NULL character. To allow values to contain embedded new-line characters, a "\n" is recognized and replaced by a new-line character. For example, line might have the value "xterm*background:green\n". Null-terminated strings without a new line are also permitted.

10.11.3.2. Looking Up from a Resource Database

To retrieve a resource from a resource database, use **XrmGetResource** or **XrmQGetResource**.

```
Bool XrmGetResource(database, str_name, str_class, str_type_return, value_return)
    XrmDatabase database;
    char *str_name;
    char *str_class;
    char **str_type_return;
    XrmValue *value_return;
```

database Specifies the database that is to be used.

str_name Specifies the fully qualified name of the value being retrieved (as a string).

str_class Specifies the fully qualified class of the value being retrieved (as a string).

str_type_return Returns a pointer to the representation type of the destination (as a string).

value_return Returns the value in the database.

```
Bool XrmQGetResource(database, quark_name, quark_class, quark_type_return, value_return)
    XrmDatabase database;
    XrmNameList quark_name;
    XrmClassList quark_class;
    XrmRepresentation *quark_type_return;
    XrmValue *value_return;
```

database Specifies the database that is to be used.

quark_name Specifies the fully qualified name of the value being retrieved (as a quark).

quark_class Specifies the fully qualified class of the value being retrieved (as a quark).

quark_type_return
Returns a pointer to the representation type of the destination (as a quark).

value_return Returns the value in the database.

The **XrmGetResource** and **XrmQGetResource** functions retrieve a resource from the specified database. Both take a fully qualified name/class pair, a destination resource representation, and the address of a value (size/address pair). The value and returned type point into database memory; therefore, you must not modify the data.

The database only frees or overwrites entries on **XrmPutResource**, **XrmQPutResource**, or **XrmMergeDatabases**. A client that is not storing new values into the database or is not merging the database should be safe using the address passed back at any time until it exits. If a resource was found, both **XrmGetResource** and **XrmQGetResource** return **True**; otherwise, they return **False**.

10.11.3.3. Database Search Lists

Most applications and toolkits do not make random probes into a resource database to fetch resources. The X toolkit access pattern for a resource database is quite stylized. A series of from 1 to 20 probes are made with only the last name/class differing in each probe. The **XrmGetResource** function is at worst a 2^n algorithm, where n is the length of the name/class list. This can be improved upon by the application programmer by prefetching a list of database levels that might match the first part of a name/class list.

To return a list of database levels, use **XrmQGetSearchList**.

typedef XrmHashTable *XrmSearchList;

Bool XrmQGetSearchList(*database, names, classes, list_return, list_length*)
    XrmDatabase *database*;
    XrmNameList *names*;
    XrmClassList *classes*;
    XrmSearchList *list_return*;
    int *list_length*;

database Specifies the database that is to be used.

names Specifies a list of resource names.

classes Specifies a list of resource classes.

list_return Returns a search list for further use. The caller must allocate sufficient space for the list before calling **XrmQGetSearchList**.

list_length Specifies the number of entries (not the byte size) allocated for list_return.

The **XrmQGetSearchList** function takes a list of names and classes and returns a list of database levels where a match might occur. The returned list is in best-to-worst order and uses the same algorithm as **XrmGetResource** for determining precedence. If list_return was large enough for the search list, **XrmQGetSearchList** returns **True**; otherwise, it returns **False**.

The size of the search list that the caller must allocate is dependent upon the number of levels and wildcards in the resource specifiers that are stored in the database. The worst case length is 3^n, where n is the number of name or class components in names or classes.

When using **XrmQGetSearchList** followed by multiple probes for resources with a common name and class prefix, only the common prefix should be specified in the name and class list to **XrmQGetSearchList**.

To search resource database levels for a given resource, use **XrmQGetSearchResource**.

```
Bool XrmQGetSearchResource(list, name, class, type_return, value_return)
    XrmSearchList list;
    XrmName name;
    XrmClass class;
    XrmRepresentation *type_return;
    XrmValue *value_return;
```

list	Specifies the search list returned by **XrmQGetSearchList**.
name	Specifies the resource name.
class	Specifies the resource class.
type_return	Returns data representation type.
value_return	Returns the value in the database.

The **XrmQGetSearchResource** function searches the specified database levels for the resource that is fully identified by the specified name and class. The search stops with the first match. **XrmQGetSearchResource** returns **True** if the resource was found; otherwise, it returns **False**.

A call to **XrmQGetSearchList** with a name and class list containing all but the last component of a resource name followed by a call to **XrmQGetSearchResource** with the last component name and class returns the same database entry as **XrmGetResource** and **XrmQGetResource** with the fully qualified name and class.

10.11.3.4. Merging Resource Databases

To merge the contents of one database into another database, use **XrmMergeDatabases**.

```
void XrmMergeDatabases(source_db, target_db)
    XrmDatabase source_db, *target_db;
```

source_db	Specifies the resource database that is to be merged into the target database.
target_db	Specifies a pointer to the resource database into which the source database is to be merged.

The **XrmMergeDatabases** function merges the contents of one database into another. It may overwrite entries in the destination database. This function is used to combine databases (for example, an application specific database of defaults and a database of user preferences). The merge is destructive; that is, the source database is destroyed.

10.11.3.5. Retrieving and Storing Databases

To retrieve a database from disk, use **XrmGetFileDatabase**.

```
XrmDatabase XrmGetFileDatabase(filename)
    char *filename;
```

filename	Specifies the resource database file name.

The **XrmGetFileDatabase** function opens the specified file, creates a new resource database, and loads it with the specifications read in from the specified file. The specified file must contain lines in the format accepted by **XrmPutLineResource**. If it cannot open the specified file, **XrmGetFileDatabase** returns NULL.

To store a copy of a database to disk, use **XrmPutFileDatabase**.

```
void XrmPutFileDatabase(database, stored_db)
    XrmDatabase database;
    char *stored_db;
```

database Specifies the database that is to be used.

stored_db Specifies the file name for the stored database.

The **XrmPutFileDatabase** function stores a copy of the specified database in the specified file. The file is an ASCII text file that contains lines in the format that is accepted by **XrmPutLineResource**.

To create a database from a string, use **XrmGetStringDatabase**.

```
XrmDatabase XrmGetStringDatabase(data)
    char *data;
```

data Specifies the database contents using a string.

The **XrmGetStringDatabase** function creates a new database and stores the resources specified in the specified null-terminated string. **XrmGetStringDatabase** is similar to **XrmGetFileDatabase** except that it reads the information out of a string instead of out of a file. Each line is separated by a new-line character in the format accepted by **XrmPutLineResource**.

10.11.4. Parsing Command Line Options

The **XrmParseCommand** function can be used to parse the command line arguments to a program and modify a resource database with selected entries from the command line.

```
typedef enum {
        XrmoptionNoArg,         /* Value is specified in OptionDescRec.value */
        XrmoptionIsArg,         /* Value is the option string itself */
        XrmoptionStickyArg,     /* Value is characters immediately following option */
        XrmoptionSepArg,        /* Value is next argument in argv */
        XrmoptionResArg,        /* Resource and value in next argument in argv */
        XrmoptionSkipArg,       /* Ignore this option and the next argument in argv */
        XrmoptionSkipLine       /* Ignore this option and the rest of argv */
} XrmOptionKind;

typedef struct {
        char *option;           /* Option specification string in argv    */
        char *resourceName;     /* Binding and resource name (sans application name)    */
        XrmOptionKind argKind;  /* Which style of option it is    */
        caddr_t value;          /* Value to provide if XrmoptionNoArg    */
} XrmOptionDescRec, *XrmOptionDescList;
```

To load a resource database from a C command line, use **XrmParseCommand**.

```
void XrmParseCommand(database, table, table_count, name, argc_in_out, argv_in_out,)
      XrmDatabase *database;
      XrmOptionDescList table;
      int table_count;
      char *name;
      int *argc_in_out;
      char **argv_in_out;
```

database Specifies a pointer to the resource database.

table Specifies the table of command line arguments to be parsed.

table_count Specifies the number of entries in the table.

name Specifies the application name.

argc_in_out Specifies the number of arguments and returns the number of remaining arguments.

argv_in_out Specifies a pointer to the command line arguments and returns the remaining arguments.

The **XrmParseCommand** function parses an (argc, argv) pair according to the specified option table, loads recognized options into the specified database with type "String," and modifies the (argc, argv) pair to remove all recognized options.

The specified table is used to parse the command line. Recognized entries in the table are removed from argv, and entries are made in the specified resource database. The table entries contain information on the option string, the option name, the style of option, and a value to provide if the option kind is **XrmoptionNoArg**. The argc argument specifies the number of arguments in argv and is set to the remaining number of arguments that were not parsed. The name argument should be the name of your application for use in building the database entry. The name argument is prefixed to the resourceName in the option table before storing the specification. No separating (binding) character is inserted. The table must contain either a period (.) or an asterisk (*) as the first character in each resourceName entry. To specify a more completely qualified resource name, the resourceName entry can contain multiple components.

For example, the following is part of the standard option table from the X Toolkit **XtInitialize** function:

```
static XrmOptionDescRec opTable[] = {
{"-background",   "*background",                XrmoptionSepArg,   (caddr_t) NULL},
{"-bd",           "*borderColor",               XrmoptionSepArg,   (caddr_t) NULL},
{"-bg",           "*background",                XrmoptionSepArg,   (caddr_t) NULL},
{"-borderwidth",  "*TopLevelShell.borderWidth", XrmoptionSepArg,(caddr_t) NULL},
{"-bordercolor",  "*borderColor",               XrmoptionSepArg,   (caddr_t) NULL},
{"-bw",           "*TopLevelShell.borderWidth", XrmoptionSepArg,(caddr_t) NULL},
{"-display",      ".display",                   XrmoptionSepArg,   (caddr_t) NULL},
{"-fg",           "*foreground",                XrmoptionSepArg,   (caddr_t) NULL},
{"-fn",           "*font",                      XrmoptionSepArg,   (caddr_t) NULL},
{"-font",         "*font",                      XrmoptionSepArg,   (caddr_t) NULL},
{"-foreground",   "*foreground",                XrmoptionSepArg,   (caddr_t) NULL},
{"-geometry",     ".TopLevelShell.geometry",    XrmoptionSepArg,   (caddr_t) NULL},
{"-iconic",       ".TopLevelShell.iconic",      XrmoptionNoArg,    (caddr_t) "on"},
{"-name",         ".name",                      XrmoptionSepArg,   (caddr_t) NULL},
{"-reverse",      "*reverseVideo",              XrmoptionNoArg,    (caddr_t) "on"},
{"-rv",           "*reverseVideo",              XrmoptionNoArg,    (caddr_t) "on"},
{"-synchronous",  ".synchronous",               XrmoptionNoArg,    (caddr_t) "on"},
{"-title",        ".TopLevelShell.title",       XrmoptionSepArg,   (caddr_t) NULL},
{"-xrm",          NULL,                         XrmoptionResArg,   (caddr_t) NULL},
```

};

In this table, if the –background (or –bg) option is used to set background colors, the stored resource specifier matches all resources of attribute background. If the –borderwidth option is used, the stored resource specifier applies only to border width attributes of class TopLevelShell (that is, outer-most windows, including pop-up windows). If the –title option is used to set a window name, only the topmost application windows receive the resource.

When parsing the command line, any unique unambiguous abbreviation for an option name in the table is considered a match for the option. Note that uppercase and lowercase matter.

10.12. Using the Context Manager

The context manager provides a way of associating data with a window in your program. Note that this is local to your program; the data is not stored in the server on a property list. Any amount of data in any number of pieces can be associated with a window, and each piece of data has a type associated with it. The context manager requires knowledge of the window and type to store or retrieve data.

Essentially, the context manager can be viewed as a two-dimensional, sparse array: one dimension is subscripted by the window and the other by a context type field. Each entry in the array contains a pointer to the data. Xlib provides context management functions with which you can save data values, get data values, delete entries, and create a unique context type. The symbols used are in **<X11/Xutil.h>**.

To save a data value that corresponds to a window and context type, use **XSaveContext**.

```
int XSaveContext(display, w, context, data)
      Display *display;
      Window w;
      XContext context;
      caddr_t data;
```

display	Specifies the connection to the X server.
w	Specifies the window with which the data is associated.
context	Specifies the context type to which the data belongs.
data	Specifies the data to be associated with the window and type.

If an entry with the specified window and type already exists, **XSaveContext** overrides it with the specified context. The **XSaveContext** function returns a nonzero error code if an error has occurred and zero otherwise. Possible errors are **XCNOMEM** (out of memory).

To get the data associated with a window and type, use **XFindContext**.

```
int XFindContext(display, w, context, data_return)
      Display *display;
      Window w;
      XContext context;
      caddr_t *data_return;
```

display	Specifies the connection to the X server.
w	Specifies the window with which the data is associated.
context	Specifies the context type to which the data belongs.

data_return Returns a pointer to the data.

Because it is a return value, the data is a pointer. The **XFindContext** function returns a nonzero error code if an error has occurred and zero otherwise. Possible errors are **XCNOENT** (context-not-found).

To delete an entry for a given window and type, use **XDeleteContext**.

```
int XDeleteContext(display, w, context)
      Display *display;
      Window w;
      XContext context;
```

display Specifies the connection to the X server.

w Specifies the window with which the data is associated.

context Specifies the context type to which the data belongs.

The **XDeleteContext** function deletes the entry for the given window and type from the data structure. This function returns the same error codes that **XFindContext** returns if called with the same arguments. **XDeleteContext** does not free the data whose address was saved.

To create a unique context type that may be used in subsequent calls to **XSaveContext** and **XFindContext**, use **XUniqueContext**.

```
XContext XUniqueContext()
```

Appendix A

Xlib Functions and Protocol Requests

This appendix provides two tables that relate to Xlib functions and the X protocol. The following table lists each Xlib function (in alphabetical order) and the corresponding protocol request that it generates.

Xlib Function	Protocol Request
XActivateScreenSaver	ForceScreenSaver
XAddHost	ChangeHosts
XAddHosts	ChangeHosts
XAddToSaveSet	ChangeSaveSet
XAllocColor	AllocColor
XAllocColorCells	AllocColorCells
XAllocColorPlanes	AllocColorPlanes
XAllocNamedColor	AllocNamedColor
XAllowEvents	AllowEvents
XAutoRepeatOff	ChangeKeyboardControl
XAutoRepeatOn	ChangeKeyboardControl
XBell	Bell
XChangeActivePointerGrab	ChangeActivePointerGrab
XChangeGC	ChangeGC
XChangeKeyboardControl	ChangeKeyboardControl
XChangeKeyboardMapping	ChangeKeyboardMapping
XChangePointerControl	ChangePointerControl
XChangeProperty	ChangeProperty
XChangeSaveSet	ChangeSaveSet
XChangeWindowAttributes	ChangeWindowAttributes
XCirculateSubwindows	CirculateWindow
XCirculateSubwindowsDown	CirculateWindow
XCirculateSubwindowsUp	CirculateWindow
XClearArea	ClearArea
XClearWindow	ClearArea
XConfigureWindow	ConfigureWindow
XConvertSelection	ConvertSelection
XCopyArea	CopyArea
XCopyColormapAndFree	CopyColormapAndFree
XCopyGC	CopyGC
XCopyPlane	CopyPlane
XCreateBitmapFromData	CreateGC
	CreatePixmap
	FreeGC
	PutImage
XCreateColormap	CreateColormap
XCreateFontCursor	CreateGlyphCursor
XCreateGC	CreateGC
XCreateGlyphCursor	CreateGlyphCursor
XCreatePixmap	CreatePixmap
XCreatePixmapCursor	CreateCursor

Xlib Function	Protocol Request
XCreatePixmapFromData	CreateGC
	CreatePixmap
	FreeGC
	PutImage
XCreateSimpleWindow	CreateWindow
XCreateWindow	CreateWindow
XDefineCursor	ChangeWindowAttributes
XDeleteProperty	DeleteProperty
XDestroySubwindows	DestroySubwindows
XDestroyWindow	DestroyWindow
XDisableAccessControl	SetAccessControl
XDrawArc	PolyArc
XDrawArcs	PolyArc
XDrawImageString	ImageText8
XDrawImageString16	ImageText16
XDrawLine	PolySegment
XDrawLines	PolyLine
XDrawPoint	PolyPoint
XDrawPoints	PolyPoint
XDrawRectangle	PolyRectangle
XDrawRectangles	PolyRectangle
XDrawSegments	PolySegment
XDrawString	PolyText8
XDrawString16	PolyText16
XDrawText	PolyText8
XDrawText16	PolyText16
XEnableAccessControl	SetAccessControl
XFetchBytes	GetProperty
XFetchName	GetProperty
XFillArc	PolyFillArc
XFillArcs	PolyFillArc
XFillPolygon	FillPoly
XFillRectangle	PolyFillRectangle
XFillRectangles	PolyFillRectangle
XForceScreenSaver	ForceScreenSaver
XFreeColormap	FreeColormap
XFreeColors	FreeColors
XFreeCursor	FreeCursor
XFreeFont	CloseFont
XFreeGC	FreeGC
XFreePixmap	FreePixmap
XGetAtomName	GetAtomName
XGetFontPath	GetFontPath
XGetGeometry	GetGeometry
XGetIconSizes	GetProperty
XGetImage	GetImage
XGetInputFocus	GetInputFocus
XGetKeyboardControl	GetKeyboardControl
XGetKeyboardMapping	GetKeyboardMapping
XGetModifierMapping	GetModifierMapping
XGetMotionEvents	GetMotionEvents
XGetModifierMapping	GetModifierMapping

Xlib Function	Protocol Request
XGetNormalHints	GetProperty
XGetPointerControl	GetPointerControl
XGetPointerMapping	GetPointerMapping
XGetScreenSaver	GetScreenSaver
XGetSelectionOwner	GetSelectionOwner
XGetSizeHints	GetProperty
XGetWMHints	GetProperty
XGetWindowAttributes	GetWindowAttributes
	GetGeometry
XGetWindowProperty	GetProperty
XGetZoomHints	GetProperty
XGrabButton	GrabButton
XGrabKey	GrabKey
XGrabKeyboard	GrabKeyboard
XGrabPointer	GrabPointer
XGrabServer	GrabServer
XInitExtension	QueryExtension
XInstallColormap	InstallColormap
XInternAtom	InternAtom
XKillClient	KillClient
XListExtensions	ListExtensions
XListFonts	ListFonts
XListFontsWithInfo	ListFontsWithInfo
XListHosts	ListHosts
XListInstalledColormaps	ListInstalledColormaps
XListProperties	ListProperties
XLoadFont	OpenFont
XLoadQueryFont	OpenFont
	QueryFont
XLookupColor	LookupColor
XLowerWindow	ConfigureWindow
XMapRaised	ConfigureWindow
	MapWindow
XMapSubwindows	MapSubwindows
XMapWindow	MapWindow
XMoveResizeWindow	ConfigureWindow
XMoveWindow	ConfigureWindow
XNoOp	NoOperation
XOpenDisplay	CreateGC
XParseColor	LookupColor
XPutImage	PutImage
XQueryBestCursor	QueryBestSize
XQueryBestSize	QueryBestSize
XQueryBestStipple	QueryBestSize
XQueryBestTile	QueryBestSize
XQueryColor	QueryColors
XQueryColors	QueryColors
XQueryExtension	QueryExtension
XQueryFont	QueryFont
XQueryKeymap	QueryKeymap
XQueryPointer	QueryPointer
XQueryTextExtents	QueryTextExtents

Xlib Function	Protocol Request
XQueryTextExtents16	QueryTextExtents
XQueryTree	QueryTree
XRaiseWindow	ConfigureWindow
XReadBitmapFile	CreateGC
	CreatePixmap
	FreeGC
	PutImage
XRecolorCursor	RecolorCursor
XRemoveFromSaveSet	ChangeSaveSet
XRemoveHost	ChangeHosts
XRemoveHosts	ChangeHosts
XReparentWindow	ReparentWindow
XResetScreenSaver	ForceScreenSaver
XResizeWindow	ConfigureWindow
XRestackWindows	ConfigureWindow
XRotateBuffers	RotateProperties
XRotateWindowProperties	RotateProperties
XSelectInput	ChangeWindowAttributes
XSendEvent	SendEvent
XSetAccessControl	SetAccessControl
XSetArcMode	ChangeGC
XSetBackground	ChangeGC
XSetClipMask	ChangeGC
XSetClipOrigin	ChangeGC
XSetClipRectangles	SetClipRectangles
XSetCloseDownMode	SetCloseDownMode
XSetCommand	ChangeProperty
XSetDashes	SetDashes
XSetFillRule	ChangeGC
XSetFillStyle	ChangeGC
XSetFont	ChangeGC
XSetFontPath	SetFontPath
XSetForeground	ChangeGC
XSetFunction	ChangeGC
XSetGraphicsExposures	ChangeGC
XSetIconName	ChangeProperty
XSetIconSizes	ChangeProperty
XSetInputFocus	SetInputFocus
XSetLineAttributes	ChangeGC
XSetModifierMapping	SetModifierMapping
XSetNormalHints	ChangeProperty
XSetPlaneMask	ChangeGC
XSetPointerMapping	SetPointerMapping
XSetScreenSaver	SetScreenSaver
XSetSelectionOwner	SetSelectionOwner
XSetSizeHints	ChangeProperty
XSetStandardProperties	ChangeProperty
XSetState	ChangeGC
XSetStipple	ChangeGC
XSetSubwindowMode	ChangeGC
XSetTile	ChangeGC
XSetTSOrigin	ChangeGC

Xlib Function	Protocol Request
XSetWMHints	ChangeProperty
XSetWindowBackground	ChangeWindowAttributes
XSetWindowBackgroundPixmap	ChangeWindowAttributes
XSetWindowBorder	ChangeWindowAttributes
XSetWindowBorderPixmap	ChangeWindowAttributes
XSetWindowBorderWidth	ConfigureWindow
XSetWindowColormap	ChangeWindowAttributes
XSetZoomHints	ChangeProperty
XStoreBuffer	ChangeProperty
XStoreBytes	ChangeProperty
XStoreColor	StoreColors
XStoreColors	StoreColors
XStoreName	ChangeProperty
XStoreNamedColor	StoreNamedColor
XSync	GetInputFocus
XTranslateCoordinates	TranslateCoordinates
XUndefineCursor	ChangeWindowAttributes
XUngrabButton	UngrabButton
XUngrabKey	UngrabKey
XUngrabKeyboard	UngrabKeyboard
XUngrabPointer	UngrabPointer
XUngrabServer	UngrabServer
XUninstallColormap	UninstallColormap
XUnloadFont	CloseFont
XUnmapSubwindows	UnmapSubwindows
XUnmapWindow	UnmapWindow
XWarpPointer	WarpPointer

The following table lists each X protocol request (in alphabetical order) and the Xlib functions that reference it.

Protocol Request	Xlib Function
AllocColor	XAllocColor
AllocColorCells	XAllocColorCells
AllocColorPlanes	XAllocColorPlanes
AllocNamedColor	XAllocNamedColor
AllowEvents	XAllowEvents
Bell	XBell
SetAccessControl	XDisableAccessControl
	XEnableAccessControl
	XSetAccessControl
ChangeActivePointerGrab	XChangeActivePointerGrab
SetCloseDownMode	XSetCloseDownMode
ChangeGC	XChangeGC
	XSetArcMode
	XSetBackground
	XSetClipMask
	XSetClipOrigin
	XSetFillRule
	XSetFillStyle
	XSetFont
	XSetForeground
	XSetFunction
	XSetGraphicsExposures
	XSetLineAttributes
	XSetPlaneMask
	XSetState
	XSetStipple
	XSetSubwindowMode
	XSetTile
	XSetTSOrigin
ChangeHosts	XAddHost
	XAddHosts
	XRemoveHost
	XRemoveHosts
ChangeKeyboardControl	XAutoRepeatOff
	XAutoRepeatOn
	XChangeKeyboardControl
ChangeKeyboardMapping	XChangeKeyboardMapping
ChangePointerControl	XChangePointerControl
ChangeProperty	XChangeProperty
	XSetCommand
	XSetIconName
	XSetIconSizes
	XSetNormalHints
	XSetSizeHints
	XSetStandardProperties
	XSetWMHints
	XSetZoomHints
	XStoreBuffer
	XStoreBytes

Protocol Request	Xlib Function
	XStoreName
ChangeSaveSet	XAddToSaveSet
	XChangeSaveSet
	XRemoveFromSaveSet
ChangeWindowAttributes	XChangeWindowAttributes
	XDefineCursor
	XSelectInput
	XSetWindowBackground
	XSetWindowBackgroundPixmap
	XSetWindowBorder
	XSetWindowBorderPixmap
	XSetWindowColormap
	XUndefineCursor
CirculateWindow	XCirculateSubwindowsDown
	XCirculateSubwindowsUp
	XCirculateSubwindows
ClearArea	XClearArea
	XClearWindow
CloseFont	XFreeFont
	XUnloadFont
ConfigureWindow	XConfigureWindow
	XLowerWindow
	XMapRaised
	XMoveResizeWindow
	XMoveWindow
	XRaiseWindow
	XResizeWindow
	XRestackWindows
	XSetWindowBorderWidth
ConvertSelection	XConvertSelection
CopyArea	XCopyArea
CopyColormapAndFree	XCopyColormapAndFree
CopyGC	XCopyGC
CopyPlane	XCopyPlane
CreateColormap	XCreateColormap
CreateCursor	XCreatePixmapCursor
CreateGC	XCreateGC
	XCreateBitmapFromData
	XCreatePixmapFromData
	XOpenDisplay
	XReadBitmapFile
CreateGlyphCursor	XCreateFontCursor
	XCreateGlyphCursor
CreatePixmap	XCreatePixmap
	XCreateBitmapFromData
	XCreatePixmapFromData
	XReadBitmapFile
CreateWindow	XCreateSimpleWindow
	XCreateWindow
DeleteProperty	XDeleteProperty
DestroySubwindows	XDestroySubwindows
DestroyWindow	XDestroyWindow

Protocol Request	Xlib Function
FillPoly	XFillPolygon
ForceScreenSaver	XActivateScreenSaver
	XForceScreenSaver
	XResetScreenSaver
FreeColormap	XFreeColormap
FreeColors	XFreeColors
FreeCursor	XFreeCursor
FreeGC	XFreeGC
	XCreateBitmapFromData
	XCreatePixmapFromData
	XReadBitmapFile
FreePixmap	XFreePixmap
GetAtomName	XGetAtomName
GetFontPath	XGetFontPath
GetGeometry	XGetGeometry
	XGetWindowAttributes
GetImage	XGetImage
GetInputFocus	XGetInputFocus
	XSync
GetKeyboardControl	XGetKeyboardControl
GetKeyboardMapping	XGetKeyboardMapping
GetModifierMapping	XGetModifierMapping
GetMotionEvents	XGetMotionEvents
GetPointerControl	XGetPointerControl
GetPointerMapping	XGetPointerMapping
GetProperty	XFetchBytes
	XFetchName
	XGetIconSizes
	XGetNormalHints
	XGetSizeHints
	XGetWMHints
	XGetWindowProperty
	XGetZoomHints
GetSelectionOwner	XGetSelectionOwner
GetWindowAttributes	XGetWindowAttributes
GrabButton	XGrabButton
GrabKey	XGrabKey
GrabKeyboard	XGrabKeyboard
GrabPointer	XGrabPointer
GrabServer	XGrabServer
ImageText16	XDrawImageString16
ImageText8	XDrawImageString
InstallColormap	XInstallColormap
InternAtom	XInternAtom
KillClient	XKillClient
ListExtensions	XListExtensions
ListFonts	XListFonts
ListFontsWithInfo	XListFontsWithInfo
ListHosts	XListHosts
ListInstalledColormaps	XListInstalledColormaps
ListProperties	XListProperties
LookupColor	XLookupColor

Protocol Request	Xlib Function
	XParseColor
MapSubwindows	XMapSubwindows
MapWindow	XMapRaised
	XMapWindow
NoOperation	XNoOp
OpenFont	XLoadFont
	XLoadQueryFont
PolyArc	XDrawArc
	XDrawArcs
PolyFillArc	XFillArc
	XFillArcs
PolyFillRectangle	XFillRectangle
	XFillRectangles
PolyLine	XDrawLines
PolyPoint	XDrawPoint
	XDrawPoints
PolyRectangle	XDrawRectangle
	XDrawRectangles
PolySegment	XDrawLine
	XDrawSegments
PolyText16	XDrawString16
	XDrawText16
PolyText8	XDrawString
	XDrawText
PutImage	XPutImage
	XCreateBitmapFromData
	XCreatePixmapFromData
	XReadBitmapFile
QueryBestSize	XQueryBestCursor
	XQueryBestSize
	XQueryBestStipple
	XQueryBestTile
QueryColors	XQueryColor
	XQueryColors
QueryExtension	XInitExtension
	XQueryExtension
QueryFont	XLoadQueryFont
	XQueryFont
QueryKeymap	XQueryKeymap
QueryPointer	XQueryPointer
QueryTextExtents	XQueryTextExtents
	XQueryTextExtents16
QueryTree	XQueryTree
RecolorCursor	XRecolorCursor
ReparentWindow	XReparentWindow
RotateProperties	XRotateBuffers
	XRotateWindowProperties
SendEvent	XSendEvent
SetClipRectangles	XSetClipRectangles
SetCloseDownMode	XSetCloseDownMode
SetDashes	XSetDashes
SetFontPath	XSetFontPath

Protocol Request	Xlib Function
SetInputFocus	XSetInputFocus
SetModifierMapping	XSetModifierMapping
SetPointerMapping	XSetPointerMapping
SetScreenSaver	XGetScreenSaver
	XSetScreenSaver
SetSelectionOwner	XSetSelectionOwner
StoreColors	XStoreColor
	XStoreColors
StoreNamedColor	XStoreNamedColor
TranslateCoordinates	XTranslateCoordinates
UngrabButton	XUngrabButton
UngrabKey	XUngrabKey
UngrabKeyboard	XUngrabKeyboard
UngrabPointer	XUngrabPointer
UngrabServer	XUngrabServer
UninstallColormap	XUninstallColormap
UnmapSubwindows	XUnmapSubWindows
UnmapWindow	XUnmapWindow
WarpPointer	XWarpPointer

The following are the available cursors that can be used with **XCreateFontCursor**.

```
#define XC_X_cursor 0
#define XC_arrow 2
#define XC_based_arrow_down 4
#define XC_based_arrow_up 6
#define XC_boat 8
#define XC_bogosity 10
#define XC_bottom_left_corner 12
#define XC_bottom_right_corner 14
#define XC_bottom_side 16
#define XC_bottom_tee 18
#define XC_box_spiral 20
#define XC_center_ptr 22
#define XC_circle 24
#define XC_clock 26
#define XC_coffee_mug 28
#define XC_cross 30
#define XC_cross_reverse 32
#define XC_crosshair 34
#define XC_diamond_cross 36
#define XC_dot 38
#define XC_dot_box_mask 40
#define XC_double_arrow 42
#define XC_draft_large 44
#define XC_draft_small 46
#define XC_draped_box 48
#define XC_exchange 50
#define XC_fleur 52
#define XC_gobbler 54
#define XC_gumby 56
#define XC_hand 58
#define XC_hand1_mask 60
#define XC_heart 62
#define XC_icon 64
#define XC_iron_cross 66
#define XC_left_ptr 68
#define XC_left_side 70
#define XC_left_tee 72
#define XC_leftbutton 74
#define XC_ll_angle 76
#define XC_lr_angle 78
#define XC_man 80
#define XC_middlebutton 82
#define XC_mouse 84
#define XC_pencil 86
#define XC_pirate 88
#define XC_plus 90
#define XC_question_arrow 92
#define XC_right_ptr 94
#define XC_right_side 96
#define XC_right_tee 98
#define XC_rightbutton 100
#define XC_rtl_logo 102
#define XC_sailboat 104
#define XC_sb_down_arrow 106
#define XC_sb_h_double_arrow 108
#define XC_sb_left_arrow 110
#define XC_sb_right_arrow 112
#define XC_sb_up_arrow 114
#define XC_sb_v_double_arrow 116
#define XC_shuttle 118
#define XC_sizing 120
#define XC_spider 122
#define XC_spraycan 124
#define XC_star 126
#define XC_target 128
#define XC_tcross 130
#define XC_top_left_arrow 132
#define XC_top_left_corner 134
#define XC_top_right_corner 136
#define XC_top_side 138
#define XC_top_tee 140
#define XC_trek 142
#define XC_ul_angle 144
#define XC_umbrella 146
#define XC_ur_angle 148
#define XC_watch 150
#define XC_xterm 152
```

Appendix C

Extensions

Because X can evolve by extensions to the core protocol, it is important that extensions not be perceived as second class citizens. At some point, your favorite extensions may be adopted as additional parts of the X Standard.

Therefore, there should be little to distinguish the use of an extension from that of the core protocol. To avoid having to initialize extensions explicitly in application programs, it is also important that extensions perform "lazy evaluations" and automatically initialize themselves when called for the first time.

This appendix describes techniques for writing extensions to Xlib that will run at essentially the same performance as the core protocol requests.

Note

> It is expected that a given extension to X consists of multiple requests. Defining ten new features as ten separate extensions is a bad practice. Rather, they should be packaged into a single extension and should use minor opcodes to distinguish the requests.

The symbols and macros used for writing stubs to Xlib are listed in <**X11/Xlibint.h**>.

Basic Protocol Support Routines

The basic protocol requests for extensions are **XQueryExtension** and **XListExtensions**.

Bool XQueryExtension(*display, name, major_opcode_return, first_event_return, first_error_return*)
    Display **display*;
    char **name;*
    int **major_opcode_return*;
    int **first_event_return*;
    int **first_error_return*;

XQueryExtension determines if the named extension is present. If so, the major opcode for the extension is returned (if it has one); otherwise, **False** is returned. Any minor opcode and the request formats are specific to the extension. If the extension involves additional event types, the base event type code is returned; otherwise, **False** is returned. The format of the events is specific to the extension. If the extension involves additional error codes, the base error code is returned; otherwise, **False** is returned. The format of additional data in the errors is specific to the extension.

The extension name should be in the ISO Latin-1 encoding, and uppercase and lowercase do matter.

char **XListExtensions(*display, nextensions_return*)
    Display **display*;
    int **nextensions_return*;

XListExtensions returns a list of all extensions supported by the server.

XFreeExtensionList(*list*)
    char ***list*;

XFreeExtensionList frees the memory allocated by **XListExtensions**.

Hooking into Xlib

These functions allow you to hook into the library. They are not normally used by application programmers but are used by people who need to extend the core X protocol and the X library interface. The functions, which generate protocol requests for X, are typically called stubs.

In extensions, stubs first should check to see if they have initialized themselves on a connection. If they have not, they then should call **XInitExtension** to attempt to initialize themselves on the connection.

If the extension needs to be informed of GC/font allocation or deallocation or if the extension defines new event types, the functions described here allow the extension to be called when these events occur.

The **XExtCodes** structure returns the information from **XInitExtension** and is defined in **<X11/Xlib.h>**:

```
typedef struct _XExtCodes {          /* public to extension, cannot be changed */
        int extension;               /* extension number */
        int major_opcode;            /* major op-code assigned by server */
        int first_event;             /* first event number for the extension */
        int first_error;             /* first error number for the extension */
} XExtCodes;
```

```
XExtCodes *XInitExtension(display, name)
      Display *display;
      char *name;
```

XInitExtension determines if the extension exists. Then, it allocates storage for maintaining the information about the extension on the connection, chains this onto the extension list for the connection, and returns the information the stub implementor will need to access the extension. If the extension does not exist, **XInitExtension** returns NULL.

In particular, the extension number in the **XExtCodes** structure is.needed in the other calls that follow. This extension number is unique only to a single connection.

```
XExtCodes *XAddExtension(display)
      Display *display;
```

For local Xlib extensions, **XAddExtension** allocates the **XExtCodes** structure, bumps the extension number count, and chains the extension onto the extension list. (This permits extensions to Xlib without requiring server extensions.)

Hooks into the Library

These functions allow you to define procedures that are to be called when various circumstances occur. The procedures include the creation of a new GC for a connection, the copying of a GC, the freeing a GC, the creating and freeing of fonts, the conversion of events defined by extensions to and from wire format, and the handling of errors.

All of these functions return the previous routine defined for this extension.

```
int (*XESetCloseDisplay(display, extension, proc))()
      Display *display;              /* display */
      int extension;                 /* extension number */
      int (*proc)();                 /* routine to call when display closed */
```

You use this procedure to define a procedure to be called whenever **XCloseDisplay** is called. This procedure returns any previously defined procedure, usually NULL.

When **XCloseDisplay** is called, your routine is called with these arguments:

```
(*proc)(display, codes)
      Display *display;
```

```
        XExtCodes *codes;

int (*XESetCreateGC( display, extension, proc))( )
    Display *display;                  /* display */
    int extension;                     /* extension number */
    int (*proc)( );                    /* routine to call when GC created */
```

You use this procedure to define a procedure to be called whenever a new GC is created. This procedure returns any previously defined procedure, usually NULL.

When a GC is created, your routine is called with these arguments:

```
(*proc)(display, gc, codes)
        Display *display;
        GC gc;
        XExtCodes *codes;

int (*XESetCopyGC( display, extension, proc))( )
    Display *display;                  /* display */
    int extension;                     /* extension number */
    int (*proc)( );                    /* routine to call when GC copied */
```

You use this procedure to define a procedure to be called whenever a GC is copied. This procedure returns any previously defined procedure, usually NULL.

When a GC is copied, your routine is called with these arguments:

```
(*proc)(display, gc, codes)
        Display *display;
        GC gc;
        XExtCodes *codes;

int (*XESetFreeGC( display, extension, proc))( )
    Display *display;                  /* display */
    int extension;                     /* extension number */
    int (*proc)( );                    /* routine to call when GC freed */
```

You use this procedure to define a procedure to be called whenever a GC is freed. This procedure returns any previously defined procedure, usually NULL.

When a GC is freed, your routine is called with these arguments:

```
(*proc)(display, gc, codes)
        Display *display;
        GC gc;
        XExtCodes *codes;

int (*XESetCreateFont( display, extension, proc))( )
    Display *display;                  /* display */
    int extension;                     /* extension number */
    int (*proc)( );                    /* routine to call when font created */
```

You use this procedure to define a procedure to be called whenever **XLoadQueryFont** and **XQueryFont** are called. This procedure returns any previously defined procedure, usually NULL.

When **XLoadQueryFont** or **XQueryFont** is called, your routine is called with these arguments:

```
(*proc)(display, fs, codes)
        Display *display;
        XFontStruct *fs;
        XExtCodes *codes;
```

```
int (*XESetFreeFont( display, extension, proc))( )
      Display *display;                    /* display */
      int extension;                       /* extension number */
      int (*proc)( );                      /* routine to call when font freed */
```

You use this procedure to define a procedure to be called whenever **XFreeFont** is called. This procedure returns any previously defined procedure, usually NULL.

When **XFreeFont** is called, your routine is called with these arguments:

```
(*proc)(display, fs, codes)
        Display *display;
        XFontStruct *fs;
        XExtCodes *codes;
```

The next two functions allow you to define new events to the library.

Note

> There is an implementation limit such that your host event structure size cannot be bigger than the size of the **XEvent** union of structures. There also is no way to guarantee that more than 24 elements or 96 characters in the structure will be fully portable between machines.

```
int (*XESetWireToEvent( display, event_number, proc))( )
      Display *display;                    /* display */
      int event_number;                    /* event routine to replace */
      Bool (*proc)( );                     /* routine to call when converting event */
```

You use this procedure to define a procedure to be called when an event needs to be converted from wire format (**xEvent**) to host format (**XEvent**). The event number defines which protocol event number to install a conversion routine for. This procedure returns any previously defined procedure.

Note

> You can replace a core event conversion routine with one of your own, although this is not encouraged. It would, however, allow you to intercept a core event and modify it before being placed in the queue or otherwise examined.

When Xlib needs to convert an event from wire format to host format, your routine is called with these arguments:

```
Status (*proc)(display, re, event)
        Display *display;
        XEvent *re;
        xEvent *event;
```

Your routine must return status to indicate if the conversion succeeded. The re argument is a pointer to where the host format event should be stored, and the event argument is the 32-byte wire event structure. In the **XEvent** structure you are creating, type must be the first member and window must be the second member. You should fill in the type member with the type specified for the **xEvent** structure. You should copy all other members from the **xEvent** structure (wire format) to the **XEvent** structure (host format). Your conversion routine should return **True** if the event should be placed in the queue or **False** if it should not be placed in the queue.

```
Status (*XESetEventToWire( display, event_number, proc))( )
      Display *display;                    /* display */
      int event_number;                    /* event routine to replace */
      int (*proc)( );                      /* routine to call when converting event */
```

You use this procedure to define a procedure to be called when an event needs to be converted from host format (**XEvent**) to wire format (**xEvent**) form. The event number defines which protocol event number to install a conversion routine for. This procedure returns any previously defined procedure. It returns zero if the conversion fails or nonzero otherwise.

Note

> You can replace a core event conversion routine with one of your own, although this is not encouraged. It would, however, allow you to intercept a core event and modify it before being sent to another client.

When Xlib needs to convert an event from wire format to host format, your routine is called with these arguments:

```
(*proc)(display, re, event)
        Display *display;
        XEvent *re;
        xEvent *event;
```

The re argument is a pointer to the host format event, and the event argument is a pointer to where the 32-byte wire event structure should be stored. In the **XEvent** structure that you are forming, you must have "type" as the first member and "window" as the second. You then should fill in the type with the type from the **xEvent** structure. All other members then should be copied from the wire format to the **XEvent** structure.

```
int (*XESetError( display, extension, proc))()
     Display *display;                  /* display */
     int extension;                     /* extension number */
     int (*proc)();                     /* routine to call when X error happens */
```

Inside Xlib, there are times that you may want to suppress the calling of the external error handling when an error occurs. This allows status to be returned on a call at the cost of the call being synchronous (though most such routines are query operations, in any case, and are typically programmed to be synchronous).

When Xlib detects a protocol error in **_XReply**, it calls your procedure with these arguments:

```
int (*proc)(display, err, codes, ret_code)
        Display *display;
        xError *err;
        XExtCodes *codes;
        int *ret_code;
```

The err argument is a pointer to the 32-byte wire format error. The codes argument is a pointer to the extension codes structure. The ret_code argument is the return code you may want **_XReply** returned to.

If your routine returns a zero value, the error is not suppressed, and the client's error handler is called. (For further information, see section 8.12.2.) If your routine returns nonzero, the error is suppressed, and **_XReply** returns the value of ret_code.

```
char *(*XESetErrorString( display, extension, proc))()
     Display *display;                  /* display */
     int extension;                     /* extension number */
     char *(*proc)();                   /* routine to call to obtain an error string */
```

The **XGetErrorText** function returns a string to the user for an error. **XESetErrorString** allows you to define a routine to be called that should return a pointer to the error message. The following is an example.

```
(*proc)(display, code, codes, buffer, nbytes)
        Display *display;
```

```
        int code;
        XExtCodes *codes;
        char *buffer;
        int nbytes;
```

Your procedure is called with the error code for every error detected. You should copy nbytes of a null-terminated string containing the error message into buffer.

```
int (*XESetFlushGC( display, extension, proc ))( )
     Display *display;                         /* display */
     int extension;                            /* extension number */
     char *(*proc)( );                         /* routine to call when I/O error happens */
```

The **XESetFlushGC** procedure is identical to **XESetCopyGC** except that **XESetFlushGC** is called when a GC cache needs to be updated in the server.

Hooks onto Xlib Data Structures

Various Xlib data structures have provisions for extension routines to chain extension supplied data onto a list. These structures are **GC**, **Visual**, **Screen**, **ScreenFormat**, **Display**, and **XFontStruct**. Because the list pointer is always the first member in the structure, a single set of routines can be used to manipulate the data on these lists.

The following structure is used in the routines in this section and is defined in <**X11/Xlib.h**>:

```
typedef struct _XExtData {
        int number;                 /* number returned by XInitExtension */
        struct _XExtData *next;     /* next item on list of data for structure */
        int (*free)();              /* if defined, called to free private */
        char *private;              /* data private to this extension. */
} XExtData;
```

When any of the data structures listed above are freed, the list is walked, and the structure's free routine (if any) is called. If free is NULL, then the library frees both the data pointed to by the private member and the structure itself.

```
union { Display *display;
        GC gc;
        Visual *visual;
        Screen *screen;
        ScreenFormat *pixmap_format;
        XFontStruct *font } XEDataObject;
```

```
XExtData **XEHeadOfExtensionList(object)
        XEDataObject object;
```

XEHeadOfExtensionList returns a pointer to the list of extension structures attached to the specified object. In concert with **XAddToExtensionList**, **XEHeadOfExtensionList** allows an extension to attach arbitrary data to any of the structures of types contained in **XEDataObject**.

```
XAddToExtensionList( structure, ext_data )
     struct _XExtData **structure;             /* pointer to structure to add */
     XExtData *ext_data;                       /* extension data structure to add */
```

The structure argument is a pointer to one of the data structures enumerated above. You must initialize ext_data->number with the extension number before calling this routine.

```
XExtData *XFindOnExtensionList( structure, number )
     struct _XExtData **structure;
     int number;                               /* extension number from XInitExtension */
```

XFindOnExtensionList returns the first extension data structure for the extension numbered number. It is expected that an extension will add at most one extension data structure to any single data structure's extension data list. There is no way to find additional structures.

The **XAllocID** macro, which allocates and returns a resource ID, is defined in **<X11/Xlib.h>**.

```
XAllocID(display)
    Display *display;
```

This macro is a call through the **Display** structure to the internal resource ID allocator. It returns a resource ID that you can use when creating new resources.

GC Caching

GCs are cached by the library to allow merging of independent change requests to the same GC into single protocol requests. This is typically called a write-back cache. Any extension routine whose behavior depends on the contents of a GC must flush the GC cache to make sure the server has up-to-date contents in its GC.

The **FlushGC** macro checks the dirty bits in the library's GC structure and calls **_XFlushGCCache** if any elements have changed. The **FlushGC** macro is defined as follows:

```
FlushGC(display, gc)
    Display *display;
    GC gc;
```

Note that if you extend the GC to add additional resource ID components, you should ensure that the library stub sends the change request immediately. This is because a client can free a resource immediately after using it, so if you only stored the value in the cache without forcing a protocol request, the resource might be destroyed before being set into the GC. You can use the **_XFlushGCCache** procedure to force the cache to be flushed. The **_XFlushGCCache** procedure is defined as follows:

```
_XFlushGCCache(display, gc)
    Display *display;
    GC gc;
```

Graphics Batching

If you extend X to add more poly graphics primitives, you may be able to take advantage of facilities in the library to allow back-to-back single calls to be transformed into poly requests. This may dramatically improve performance of programs that are not written using poly requests. A pointer to an **xReq**, called last_req in the display structure, is the last request being processed. By checking that the last request type, drawable, gc, and other options are the same as the new one and that there is enough space left in the buffer, you may be able to just extend the previous graphics request by extending the length field of the request and appending the data to the buffer. This can improve performance by five times or more in naive programs. For example, here is the source for the **XDrawPoint** stub. (Writing extension stubs is discussed in the next section.)

```
#include "copyright.h"

#include "Xlibint.h"

/* precompute the maximum size of batching request allowed */

static int size = sizeof(xPolyPointReq) + EPERBATCH * sizeof(xPoint);

XDrawPoint(dpy, d, gc, x, y)
    register Display *dpy;
    Drawable d;
    GC gc;
```

```
        int x, y; /* INT16 */
    {
        xPoint *point;
        LockDisplay(dpy);
        FlushGC(dpy, gc);
        {
        register xPolyPointReq *req = (xPolyPointReq *) dpy->last_req;
        /* if same as previous request, with same drawable, batch requests */
        if (
              (req->reqType == X_PolyPoint)
           && (req->drawable == d)
           && (req->gc == gc->gid)
           && (req->coordMode == CoordModeOrigin)
           && ((dpy->bufptr + sizeof (xPoint)) <= dpy->bufmax)
           && (((char *)dpy->bufptr - (char *)req) < size) ) {
             point = (xPoint *) dpy->bufptr;
             req->length += sizeof (xPoint) >> 2;
             dpy->bufptr += sizeof (xPoint);
             }

        else {
            GetReqExtra(PolyPoint, 4, req); /* 1 point = 4 bytes */
            req->drawable = d;
            req->gc = gc->gid;
            req->coordMode = CoordModeOrigin;
            point = (xPoint *) (req + 1);
            }
        point->x = x;
        point->y = y;
        }
        UnlockDisplay(dpy);
        SyncHandle();
    }
```

To keep clients from generating very long requests that may monopolize the server, there is a symbol defined in <**X11/Xlibint.h**> of EPERBATCH on the number of requests batched. Most of the performance benefit occurs in the first few merged requests. Note that **FlushGC** is called *before* picking up the value of last_req, because it may modify this field.

Writing Extension Stubs

All X requests always contain the length of the request, expressed as a 16-bit quantity of 32 bits. This means that a single request can be no more than 256K bytes in length. Some servers may not support single requests of such a length. The value of dpy->max_request_size contains the maximum length as defined by the server implementation. For further information, see "X Window System Protocol".

Requests, Replies, and Xproto.h

The <**X11/Xproto.h**> file contains three sets of definitions that are of interest to the stub implementor: request names, request structures, and reply structures.

You need to generate a file equivalent to <**X11/Xproto.h**> for your extension and need to include it in your stub routine. Each stub routine also must include <**X11/Xlibint.h**>.

The identifiers are deliberately chosen in such a way that, if the request is called X_DoSomething, then its request structure is xDoSomethingReq, and its reply is xDoSomethingReply. The GetReq family of macros, defined in <**X11/Xlibint.h**>, takes advantage of this naming scheme.

For each X request, there is a definition in <**X11/Xproto.h**> that looks similar to this:

```
#define X_DoSomething   42
```

In your extension header file, this will be a minor opcode, instead of a major opcode.

Request Format

Every request contains an 8-bit major opcode and a 16-bit length field expressed in units of four bytes. Every request consists of four bytes of header (containing the major opcode, the length field, and a data byte) followed by zero or more additional bytes of data. The length field defines the total length of the request, including the header. The length field in a request must equal the minimum length required to contain the request. If the specified length is smaller or larger than the required length, the server should generate a **BadLength** error. Unused bytes in a request are not required to be zero.

```
long XMaxRequestSize(display)
        Display *display;
```

XMaxRequestSize returns the maximum request size (in 4-byte units) supported by the server. Single protocol requests to the server can be no longer than this size. Extensions should be designed in such a way that long protocol requests can be split up into smaller requests. The protocol guarantees the size to be no smaller than 4096 unit (16384 bytes).

Major opcodes 128 through 255 are reserved for extensions. Extensions are intended to contain multiple requests, so extension requests typically have an additional minor opcode encoded in the "spare" data byte in the request header, but the placement and interpretation of this minor opcode as well as all other fields in extension requests are not defined by the core protocol. Every request is implicitly assigned a sequence number (starting with one) used in replies, errors, and events.

To help but not cure portability problems to certain machines, the **B16** and **B32** macros have been defined so that they can become bitfield specifications on some machines. For example, on a Cray, these should be used for all 16-bit and 32-bit quantities, as discussed below.

Most protocol requests have a corresponding structure typedef in <**X11/Xproto.h**>, which looks like:

```
typedef struct _DoSomethingReq {
        CARD8 reqType;              /* X_DoSomething */
        CARD8 someDatum;            /* used differently in different requests */
        CARD16 length B16;          /* total # of bytes in request, divided by 4 */
        ...
        /* request-specific data */
        ...
} xDoSomethingReq;
```

If a core protocol request has a single 32-bit argument, you need not declare a request structure in your extension header file. Instead, such requests use <**X11/Xproto.h**>'s **xResourceReq** structure. This structure is used for any request whose single argument is a **Window**, **Pixmap**, **Drawable**, **GContext**, **Font**, **Cursor**, **Colormap**, **Atom**, or **VisualID**.

```
typedef struct _ResourceReq {
        CARD8 reqType;              /* the request type, e.g. X_DoSomething */
        BYTE pad;                   /* not used */
        CARD16 length B16;          /* 2 (= total # of bytes in request, divided by 4) */
        CARD32 id B32;              /* the Window, Drawable, Font, GContext, etc. */
} xResourceReq;
```

If convenient, you can do something similar in your extension header file.

In both of these structures, the reqType field identifies the type of the request (for example, X_MapWindow or X_CreatePixmap). The length field tells how long the request is in units of 4-byte longwords. This length includes both the request structure itself and any variable length data, such as strings or lists, that follow the request structure. Request structures come in different sizes, but all requests are padded to be multiples of four bytes long.

A few protocol requests take no arguments at all. Instead, they use <**X11/Xproto.h**>'s **xReq** structure, which contains only a reqType and a length (and a pad byte).

If the protocol request requires a reply, then <**X11/Xproto.h**> also contains a reply structure typedef:

```
typedef struct _DoSomethingReply {
        BYTE type;                        /* always X_Reply */
        BYTE someDatum;                   /* used differently in different requests */
        CARD16 sequenceNumber B16;        /* # of requests sent so far */
        CARD32 length B32;                /* # of additional bytes, divided by 4 */
        ...
        /* request-specific data */
        ...
} xDoSomethingReply;
```

Most of these reply structures are 32 bytes long. If there are not that many reply values, then they contain a sufficient number of pad fields to bring them up to 32 bytes. The length field is the total number of bytes in the request minus 32, divided by 4. This length will be nonzero only if:

- The reply structure is followed by variable length data such as a list or string.
- The reply structure is longer than 32 bytes.

Only **GetWindowAttributes**, **QueryFont**, **QueryKeymap**, and **GetKeyboardControl** have reply structures longer than 32 bytes in the core protocol.

A few protocol requests return replies that contain no data. <**X11/Xproto.h**> does not define reply structures for these. Instead, they use the **xGenericReply** structure, which contains only a type, length, and sequence number (and sufficient padding to make it 32 bytes long).

Starting to Write a Stub Routine

An Xlib stub routine should always start like this:

```
#include "Xlibint.h"

XDoSomething (arguments, ... )
/* argument declarations */
{

register XDoSomethingReq *req;
```

If the protocol request has a reply, then the variable declarations should include the reply structure for the request. The following is an example:

```
xDoSomethingReply rep;
```

Locking Data Structures

To lock the display structure for systems that want to support multithreaded access to a single display connection, each stub will need to lock its critical section. Generally, this section is the point from just before the appropriate GetReq call until all arguments to the call have been stored into the buffer. The precise instructions needed for this locking depend upon the machine architecture. Two calls, which are generally implemented as macros, have been provided.

```
LockDisplay(display)
    Display *display;

UnlockDisplay(display)
    Display *display;
```

Sending the Protocol Request and Arguments

After the variable declarations, a stub routine should call one of four macros defined in <**X11/Xlibint.h**>: **GetReq**, **GetReqExtra**, **GetResReq**, or **GetEmptyReq**. All of these macros take, as their first argument, the name of the protocol request as declared in <**X11/Xproto.h**> except with X_ removed. Each one declares a **Display** structure pointer, called dpy, and a pointer to a request structure, called req, which is of the appropriate type. The macro then appends the request structure to the output buffer, fills in its type and length field, and sets req to point to it.

If the protocol request has no arguments (for instance, X_GrabServer), then use **GetEmptyReq**.

```
GetEmptyReq (DoSomething);
```

If the protocol request has a single 32-bit argument (such as a **Pixmap**, **Window**, **Drawable**, **Atom**, and so on), then use **GetResReq**. The second argument to the macro is the 32-bit object. **X_MapWindow** is a good example.

```
GetResReq (DoSomething, rid);
```

The rid argument is the **Pixmap**, **Window**, or other resource ID.

If the protocol request takes any other argument list, then call **GetReq**. After the **GetReq**, you need to set all the other fields in the request structure, usually from arguments to the stub routine.

```
GetReq (DoSomething);
/* fill in arguments here */
req->arg1 = arg1;
req->arg2 = arg2;
```

A few stub routines (such as **XCreateGC** and **XCreatePixmap**) return a resource ID to the caller but pass a resource ID as an argument to the protocol request. Such routines use the macro **XAllocID** to allocate a resource ID from the range of IDs that were assigned to this client when it opened the connection.

```
rid = req->rid = XAllocID();
return (rid);
```

Finally, some stub routines transmit a fixed amount of variable length data after the request. Typically, these routines (such as **XMoveWindow** and **XSetBackground**) are special cases of more general functions like **XMoveResizeWindow** and **XChangeGC**. These special case routines use **GetReqExtra**, which is the same as **GetReq** except that it takes an additional argument (the number of extra bytes to allocate in the output buffer after the request structure). This number should always be a multiple of four.

Variable Length Arguments

Some protocol requests take additional variable length data that follow the **xDoSomethingReq** structure. The format of this data varies from request to request. Some requests require a sequence of 8-bit bytes, others a sequence of 16-bit or 32-bit entities, and still others a sequence of structures.

It is necessary to add the length of any variable length data to the length field of the request structure. That length field is in units of 32-bit longwords. If the data is a string or other sequence of 8-bit bytes, then you must round the length up and shift it before adding:

```
req->length += (nbytes+3)>>2;
```

To transmit variable length data, use the **Data** macros. If the data fits into the output buffer, then this macro copies it to the buffer. If it does not fit, however, the **Data** macro calls **_XSend**, which transmits first the contents of the buffer and then your data. The **Data** macros take three arguments: the Display, a pointer to the beginning of the data, and the number of bytes to be sent.

Data(*display*, (char *) *data*, *nbytes*);

Data16(*display*, (short *) *data*, *nbytes*);

Data32(*display*, (long *) *data*, *nbytes*);

Data, **Data16**, and **Data32** are macros that may use their last argument more than once, so that argument should be a variable rather than an expression such as "nitems*sizeof(item)". You should do that kind of computation in a separate statement before calling them. Use the appropriate macro when sending byte, short, or long data.

If the protocol request requires a reply, then call the procedure **_XSend** instead of the **Data** macro. **_XSend** takes the same arguments, but because it sends your data immediately instead of copying it into the output buffer (which would later be flushed anyway by the following call on **_XReply**), it is faster.

Replies

If the protocol request has a reply, then call **_XReply** after you have finished dealing with all the fixed and variable length arguments. **_XReply** flushes the output buffer and waits for an **xReply** packet to arrive. If any events arrive in the meantime, **_XReply** places them in the queue for later use.

```
Status _XReply(display, rep, extra, discard)
    Display *display;
    xReply *rep;
    int extra;                  /* number of 32-bit words expected after the reply */
    Bool discard;               /* should I discard data following "extra" words? */
```

_XReply waits for a reply packet and copies its contents into the specified rep. **_XReply** handles error and event packets that occur before the reply is received. **_XReply** takes four arguments:

- A **Display** * structure
- A pointer to a reply structure (which must be cast to an **xReply** *)
- The number of additional bytes (beyond sizeof(**xReply**) = 32 bytes) in the reply structure
- A Boolean that indicates whether **_XReply** is to discard any additional bytes beyond those it was told to read

Because most reply structures are 32 bytes long, the third argument is usually 0. The only core protocol exceptions are the replies to **GetWindowAttributes**, **QueryFont**, **QueryKeymap**, and **GetKeyboardControl**, which have longer replies.

The last argument should be **False** if the reply structure is followed by additional variable length data (such as a list or string). It should be **True** if there is not any variable length data.

Note

> This last argument is provided for upward-compatibility reasons to allow a client to communicate properly with a hypothetical later version of the server that sends more data than the client expected. For example, some later version of **GetWindowAttributes** might use a larger, but compatible, **xGetWindowAttributesReply** that contains additional attribute data at the end.

_XReply returns **True** if it received a reply successfully or **False** if it received any sort of error.

For a request with a reply that is not followed by variable length data, you write something like:

```
_XReply(display, (xReply *)&rep, 0, True);
*ret1 = rep.ret1;
*ret2 = rep.ret2;
*ret3 = rep.ret3;
UnlockDisplay(dpy);
SyncHandle();
return (rep.ret4);
}
```

If there is variable length data after the reply, change the **True** to **False**, and use the appropriate **_XRead** function to read the variable length data.

_XRead(*display*, *data*, *nbytes*)
    Display **display*;
    char **data*;
    long *nbytes*;

_XRead reads the specified number of bytes into data.

_XRead16(*display*, *data*, *nbytes*)
    Display **display*;
    short **data*;
    long *nbytes*;

_XRead16 reads the specified number of bytes, unpacking them as 16-bit quanities, into the specified array as shorts.

_XRead32(*display*, *data*, *nbytes*)
    Display **display*;
    long **data*;
    long *nbytes*;

_XRead32 reads the specified number of bytes, unpacking them as 32-bit quanities, into the specified array as longs.

_XRead16Pad(*display*, *data*, *nbytes*)
    Display **display*;
    short **data*;
    long *nbytes*;

_XRead16Pad reads the specified number of bytes, unpacking them as 16-bit quanities, into the specified array as shorts. If the number of bytes is not a multiple of four, **_XRead16Pad** reads up to three additional pad bytes.

```
_XReadPad(display, data, nbytes)
      Display *display;
      char *data;
      long nbytes;
```

_XReadPad reads the specified number of bytes into data. If the number of bytes is not a multiple of four, **_XReadPad** reads up to three additional pad bytes.

Each protocol request is a little different. For further information, see the Xlib sources for examples.

Synchronous Calling

To ease debugging, each routine should have a call, just before returning to the user, to a routine called **SyncHandle**. This routine generally is implemented as a macro. If synchronous mode is enabled (see **XSynchronize**), the request is sent immediately. The library, however, waits until any error the routine could generate at the server has been handled.

Allocating and Deallocating Memory

To support the possible reentry of these routines, you must observe several conventions when allocating and deallocating memory, most often done when returning data to the user from the window system of a size the caller could not know in advance (for example, a list of fonts or a list of extensions). The standard C library routines on many systems are not protected against signals or other multithreaded uses. The following analogies to standard I/O library routines have been defined:

Xmalloc()	Replaces malloc()
Xfree()	Replaces free()
Xcalloc()	Replaces calloc()

These should be used in place of any calls you would make to the normal C library routines.

If you need a single scratch buffer inside a critical section (for example, to pack and unpack data to and from the wire protocol),
the general memory allocators may be too expensive to use (particularly in output routines, which are performance critical). The routine below returns a scratch buffer for your use:

```
char *_XAllocScratch(display, nbytes)
     Display *display;
     unsigned long nbytes;
```

This storage must only be used inside of the critical section of your stub.

Portability Considerations

Many machine architectures, including many of the more recent RISC architectures, do not correctly access data at unaligned locations; their compilers pad out structures to preserve this characteristic. Many other machines capable of unaligned references pad inside of structures as well to preserve alignment, because accessing aligned data is usually much faster. Because the library and the server use structures to access data at arbitrary points in a byte stream, all data in request and reply packets *must* be naturally aligned; that is, 16-bit data starts on 16-bit boundaries in the request and 32-bit data on 32-bit boundaries. All requests *must* be a multiple of 32 bits in length to preserve the natural alignment in the data stream. You must pad structures out to 32-bit boundaries. Pad information does not have to be zeroed unless you want to preserve such fields for future use in your protocol requests. Floating point varies radically between machines and should be avoided completely if at all possible.

This code may run on machines with 16-bit ints. So, if any integer argument, variable, or return value either can take only nonnegative values or is declared as a CARD16 in the protocol, be sure to declare it as unsigned int and not as int. (This, of course, does not apply to Booleans or enumerations.)

Similarly, if any integer argument or return value is declared CARD32 in the protocol, declare it as an unsigned long and not as int or long. This also goes for any internal variables that may take on values larger than the maximum 16-bit unsigned int.

The library currently assumes that a char is 8 bits, a short is 16 bits, an int is 16 or 32 bits, and a long is 32 bits. The **PackData** macro is a half-hearted attempt to deal with the possibility of 32 bit shorts. However, much more work is needed to make this work properly.

Deriving the Correct Extension Opcode

The remaining problem a writer of an extension stub routine faces that the core protocol does not face is to map from the call to the proper major and minor opcodes. While there are a number of strategies, the simplest and fastest is outlined below.

1. Declare an array of pointers, _NFILE long (this is normally found in <**stdio.h**> and is the number of file descriptors supported on the system) of type **XExtCodes**. Make sure these are all initialized to NULL.
2. When your stub is entered, your initialization test is just to use the display pointer passed in to access the file descriptor and an index into the array. If the entry is NULL, then this is the first time you are entering the routine for this display. Call your initialization routine and pass it to the display pointer.
3. Once in your initialization routine, call **XInitExtension**; if it succeeds, store the pointer returned into this array. Make sure to establish a close display handler to allow you to zero the entry. Do whatever other initialization your extension requires. (For example, install event handlers and so on). Your initialization routine would normally return a pointer to the **XExtCodes** structure for this extension, which is what would normally be found in your array of pointers.
4. After returning from your initialization routine, the stub can now continue normally, because it has its major opcode safely in its hand in the **XExtCodes** structure.

Appendix D

Version 10 Compatibility Functions

Drawing and Filling Polygons and Curves

Xlib provides functions that you can use to draw or fill arbitrary polygons or curves. These functions are provided mainly for compatibility with X10 and have no server support. That is, they call other Xlib functions, not the server directly. Thus, if you just have straight lines to draw, using **XDrawLines** or **XDrawSegments** is much faster.

The functions discussed here provide all the functionality of the X10 functions **XDraw**, **XDrawFilled**, **XDrawPatterned**, **XDrawDashed**, and **XDrawTiled**. They are as compatible as possible given X11's new line drawing functions. One thing to note, however, is that **VertexDrawLastPoint** is no longer supported. Also, the error status returned is the opposite of what it was under X10 (this is the X11 standard error status). **XAppendVertex** and **XClearVertexFlag** from X10 also are not supported.

Just how the graphics context you use is set up actually determines whether you get dashes or not, and so on. Lines are properly joined if they connect and include the closing of a closed figure (see **XDrawLines**). The functions discussed here fail (return zero) only if they run out of memory or are passed a **Vertex** list that has a **Vertex** with **VertexStartClosed** set that is not followed by a **Vertex** with **VertexEndClosed** set.

To achieve the effects of the X10 **XDraw**, **XDrawDashed**, and **XDrawPatterned**, use **XDraw**.

```
#include <X11/X10.h>

Status XDraw( display, d, gc, vlist, vcount)
      Display *display;
      Drawable d;
      GC gc;
      Vertex *vlist;
      int vcount;
```

display	Specifies the connection to the X server.
d	Specifies the drawable.
gc	Specifies the GC.
vlist	Specifies a pointer to the list of vertices that indicate what to draw.
vcount	Specifies how many vertices are in vlist.

XDraw draws an arbitrary polygon or curve. The figure drawn is defined by the specified list of vertices (vlist). The points are connected by lines as specified in the flags in the vertex structure.

Each Vertex, as defined in **<X11/X10.h>**, is a structure with the following members:

```
typedef struct _Vertex {
      short x,y;
      unsigned short flags;
} Vertex;
```

The x and y members are the coordinates of the vertex that are relative to either the upper-left inside corner of the drawable (if **VertexRelative** is zero) or the previous vertex (if **VertexRelative** is one).

The flags, as defined in <**X11/X10.h**>, are as follows:

```
VertexRelative       0x0001   /* else absolute */
VertexDontDraw       0x0002   /* else draw */
VertexCurved         0x0004   /* else straight */
VertexStartClosed    0x0008   /* else not */
VertexEndClosed      0x0010   /* else not */
```

- If **VertexRelative** is not set, the coordinates are absolute (that is, relative to the drawable's origin). The first vertex must be an absolute vertex.
- If **VertexDontDraw** is one, no line or curve is drawn from the previous vertex to this one. This is analogous to picking up the pen and moving to another place before drawing another line.
- If **VertexCurved** is one, a spline algorithm is used to draw a smooth curve from the previous vertex through this one to the next vertex. Otherwise, a straight line is drawn from the previous vertex to this one. It makes sense to set **VertexCurved** to one only if a previous and next vertex are both defined (either explicitly in the array or through the definition of a closed curve).
- It is permissible for **VertexDontDraw** bits and **VertexCurved** bits both to be one. This is useful if you want to define the previous point for the smooth curve but do not want an actual curve drawing to start until this point.
- If **VertexStartClosed** is one, then this point marks the beginning of a closed curve. This vertex must be followed later in the array by another vertex whose effective coordinates are identical and that has a **VertexEndClosed** bit of one. The points in between form a cycle to determine predecessor and successor vertices for the spline algorithm.

This function uses these GC components: function, plane-mask, line-width, line-style, cap-style, join-style, fill-style, subwindow-mode, clip-x-origin, clip-y-origin, and clip-mask. It also uses these GC mode-dependent components: foreground, background, tile, stipple, tile-stipple-x-origin, tile-stipple-y-origin, dash-offset, and dash-list.

To achieve the effects of the X10 **XDrawTiled** and **XDrawFilled**, use **XDrawFilled**.

```
#include <X11/X10.h>

Status XDrawFilled(display, d, gc, vlist, vcount)
      Display *display;
      Drawable d;
      GC gc;
      Vertex *vlist;
      int vcount;
```

display	Specifies the connection to the X server.
d	Specifies the drawable.
gc	Specifies the GC.
vlist	Specifies a pointer to the list of vertices that indicate what to draw.
vcount	Specifies how many vertices are in vlist.

XDrawFilled draws arbitrary polygons or curves and then fills them.

This function uses these GC components: function, plane-mask, line-width, line-style, cap-style, join-style, fill-style, subwindow-mode, clip-x-origin, clip-y-origin, and clip-mask. It also uses these GC mode-dependent components: foreground, background, tile, stipple, tile-stipple-x-origin, tile-stipple-y-origin, dash-offset, dash-list, fill-style, and fill-rule.

Associating User Data with a Value

These functions have been superseded by the context management functions (see section 10.12). It is often necessary to associate arbitrary information with resource IDs. Xlib provides the **XAssocTable** functions that you can use to make such an association. Application programs often need to be able to easily refer to their own data structures when an event arrives. The **XAssocTable** system provides users of the X library with a method for associating their own data structures with X resources (**Pixmaps**, **Fonts**, **Windows**, and so on).

An **XAssocTable** can be used to type X resources. For example, the user may want to have three or four types of windows, each with different properties. This can be accomplished by associating each X window ID with a pointer to a window property data structure defined by the user. A generic type has been defined in the X library for resource IDs. It is called an XID.

There are a few guidelines that should be observed when using an **XAssocTable**:

- All XIDs are relative to the specified display.
- Because of the hashing scheme used by the association mechanism, the following rules for determining the size of a **XAssocTable** should be followed. Associations will be made and looked up more efficiently if the table size (number of buckets in the hashing system) is a power of two and if there are not more than 8 XIDs per bucket.

To return a pointer to a new **XAssocTable**, use **XCreateAssocTable**.

```
XAssocTable *XCreateAssocTable(size)
    int size;
```

size Specifies the number of buckets in the hash system of **XAssocTable**.

The size argument specifies the number of buckets in the hash system of **XAssocTable**. For reasons of efficiency the number of buckets should be a power of two. Some size suggestions might be: use 32 buckets per 100 objects, and a reasonable maximum number of objects per buckets is 8. If an error allocating memory for the **XAssocTable** occurs, a NULL pointer is returned.

To create an entry in a given **XAssocTable**, use **XMakeAssoc**.

```
XMakeAssoc(display, table, x_id, data)
    Display *display;
    XAssocTable *table;
    XID x_id;
    char *data;
```

display Specifies the connection to the X server.

table Specifies the assoc table.

x_id Specifies the X resource ID.

data Specifies the data to be associated with the X resource ID.

XMakeAssoc inserts data into an **XAssocTable** keyed on an XID. Data is inserted into the table only once. Redundant inserts are ignored. The queue in each association bucket is sorted from the lowest XID to the highest XID.

To obtain data from a given **XAssocTable**, use **XLookUpAssoc**.

```
char *XLookUpAssoc(display, table, x_id)
    Display *display;
    XAssocTable *table;
    XID x_id;
```

display Specifies the connection to the X server.

table Specifies the assoc table.

x_id Specifies the X resource ID.

XLookUpAssoc retrieves the data stored in an **XAssocTable** by its XID. If an appropriately matching XID can be found in the table, **XLookUpAssoc** returns the data associated with it. If the x_id cannot be found in the table, it returns NULL.

To delete an entry from a given **XAssocTable**, use **XDeleteAssoc**.

```
XDeleteAssoc(display, table, x_id)
      Display *display;
      XAssocTable *table;
      XID x_id;
```

display Specifies the connection to the X server.

table Specifies the assoc table.

x_id Specifies the X resource ID.

XDeleteAssoc deletes an association in an **XAssocTable** keyed on its XID. Redundant deletes (and deletes of nonexistent XIDs) are ignored. Deleting associations in no way impairs the performance of an **XAssocTable**.

To free the memory associated with a given **XAssocTable**, use **XDestroyAssocTable**.

```
XDestroyAssocTable(table)
      XAssocTable *table;
```

table Specifies the assoc table.

Glossary

Access control list

X maintains a list of hosts from which client programs can be run. By default, only programs on the local host and hosts specified in an initial list read by the server can use the display. This access control list can be changed by clients on the local host. Some server implementations can also implement other authorization mechanisms in addition to or in place of this mechanism. The action of this mechanism can be conditional based on the authorization protocol name and data received by the server at connection setup.

Active grab

A grab is active when the pointer or keyboard is actually owned by the single grabbing client.

Ancestors

If W is an inferior of A, then A is an ancestor of W.

Atom

An atom is a unique ID corresponding to a string name. Atoms are used to identify properties, types, and selections.

Background

An **InputOutput** window can have a background, which is defined as a pixmap. When regions of the window have their contents lost or invalidated, the server automatically tiles those regions with the background.

Backing store

When a server maintains the contents of a window, the pixels saved off-screen are known as a backing store.

Bit gravity

When a window is resized, the contents of the window are not necessarily discarded. It is possible to request that the server relocate the previous contents to some region of the window (though no guarantees are made). This attraction of window contents for some location of a window is known as bit gravity.

Bit plane

When a pixmap or window is thought of as a stack of bitmaps, each bitmap is called a bit plane or plane.

Bitmap

A bitmap is a pixmap of depth one.

Border

An **InputOutput** window can have a border of equal thickness on all four sides of the window. The contents of the border are defined by a pixmap, and the server automatically maintains the contents of the border. Exposure events are never generated for border regions.

Button grabbing

Buttons on the pointer can be passively grabbed by a client. When the button is pressed, the pointer is then actively grabbed by the client.

Byte order

For image (pixmap/bitmap) data, the server defines the byte order, and clients with different native byte ordering must swap bytes as necessary. For all other parts of the protocol, the client defines the byte order, and the server swaps bytes as necessary.

Children

The children of a window are its first-level subwindows.

Class

Windows can be of different classes or types. See the entries for **InputOnly** and **InputOutput** windows for further information about valid window types.

Client

An application program connects to the window system server by some interprocess communication (IPC) path, such as a TCP connection or a shared memory buffer. This program is referred to as a client of the window system server. More precisely, the client is the IPC path itself. A program with multiple paths open to the server is viewed as multiple clients by the protocol. Resource lifetimes are controlled by connection lifetimes, not by program lifetimes.

Clipping region

In a graphics context, a bitmap or list of rectangles can be specified to restrict output to a particular region of the window. The image defined by the bitmap or rectangles is called a clipping region.

Colormap

A colormap consists of a set of entries defining color values. The colormap associated with a window is used to display the contents of the window; each pixel value indexes the colormap to produce RGB values that drive the guns of a monitor. Depending on hardware limitations, one or more colormaps can be installed at one time so that windows associated with those maps display with true colors.

Connection

The IPC path between the server and client program is known as a connection. A client program typically (but not necessarily) has one connection to the server over which requests and events are sent.

Containment

A window contains the pointer if the window is viewable and the hotspot of the cursor is within a visible region of the window or a visible region of one of its inferiors. The border of the window is included as part of the window for containment. The pointer is in a window if the window contains the pointer but no inferior contains the pointer.

Coordinate system

The coordinate system has X horizontal and Y vertical, with the origin [0, 0] at the upper left. Coordinates are discrete and are in terms of pixels. Each window and pixmap has its own coordinate system. For a window, the origin is inside the border at the inside upper-left corner.

Cursor

A cursor is the visible shape of the pointer on a screen. It consists of a hotspot, a source bitmap, a shape bitmap, and a pair of colors. The cursor defined for a window controls the visible appearance when the pointer is in that window.

Depth

The depth of a window or pixmap is the number of bits per pixel it has. The depth of a graphics context is the depth of the drawables it can be used in conjunction with graphics output.

Device

Keyboards, mice, tablets, track-balls, button boxes, and so on are all collectively known as input devices. Pointers can have one or more buttons (the most common number is three). The core protocol only deals with two devices: the keyboard and the pointer.

DirectColor

DirectColor is a class of colormap in which a pixel value is decomposed into three separate subfields for indexing. The first subfield indexes an array to produce red intensity values. The second subfield indexes a second array to produce blue intensity values. The third subfield indexes a third array to produce green intensity values. The RGB (red, green, and blue) values in the colormap entry can be changed dynamically.

Display

A server, together with its screens and input devices, is called a display. The Xlib **Display** structure contains all information about the particular display and its screens as well as the state that Xlib needs to communicate with the display over a particular connection.

Drawable

Both windows and pixmaps can be used as sources and destinations in graphics operations. These windows and pixmaps are collectively known as drawables. However, an **InputOnly** window cannot be used as a source or destination in a graphics operation.

Event

Clients are informed of information asynchronously by means of events. These events can be either asynchronously generated from devices or generated as side effects of client requests. Events are grouped into types. The server never sends an event to a client unless the client has specifically asked to be informed of that type of event. However, clients can force events to be sent to other clients. Events are typically reported relative to a window.

Event mask

Events are requested relative to a window. The set of event types a client requests relative to a window is described by using an event mask.

Event propagation

Device-related events propagate from the source window to ancestor windows until some client has expressed interest in handling that type of event or until the event is discarded explicitly.

Event synchronization

There are certain race conditions possible when demultiplexing device events to clients (in particular, deciding where pointer and keyboard events should be sent when in the middle of window management operations). The event synchronization mechanism allows synchronous processing of device events.

Event source

The deepest viewable window that the pointer is in is called the source of a device-related event.

Exposure event

Servers do not guarantee to preserve the contents of windows when windows are obscured or reconfigured. Exposure events are sent to clients to inform them when contents of regions of windows have been lost.

Extension

Named extensions to the core protocol can be defined to extend the system. Extensions to output requests, resources, and event types are all possible and expected.

Font

A font is an array of glyphs (typically characters). The protocol does no translation or interpretation of character sets. The client simply indicates values used to index the glyph array. A font contains additional metric information to determine interglyph and interline spacing.

Frozen events

Clients can freeze event processing during keyboard and pointer grabs.

GC

GC is an abbreviation for graphics context. See **Graphics context**.

Glyph

A glyph is an image in a font, typically of a character.

Grab

Keyboard keys, the keyboard, pointer buttons, the pointer, and the server can be grabbed for exclusive use by a client. In general, these facilities are not intended to be used by normal applications but are intended for various input and window managers to implement various styles of user interfaces.

Graphics context

Various information for graphics output is stored in a graphics context (GC), such as foreground pixel, background pixel, line width, clipping region, and so on. A graphics context can only be used with drawables that have the same root and the same depth as the graphics context.

Gravity

The contents of windows and windows themselves have a gravity, which determines how the contents move when a window is resized. See **Bit gravity** and **Window gravity**.

GrayScale

GrayScale can be viewed as a degenerate case of **PseudoColor**, in which the red, green, and blue values in any given colormap entry are equal and thus, produce shades of gray. The gray values can be changed dynamically.

Hotspot

A cursor has an associated hotspot, which defines the point in the cursor corresponding to the coordinates reported for the pointer.

Identifier

An identifier is a unique value associated with a resource that clients use to name that resource. The identifier can be used over any connection to name the resource.

Inferiors

The inferiors of a window are all of the subwindows nested below it: the children, the children's children, and so on.

Input focus

The input focus is usually a window defining the scope for processing of keyboard input. If a generated keyboard event usually would be reported to this window or one of its inferiors, the event is reported as usual. Otherwise, the event is reported with respect to the focus window. The input focus also can be set such that all keyboard events are discarded and such that the focus window is dynamically taken to be the root window of whatever screen the pointer is on at each keyboard event.

Input manager

Control over keyboard input is typically provided by an input manager client, which usually is part of a window manager.

InputOnly window

An **InputOnly** window is a window that cannot be used for graphics requests. **InputOnly** windows are invisible and are used to control such things as cursors, input event generation, and grabbing. **InputOnly** windows cannot have **InputOutput** windows as inferiors.

InputOutput window

An **InputOutput** window is the normal kind of window that is used for both input and output. **InputOutput** windows can have both **InputOutput** and **InputOnly** windows as inferiors.

Key grabbing

Keys on the keyboard can be passively grabbed by a client. When the key is pressed, the keyboard is then actively grabbed by the client.

Keyboard grabbing

A client can actively grab control of the keyboard, and key events will be sent to that client rather than the client the events would normally have been sent to.

Keysym

An encoding of a symbol on a keycap on a keyboard.

Mapped

A window is said to be mapped if a map call has been performed on it. Unmapped windows and their inferiors are never viewable or visible.

Modifier keys

Shift, Control, Meta, Super, Hyper, Alt, Compose, Apple, CapsLock, ShiftLock, and similar keys are called modifier keys.

Monochrome

Monochrome is a special case of **StaticGray** in which there are only two colormap entries.

Obscure

A window is obscured if some other window obscures it. A window can be partially obscured and so still have visible regions. Window A obscures window B if both are viewable **InputOutput** windows, if A is higher in the global stacking order, and if the rectangle defined by the outside edges of A intersects the rectangle defined by the outside edges of B. Note the distinction between obscures and occludes. Also note that window borders are included in the calculation.

Occlude

A window is occluded if some other window occludes it. Window A occludes window B if both are mapped, if A is higher in the global stacking order, and if the rectangle defined by the outside edges of A intersects the rectangle defined by the outside edges of B. Note the distinction between occludes and obscures. Also note that window borders are included in the calculation and that **InputOnly** windows never obscure other windows but can occlude other windows.

Padding

Some padding bytes are inserted in the data stream to maintain alignment of the protocol requests on natural boundaries. This increases ease of portability to some machine architectures.

Parent window

If C is a child of P, then P is the parent of C.

Passive grab

Grabbing a key or button is a passive grab. The grab activates when the key or button is actually pressed.

Pixel value

A pixel is an N-bit value, where N is the number of bit planes used in a particular window or pixmap (that is, is the depth of the window or pixmap). A pixel in a window indexes a colormap to derive an actual color to be displayed.

Pixmap

A pixmap is a three-dimensional array of bits. A pixmap is normally thought of as a two-dimensional array of pixels, where each pixel can be a value from 0 to 2^N-1, and where N is the depth (z axis) of the pixmap. A pixmap can also be thought of as a stack of N bitmaps. A pixmap can only be used on the screen that it was created in.

Plane

When a pixmap or window is thought of as a stack of bitmaps, each bitmap is called a plane or bit plane.

Plane mask

Graphics operations can be restricted to only affect a subset of bit planes of a destination. A plane mask is a bit mask describing which planes are to be modified. The plane mask is stored in a graphics context.

Pointer

The pointer is the pointing device currently attached to the cursor and tracked on the screens.

Pointer grabbing

A client can actively grab control of the pointer. Then button and motion events will be sent to that client rather than the client the events would normally have been sent to.

Pointing device

A pointing device is typically a mouse, tablet, or some other device with effective dimensional motion. The core protocol defines only one visible cursor, which tracks whatever pointing device is attached as the pointer.

Property

Windows can have associated properties that consist of a name, a type, a data format, and some data. The protocol places no interpretation on properties. They are intended as a general-purpose naming mechanism for clients. For example, clients might use properties to share information such as resize hints, program names, and icon formats with a window manager.

Property list

The property list of a window is the list of properties that have been defined for the window.

PseudoColor

PseudoColor is a class of colormap in which a pixel value indexes the colormap entry to produce independent RGB values; that is, the colormap is viewed as an array of triples (RGB values). The RGB values can be changed dynamically.

Rectangle

A rectangle specified by [x,y,w,h] has an infinitely thin outline path with corners at [x,y], [x+w,y], [x+w,y+h], and [x, y+h]. When a rectangle is filled, the lower-right edges are not drawn. For example, if w=h=0, nothing would be drawn. For w=h=1, a single pixel would be drawn.

Redirecting control

Window managers (or client programs) may enforce window layout policy in various ways. When a client attempts to change the size or position of a window, the operation may be redirected to a specified client rather than the operation actually being performed.

Reply

Information requested by a client program using the X protocol is sent back to the client with a reply. Both events and replies are multiplexed on the same connection. Most requests do not generate replies, but some requests generate multiple replies.

Request

A command to the server is called a request. It is a single block of data sent over a connection.

Resource

Windows, pixmaps, cursors, fonts, graphics contexts, and colormaps are known as resources. They all have unique identifiers associated with them for naming purposes. The lifetime of a resource usually is bounded by the lifetime of the connection over which the resource was created.

RGB values

RGB values are the red, green, and blue intensity values that are used to define a color. These values are always represented as 16-bit, unsigned numbers, with 0 the minimum intensity and 65535 the maximum intensity. The X server scales these values to match the display hardware.

Root

The root of a pixmap or graphics context is the same as the root of whatever drawable was used when the pixmap or GC was created. The root of a window is the root window under which the window was created.

Root window

Each screen has a root window covering it. The root window cannot be reconfigured or unmapped, but otherwise it acts as a full-fledged window. A root window has no parent.

Save set

The save set of a client is a list of other clients' windows that, if they are inferiors of one of the client's windows at connection close, should not be destroyed and that should be remapped if currently unmapped. Save sets are typically used by window managers to avoid lost windows if the manager should terminate abnormally.

Scanline

A scanline is a list of pixel or bit values viewed as a horizontal row (all values having the same y coordinate) of an image, with the values ordered by increasing the x coordinate.

Scanline order

An image represented in scanline order contains scanlines ordered by increasing the y coordinate.

Screen

A server can provide several independent screens, which typically have physically independent monitors. This would be the expected configuration when there is only a single keyboard and pointer shared among the screens. A **Screen** structure contains the information about that screen and is linked to the **Display** structure.

Selection

A selection can be thought of as an indirect property with dynamic type. That is, rather than having the property stored in the X server, it is maintained by some client (the owner). A selection is global and is thought of as belonging to the user and being maintained by clients, rather than being private to a particular window subhierarchy or a particular set of clients. When a client asks for the contents of a selection, it specifies a selection target type, which can be used to control the transmitted representation of the contents. For example, if the selection is "the last thing the user clicked on," and that is currently an image, then the target type might specify whether the contents of the image should be sent in XY format or Z format.

The target type can also be used to control the class of contents transmitted; for example, asking for the "looks" (fonts, line spacing, indentation, and so forth) of a paragraph selection, rather than the text of the paragraph. The target type can also be used for other purposes. The protocol does not constrain the semantics.

Server

The server, which is also referred to as the X server, provides the basic windowing mechanism. It handles IPC connections from clients, demultiplexes graphics requests onto the screens, and multiplexes input back to the appropriate clients.

Server grabbing

The server can be grabbed by a single client for exclusive use. This prevents processing of any requests from other client connections until the grab is completed. This is typically only a transient state for such things as rubber-banding, pop-up menus, or executing requests indivisibly.

Sibling

Children of the same parent window are known as sibling windows.

Stacking order

Sibling windows, similar to sheets of paper on a desk, can stack on top of each other. Windows above both obscure and occlude lower windows. The relationship between sibling windows is known as the stacking order.

StaticColor

StaticColor can be viewed as a degenerate case of **PseudoColor** in which the RGB values are predefined and read-only.

StaticGray

StaticGray can be viewed as a degenerate case of **GrayScale** in which the gray values are predefined and read-only. The values are typically linear or near-linear increasing ramps.

Status

Many Xlib functions return a success status. If the function does not succeed, however, its arguments are not disturbed.

Stipple

A stipple pattern is a bitmap that is used to tile a region to serve as an additional clip mask for a fill operation with the foreground color.

Tile

A pixmap can be replicated in two dimensions to tile a region. The pixmap itself is also known as a tile.

Timestamp

A timestamp is a time value expressed in milliseconds. It is typically the time since the last server reset. Timestamp values wrap around (after about 49.7 days). The server, given its current time is represented by timestamp T, always interprets timestamps from clients by treating half of the timestamp space as being earlier in time than T and half of the timestamp space as being later in time than T. One timestamp value, represented by the constant **CurrentTime**, is never generated by the server. This value is reserved for use in requests to represent the current server time.

TrueColor

TrueColor can be viewed as a degenerate case of **DirectColor** in which the subfields in the pixel value directly encode the corresponding RGB values. That is, the colormap has predefined read-only RGB values. The values are typically linear or near-linear increasing ramps.

Type

A type is an arbitrary atom used to identify the interpretation of property data. Types are completely uninterpreted by the server. They are solely for the benefit of clients. X predefines type atoms for many frequently used types, and clients also can define new types.

Viewable

A window is viewable if it and all of its ancestors are mapped. This does not imply that any portion of the window is actually visible. Graphics requests can be performed on a window when it is not viewable, but output will not be retained unless the server is maintaining backing store.

Visible

A region of a window is visible if someone looking at the screen can actually see it; that is, the window is viewable and the region is not occluded by any other window.

Window gravity

When windows are resized, subwindows may be repositioned automatically relative to some position in the window. This attraction of a subwindow to some part of its parent is known as window gravity.

Window manager

Manipulation of windows on the screen and much of the user interface (policy) is typically provided by a window manager client.

XY format

The data for a pixmap is said to be in XY format if it is organized as a set of bitmaps representing individual bit planes with the planes appearing from most-significant to least-significant bit order.

Z format

The data for a pixmap is said to be in Z format if it is organized as a set of pixel values in scanline order.

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X Toolkit Intrinsics – C Language Interface

X Window System

X Version 11, Release 3

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Table of Contents

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About This Manual

X Toolkit Intrinsics – C Language Interface is intended to be read by both application programmers who will use one or more of the many widget sets built with the Intrinsics and by widget programmers who will use the Intrinsics to build widgets for one of the widget sets. Not all the information in this manual, however, applies to both audiences. That is, because the application programmer is likely to use only a number of the Intrinsics functions in writing an application and because the widget programmer is is likely to use many more, if not all, of the Intrinsics functions in building a widget, an attempt has been made to highlight those areas of information that are deemed to be of special interest for the application programmer. (It is assumed the widget programmer will have to be familiar with all the information.) Therefore, all entries in the table of contents that are printed in **bold** indicate the information that should be of special interest to an application programmer.

It is also assumed that as application programmers become more familiar with the concepts discussed in this manual they will find it more convenient to implement portions of their applications as special-purpose or custom widgets. It is possible, none the less, to use widgets without knowing how to build them.

Conventions Used in this Manual

This document uses the following conventions:

- Global symbols are printed in **this special font**. These can be either function names, symbols defined in include files, data types, or structure names. Arguments to functions, procedures, or macros are printed in *italics*.
- Each function is introduced by a general discussion that distinguishes it from other functions. The function declaration itself follows, and each argument is specifically explained. General discussion of the function, if any is required, follows the arguments.
- To eliminate any ambiguity between those arguments that you pass and those that a function returns to you, the explanations for all arguments that you pass start with the word *specifies* or, in the case of multiple arguments, the word *specify*. The explanations for all arguments that are returned to you start with the word *returns* or, in the case of multiple arguments, the word *return*.

Chapter 1

Intrinsics and Widgets

The Intrinsics and a widget set make up the X Toolkit. The Intrinsics provide the base mechanisms necessary to build a wide variety of widget sets and application environments. Because the Intrinsics mask implementation details from the widget and application programmer, the widgets and the application environments built with them are fully extensible and support independently developed new or extended components. By following a small set of conventions, widget programmers can extend their widget sets in new ways and can have these extensions function smoothly with the existing facilities.

The Intrinsics is a library package layered on top of Xlib. As such, the Intrinsics provide mechanisms (functions and structures) for extending the basic programming abstractions provided by the X Window System. By providing mechanisms for intercomponent and intracomponent interactions, the Intrinsics provide the next layer of functionality from which the widget sets are built.

Figure 1-1 illustrates this extended three-tiered X programming environment.

```
+-----------------------------------------------+
|                                               |
|          Application                          |
|                                               |
+-----------------------------------------------+
|                                 |         |   |
|          Widget                 |         |   |
|          Set                    |         |   |
|                                 |         |   |
|---------------------------------|         |   |
|         |                                 |   |
|         | Intrinsics                      |   |
|         |                                 |   |
|         ----------------------------------|   |
|                                               |
|          Xlib                                 |
|                                               |
+-----------------------------------------------+
```

A typical X Toolkit application is most likely to be a client of a given widget set, a subset of the Intrinsics functions, and a smaller set of Xlib functions. This is illustrated by a left-to-right viewing of Figure 1-1. At the same time, a widget set is a client of both the Intrinsics and Xlib, and the Intrinsics are a client of Xlib only. This is illustrated by a top-to-bottom viewing of Figure 1-1.

For the application programmer, the X Toolkit provides:

- A consistent interface (widget set) for writing applications
- A small set of Intrinsics mechanisms that also are used in writing applications

For the widget programmer, the X Toolkit provides:

- A set of Intrinsics mechanisms for building widgets
- An architectural model for constructing and composing widgets

- A consistent interface (widget set) for programming

To the extent possible, the X Toolkit is policy free. The application environment, not the X Toolkit, defines, implements, and enforces:

- Policy
- Consistency
- Style

Each individual widget implementation defines its own policy. The X Toolkit design allows for the development of radically differing widget implementations.

1.1. Terminology

In addition to the terms already defined for X programming (see *Xlib – C Language X Interface*), the following terms are specific to the Intrinsics and used throughout this book.

Application programmer

A programmer who uses the X Toolkit to produce an application user interface.

Class

The general group to which a specific object belongs.

Client

A function that uses a widget in an application or for composing other widgets.

Instance

A specific widget object as opposed to a general widget class.

Method

The functions or procedures that a widget class implements.

Name

The name that is specific to an instance of a widget for a given client.

Object

A software data abstraction consisting of private data and private and public functions that operate on the private data. Users of the abstraction can interact with the object only through calls to the object's public functions. In the X Toolkit, some of the object's public functions are called directly by the application, while others are called indirectly when the application calls the common Intrinsics functions. In general, if a function is common to all widgets, an application uses a single Intrinsic function to invoke the function for all types of widgets. If a function is unique to a single widget type, the widget exports the function as another "Xt" function.

Resource

A named piece of data in a widget that can be set by a client, by an application, or by user defaults.

User

A person interacting with a workstation.

Widget

An object providing a user-interface abstraction (for example, a Scrollbar widget).

Widget class

The general group to which a specific widget belongs, otherwise known as the type of the widget.

Widget programmer

A programmer who adds new widgets to the X Toolkit.

1.2. Intrinsics

The Intrinsics provide the base mechanisms (functions and structures) that simplify the design of application user interfaces. In addition, it assists widget and application programmers by providing a commonly used set of underlying user-interface functions to manage:

- Toolkit initialization
- Widgets
- Memory
- Window, file, and timer events
- Widget geometry
- Input focus
- Selections
- Resources and resource conversion
- Translation of events
- Graphics contexts
- Pixmaps
- Errors and warnings

Although all Intrinsics mechanisms are primarily intended for use by widget programmers, some are also intended for use by application programmers. The architectural model for the Intrinsics lets the widget programmer create new widgets by using the supplied mechanisms and/or by combining existing widgets. Therefore, an application interface layers built with the Intrinsics will provide a coordinated set of widgets and composition policies. While some of the widgets that are built with the Intrinsics are common across a number of application domains, others are restricted to a specific application domain.

The Intrinsics are based on an architectural model that also is flexible enough to accommodate a variety of different application interface layers. In addition, the supplied set of Intrinsics mechanisms are:

- Functionally complete and policy free
- Stylistically and functionally consistent with the X Window System primitives
- Portable across languages, computer architectures, and operating systems

Applications that use the Intrinsics mechanisms must include the following header files:

- **<X11/Intrinsic.h>**
- **<X11/StringDefs.h>**

In addition, they may also include:

- **<X11/Xatoms.h>**
- **<X11/Shell.h>**

Finally, widget implementations should include:

- **<X11/IntrinsicP.h>** instead of **<X11/Intrinsic.h>**.

The applications should also include the additional headers for each widget class that they are to use (for example, **<X11/Label.h>** or **<X11/Scroll.h>**). On a UNIX-based system, the Intrinsics object library file is named **libXt.a** and is usually referenced as –lXt.

1.3. Widgets

The fundamental abstraction and data type of the X Toolkit is the *widget*, which is a combination of an X window and its associated semantics and which is dynamically allocated and contains state information. Logically, a widget is a rectangle with associated input/output semantics. Some widgets display information (for example, text or graphics), and others are merely containers for other widgets (for example, a menu box). Some widgets are output-only and do not react to pointer or keyboard input, and others change their display in response to input and can invoke functions that an application has attached to them.

Every widget belongs to exactly one widget class that is statically allocated and initialized and that contains the operations allowable on widgets of that class. Logically, a widget class is the procedures and data that is associated with all widgets belonging to that class. These procedures and data can be inherited by subclasses. Physically, a widget class is a pointer to a structure. The contents of this structure are constant for all widgets of the widget class but will vary from class to class. (Here, constant means the class structure is initialized at compile-time and never changed, except for a one-time class initialization and in-place compilation of resource lists, which takes place when the first widget of the class or subclass is created.) For further information, see Section 2.4.

The organization of the declarations and code for a new widget class between a public .h file, a private .h file, and the implementation .c file is described in Section 1.4. The predefined widget classes adhere to these conventions.

A widget instance is composed of two parts:

- A data structure that contains instance-specific values
- A class structure that contains information that is applicable to all widgets of that class

Much of the input/output of a widget (for example, fonts, colors, sizes, border widths, and so on) is customizable by users.

The next three sections discuss the base widget classes:

- Core widgets
- Composite widgets
- Constraint widgets

The chapter ends with a discussion of widget classing.

1.3.1. Core Widgets

The **Core** widget contains the definitions of fields common to all widgets. All widgets are subclasses of **Core**, which is defined by the **CoreClassPart** and **CorePart** structures.

1.3.1.1. CoreClassPart Structure

The common fields for all widget classes are defined in the **CoreClassPart** structure:

```
typedef struct {
        WidgetClass superclass;              See Section 1.4
        String class_name;                   See Section 1.4
        Cardinal widget_size;                See Section 2.4
        XtProc class_initialize;             See Section 1.4
        XtWidgetClassProc class_part_initialize;See Section 1.4
        Boolean class_inited;                See Section 1.4
        XtInitProc initialize;               See Section 2.4
        XtArgsProc initialize_hook;          See Section 2.4
        XtRealizeProc realize;               See Section 2.4
        XtActionList actions;                See Chapter 10
        Cardinal num_actions;                See Chapter 10
        XtResourceList resources;            See Chapter 9
        Cardinal num_resources;              See Chapter 9
        XrmClass xrm_class;                  Private to resource manager
        Boolean compress_motion;             See Section 7.9.1
        Boolean compress_exposure;           See Section 7.9.3
        Boolean compress_enterleave;         See Section 7.9.2
```

```
        Boolean visible_interest;            See Section 7.10
        XtWidgetProc destroy;                See Section 2.7
        XtWidgetProc resize;                 See Chapter 6
        XtExposeProc expose;                 See Section 7.10
        XtSetValuesFunc set_values;          See Section 9.7
        XtArgsFunc set_values_hook;          See Section 9.7
        XtAlmostProc set_values_almost;      See Section 9.7
        XtArgsProc get_values_hook;          See Section 9.7
        XtAcceptFocusProc accept_focus;      See Section 7.3
        XtVersionType version;               See Section 1.4
        _XtOffsetList callback_private;      Private to callbacks
        String tm_table;                     See Chapter 10
        XtGeometryHandler query_geometry;    See Chapter 6
        XtStringProc display_accelerator;    See Chapter 10
        caddr_t extension;                   See Section 1.4
} CoreClassPart;
```

All widget classes have the core class fields as their first component. The prototypical **WidgetClass** is defined with only this set of fields. Various routines can cast widget class pointers, as needed, to specific widget class types, for example:

```
        typedef struct {
                CoreClassPart core_class;
        } WidgetClassRec, *WidgetClass;
```

The predefined class record and pointer for **WidgetClassRec** are:

```
        extern WidgetClassRec widgetClassRec;

        extern WidgetClass widgetClass;
```

The opaque types **Widget** and **WidgetClass** and the opaque variable **widgetClass** are defined for generic actions on widgets.

1.3.1.2. CorePart Structure

The common fields for all widget instances are defined in the **CorePart** structure:

```
typedef struct _CorePart {
        Widget self;
        WidgetClass widget_class;            See Section 1.4
        Widget parent;                       See Section 1.4
        XrmName xrm_name;                    Private to resource manager
        Boolean being_destroyed;             See Section 2.7
        XtCallbackList destroy_callbacks;    See Section 2.7
        caddr_t constraints;                 See Section 3.7
        Position x;                          See Chapter 6
        Position y;                          See Chapter 6
        Dimension width;                     See Chapter 6
        Dimension height;                    See Chapter 6
        Dimension border_width;              See Chapter 6
        Boolean managed;                     See Chapter 3
        Boolean sensitive;                   See Section 7.7
        Boolean ancestor_sensitive;          See Section 7.7
        XtEventTable event_table;            Private to event manager
        XtTMRec tm;                          Private to translation manager
        XtTranslations accelerators;         See Chapter 10
```

```
        Pixel border_pixel;                See Section 2.6
        Pixmap border_pixmap;              See Section 2.6
        WidgetList popup_list;             See Chapter 5
        Cardinal num_popups;               See Chapter 5
        String name;                       See Chapter 9
        Screen *screen;                    See Section 2.6
        Colormap colormap;                 See Section 2.6
        Window window;                     See Section 2.6
        Cardinal depth;                    See Section 2.5
        Pixel background_pixel;            See Section 2.6
        Pixmap background_pixmap;          See Section 2.6
        Boolean visible;                   See Section 7.10
        Boolean mapped_when_managed;       See Chapter 3
} CorePart;
```

All widget instances have the core fields as their first component. The prototypical type **Widget** is defined with only this set of fields. Various routines can cast widget pointers, as needed, to specific widget types; for example:

```
        typedef struct {
                CorePart core;
        } WidgetRec, *Widget;
```

1.3.1.3. CorePart Default Values

The default values for the core fields, which are filled in by the **Core** resource list and the **Core** initialize procedure, are:

Field	Default Value
self	Address of the widget structure (may not be changed)
widget_class	widget_class argument to **XtCreateWidget** (may not be changed)
parent	parent argument to **XtCreateWidget** (may not be changed)
xrm_name	Encoded name argument to **XtCreateWidget** (may not be changed)
being_destroyed	Parent's being_destroyed value
destroy_callbacks	NULL
constraints	NULL
x	0
y	0
width	0
height	0
border_width	1
managed	**False**
sensitive	**True**
ancestor_sensitive	Bitwise AND of parent's sensitive & ancestor_sensitive
event_table	Initialized by the event manager
tm	Initialized by the translation manager
accelerators	NULL
border_pixel	**XtDefaultForeground**
border_pixmap	NULL
popup_list	NULL
num_popups	0
name	name argument to **XtCreateWidget** (may not be changed)

screen	Parent's screen, top-level widget gets it from display specifier (may not be changed)
colormap	Default color map for the screen
window	NULL
depth	Parent's depth, top-level widget gets root window depth
background_pixel	**XtDefaultBackground**
background_pixmap	NULL
visible	**True**
map_when_managed	**True**

1.3.2. Composite Widgets

Composite widgets are a subclass of the **Core** widget (see Chapter 3) are intended to be containers for other widgets, and are defined by the **CompositeClassPart** and **CompositePart** structures.

1.3.2.1. CompositeClassPart Structure

In addition to the **Core** widget class fields, **Composite** widgets have the following class fields:

```
typedef struct {
        XtGeometryHandler geometry_manager;See Chapter 6
        XtWidgetProc change_managed;         See Chapter 3
        XtWidgetProc insert_child;           See Chapter 3
        XtWidgetProc delete_child;           See Chapter 3
        caddr_t extension;                   See Section 1.4
} CompositeClassPart;
```

Composite widget classes have the composite fields immediately following the core fields:

```
typedef struct {
        CoreClassPart                        core_class;
        CompositeClassPart                   composite_class;
} CompositeClassRec, *CompositeWidgetClass;
```

The predefined class record and pointer for **CompositeClassRec** are:

```
        extern CompositeClassRec compositeClassRec;

        extern WidgetClass compositeWidgetClass;
```

The opaque types **CompositeWidget** and **CompositeWidgetClass** and the opaque variable **compositeWidgetClass** are defined for generic operations on widgets that are a subclass of **CompositeWidget**.

1.3.2.2. CompositePart Structure

In addition to the **CorePart** fields, **Composite** widgets have the following fields defined in the **CompositePart** structure:

```
typedef struct {
        WidgetList children;                 See Section 1.4
        Cardinal num_children;               See Section 1.4
        Cardinal num_slots;                  See Chapter 3
        XtOrderProc insert_position;         See Section 2.4
} CompositePart;
```

Composite widgets have the composite fields immediately following the core fields:

```
typedef struct {
        CorePart core;
        CompositePart composite;
} CompositeRec, *CompositeWidget;
```

1.3.2.3. CompositePart Default Values

The default values for the composite fields, which are filled in by the **Composite** resource list and the **Composite** initialize procedure, are:

Field	Default Value
children	NULL
num_children	0
num_slots	0
insert_position	Internal function InsertAtEnd

1.3.3. Constraint Widgets

Constraint widgets are a subclass of the **Composite** widget (see Section 3.7) that maintain additional state data for each child, for example, client-defined constraints on the child's geometry. They are defined by the **ConstraintClassPart** and **ConstraintPart** structures.

1.3.3.1. ConstraintClassPart Structure

In addition to the **Composite** class fields, **Constraint** widgets have the following class fields:

```
typedef struct {
        XtResourceList resources;          See Section 3.7
        Cardinal num_resources;            See Section 3.7
        Cardinal constraint_size;          See Section 3.7
        XtInitProc initialize;             See Section 3.7
        XtWidgetProc destroy;              See Section 3.7
        XtSetValuesFunc set_values;        See Section 3.7
        caddr_t extension;                 See Section 1.4
} ConstraintClassPart;
```

Constraint widget classes have the constraint fields immediately following the composite fields:

```
typedef struct {
        CoreClassPart                      core_class;
        CompositeClassPart                 composite_class;
        ConstraintClassPart                constraint_class;
} ConstraintClassRec, *ConstraintWidgetClass;
```

The predefined class record and pointer for **ConstraintClassRec** are:

```
        extern ConstraintClassRec constraintClassRec;

        extern WidgetClass constraintWidgetClass;
```

The opaque types **ConstraintWidget** and **ConstraintWidgetClass** and the opaque variable **constraintWidgetClass** are defined for generic operations on widgets that are a subclass of **ConstraintWidgetClass**.

1.3.3.2. ConstraintPart Structure

In addition to the **CompositePart** fields, **Constraint** widgets have the following fields defined in the **ConstraintPart** structure:

```
typedef struct { int empty; } ConstraintPart;
```

Constraint widgets have the constraint fields immediately following the composite fields:

```
typedef struct {
        CorePart core;
        CompositePart composite;
        ConstraintPart constraint;
} ConstraintRec, *ConstraintWidget;
```

1.4. Widget Classing

The widget_class field of a widget points to its widget class structure, which contains information that is constant across all widgets of that class. As a consequence, widget classes usually do not implement directly callable procedures; rather, they implement procedures that are available through their widget class structure. These methods are invoked by generic procedures that envelop common actions around the procedures implemented by the widget class. Such procedures are applicable to all widgets of that class and also to widgets that are subclasses of that class.

All widget classes are a subclass of **Core** and can be subclassed further. Subclassing reduces the amount of code and declarations you write to make a new widget class that is similar to an existing class. For example, you do not have to describe every resource your widget uses in an **XtResourceList**. Instead, you describe only the resources your widget has that its superclass does not. Subclasses usually inherit many of their superclass's procedures (for example, the expose procedure or geometry handler).

Subclassing, however, can be taken too far. If you create a subclass that inherits none of the procedures of its superclass, you should consider whether or not you have chosen the most appropriate superclass.

To make good use of subclassing, widget declarations and naming conventions are highly stylized. A widget consists of three files:

- A public .h file that is used by client widgets or applications
- A private .h file that is used by widgets that are subclasses of the widget
- A .c file that implements the widget class

1.4.1. Widget Naming Conventions

The Intrinsics provide a vehicle by which programmers can create new widgets and organize a collection of widgets into an application. To ensure that applications need not deal with as many styles of capitalization and spelling as the number of widget classes it uses, the following guidelines should be followed when writing new widgets:

- Use the X naming conventions that are applicable. For example, a record component name is all lowercase and uses underscores (_) for compound words (for example, background_pixmap). Type and procedure names start with uppercase and use capitalization for compound words (for example, **ArgList** or **XtSetValues**).
- A resource name string is spelled identically to the field name except that compound names use capitalization rather than underscore. To let the compiler catch spelling errors, each resource name should have a macro definition prefixed with **XtN**. For example, the background_pixmap field has the corresponding resource name identifier XtNbackgroundPixmap, which is defined as the string "backgroundPixmap". Many predefined names are listed in **<X11/StringDefs.h>**. Before you invent a new name, you should make sure that

your proposed name is not already defined or that there is not already a name that you can use.

- A resource class string starts with a capital letter and uses capitalization for compound names (for example,"BorderWidth"). Each resource class string should have a macro definition prefixed with **XtC** (for example, XtCBorderWidth).
- A resource representation string is spelled identically to the type name (for example, "TranslationTable"). Each representation string should have a macro definition prefixed with **XtR** (for example, XtRTranslationTable).
- New widget classes start with a capital and use uppercase for compound words. Given a new class name AbcXyz you should derive several names:
  - Partial widget instance structure name AbcXyzPart
  - Complete widget instance structure names AbcXyzRec and _AbcXyzRec
  - Widget instance pointer type name AbcXyzWidget
  - Partial class structure name AbcXyzClassPart
  - Complete class structure names AbcXyzClassRec and _AbcXyzClassRec
  - Class structure variable abcXyzClassRec
  - Class pointer variable abcXyzWidgetClass
- Action procedures available to translation specifications should follow the same naming conventions as procedures. That is, they start with a capital letter and compound names use uppercase (for example, "Highlight" and "NotifyClient").

1.4.2. Widget Subclassing in Public .h Files

The public .h file for a widget class is imported by clients and contains:

- A reference to the public .h files for the superclass
- The names and classes of the new resources that this widget adds to its superclass
- The class record pointer that you use to create widget instances
- The C type that you use to declare widget instances of this class
- Entry points for new class methods

For example, the following is the public .h file for a possible implementation of a Label widget:

```
#ifndef LABEL_H
#define LABEL_H

/* New resources */
#define XtNjustify          "justify"
#define XtNforeground       "foreground"
#define XtNlabel            "label"
#define XtNfont             "font"
#define XtNinternalWidth    "internalWidth"
#define XtNinternalHeight   "internalHeight"

/* Class record pointer */
extern WidgetClass labelWidgetClass;

/* C Widget type definition */
typedef struct _LabelRec     *LabelWidget;

/* New class method entry points */
extern void Label SetText();
        /* Widget w */
```

```
        /* String text */

extern String Label GetText();
        /* Widget w */

#endif LABEL_H
```

The conditional inclusion of the text allows the application to include header files for different widgets without being concerned that they already may be included as a superclass of another widget.

To accommodate operating systems with file name length restrictions, the name of the public .h file is the first ten characters of the widget class. For example, the public .h file for the **Constraint** widget is **Constraint.h**.

1.4.3. Widget Subclassing in Private .h Files

The private .h file for a widget is imported by widget classes that are subclasses of the widget and contains:

- A reference to the public .h file for the class
- A reference to the private .h file for the superclass
- The new fields that the widget instance adds to its superclass's widget structure
- The complete widget instance structure for this widget
- The new fields that this widget class adds to its superclass's **Constraint** structure if the widget is a subclass of **Constraint**
- The complete **Constraint** structure if the widget is a subclass of **Constraint**
- The new fields that this widget class adds to its superclass's widget class structure
- The complete widget class structure for this widget
- The name of a constant of the generic widget class structure
- An inherit procedure for subclasses that wish to inherit a superclass operation for each new procedure in the widget class structure

For example, the following is the private .h file for a possible Label widget:

```
#ifndef LABELP_H
#define LABELP_H

#include <X11/Label.h>

/* New fields for the Label widget record */
typedef struct {
/* Settable resources */
        Pixel foreground;
        XFontStruct *font;
        String label;                   /* text to display */
        XtJustify justify;
        Dimension internal_width;       /* # of pixels horizontal border */
        Dimension internal_height;      /* # of pixels vertical border */

/* Data derived from resources */
        GC normal_GC;
        GC gray_GC;
        Pixmap gray_pixmap;
        Position label_x;
        Position label_y;
```

```
        Dimension label_width;
        Dimension label_height;
        Cardinal label_len;
        Boolean display_sensitive;
} LabelPart;

/* Full instance record declaration */
typedef struct _LabelRec {
        CorePart core;
        LabelPart label;
} LabelRec;

/* Types for label class methods */
typedef void (*LabelSetTextProc)();
        /* Widget w */
        /* String text */

typedef String (*LabelGetTextProc)();
        /* Widget w */

/* New fields for the Label widget class record */
typedef struct {
        LabelSetTextProc set_text;
        LabelGetTextProc get_text;
        caddr_t extension;
} LabelClassPart;

/* Full class record declaration */
typedef struct _LabelClassRec {
        CoreClassPart core_class;
        LabelClassPart label_class;
} LabelClassRec;

/* Class record variable */
extern LabelClassRec labelClassRec;

#define LabelInheritSetText((LabelSetTextProc)_XtInherit)
#define LabelInheritGetText((LabelGetTextProc)_XtInherit)
#endif LABELP_H
```

To accommodate operating systems with file name length restrictions, the name of the private .h file is the first nine characters of the widget class followed by a capital P. For example, the private .h file for the **Constraint** widget is **ConstrainP.h**.

1.4.4. Widget Subclassing in .c Files

The .c file for a widget contains the structure initializer for the class record variable, which contains the following parts:

- Class information (for example, superclass, class_name, widget_size, class_initialize, and class_inited)
- Data constants (for example, resources and num_resources, actions and num_actions, visible_interest, compress_motion, compress_exposure, and version)
- Widget operations (for example, initialize, realize, destroy, resize, expose, set_values, accept_focus, and any operations specific to the widget)

The superclass field points to the superclass **WidgetClass** record. For direct subclasses of the generic core widget, superclass should be initialized to the address of the **widgetClassRec** structure. The superclass is used for class chaining operations and for inheriting or enveloping a superclass's operations. (See Sections 1.4.7, 1.4.9, and 1.4.10).

The class_name field contains the text name for this class (used by the resource manager). For example, the Label widget has the string "Label". More than one widget class can share the same text class name.

The widget_size field is the size of the corresponding widget structure (not the size of the Class structure).

The version field indicates the toolkit version number and is used for run-time consistency checking of the X Toolkit and widgets in an application. Widget writers must set it to the symbolic value **XtVersion** in the widget class initialization. Those widget writers who know that their widgets are backwards compatible with previous versions of the Intrinsics can put the special value **XtVersionDontCheck** in the version field to turn off version checking for those widgets.

The extension field is for future upwards compatibility. If you add additional fields to class parts, all subclass structure layouts change, requiring complete recompilation. To allow clients to avoid recompilation, an extension field at the end of each class part can point to a record that contains any additional class information required.

All other fields are described in their respective sections.

The following is an abbreviated version of the ".c" file for the Label widget. (The resources table is described in the Chapter 9.)

```
/* Resources specific to Label */
#define XtRJustify        "Justify"
static XtResource resources[] = {
        {XtNforeground, XtCForeground, XtRPixel, sizeof(Pixel),
          XtOffset(LabelWidget, label.foreground), XtRString, XtDefaultForeground},
        {XtNfont,  XtCFont, XtRFontStruct, sizeof(XFontStruct *),
          XtOffset(LabelWidget, label.font),XtRString, XtDefaultFont},
        {XtNlabel,  XtCLabel, XtRString, sizeof(String),
          XtOffset(LabelWidget, label.label), XtRString, NULL},
                        .
                        .
                        .
}

/* Forward declarations of procedures */
static void ClassInitialize();
static void Initialize();
static void Realize();
static void SetText();
static void GetText();
        .
        .
        .

/* Class record constant */
LabelClassRec labelClassRec = {
  {
   /* core_class fields */
        /* superclass          */          (WidgetClass) &widgetClassRec,
        /* class_name          */          "Label",
        /* widget_size         */          sizeof(LabelRec),
        /* class_initialize    */          ClassInitialize,
```

```
        /* class_part_initialize  */          NULL,
        /* class_inited           */          False,
        /* initialize             */          Initialize,
        /* initialize_hook        */          NULL,
        /* realize                */          Realize,
        /* actions                */          NULL,
        /* num_actions            */          0,
        /* resources              */          resources,
        /* num_resources          */          XtNumber(resources),
        /* xrm_class              */          NULLQUARK,
        /* compress_motion        */          True,
        /* compress_exposure      */          True,
        /* compress_enterleave    */          True,
        /* visible_interest       */          False,
        /* destroy                */          NULL,
        /* resize                 */          Resize,
        /* expose                 */          Redisplay,
        /* set_values             */          SetValues,
        /* set_values_hook        */          NULL,
        /* set_values_almost      */          XtInheritSetValuesAlmost,
        /* get_values_hook        */          NULL,
        /* accept_focus           */          NULL,
        /* version                */          XtVersion,
        /* callback_offsets       */          NULL,
        /* tm_table               */          NULL,
        /* query_geometry         */          XtInheritQueryGeometry,
        /* display_accelerator    */          NULL,
        /* extension              */          NULL
  },
  {
   /* Label_class fields          */
        /* get_text               */          GetText,
        /* set_text               */          SetText,
        /* extension              */          NULL
  }
};

/* Class record pointer */
WidgetClass labelWidgetClass = (WidgetClass) &labelClassRec;

/* New method access routines */
void Label SetText(w, text)
        Widget w;
        String text;
{
        Label WidgetClass lwc = (Label WidgetClass)XtClass(w);
        XtCheckSubclass(w, labelWidgetClass, NULL);
        *(lwc->label_class.set_text)(w, text)
}
/* Private procedures */
        .
        .
        .
```

1.4.5. Widget Class and Superclass Look Up

To obtain the class of a widget, use **XtClass**.

WidgetClass XtClass(*w*)
    Widget *w*;

w   Specifies the widget.

The **XtClass** function returns a pointer to the widget's class structure.

To obtain the superclass of a widget, use **XtSuperclass**.

WidgetClass XtSuperclass(*w*)
    Widget *w*;

w   Specifies the widget.

The **XtSuperclass** function returns a pointer to the widget's superclass class structure.

1.4.6. Widget Subclass Verification

To check the subclass that a widget belongs to, use **XtIsSubclass**.

Boolean XtIsSubclass(*w*, *widget_class*)
    Widget *w*;
    WidgetClass *widget_class*;

w   Specifies the widget.

widget_class   Specifies the widget class to test against.

The **XtIsSubclass** function returns **True** if the class of the specified widget is equal to or is a subclass of the specified widget class. The specified widget can be any number of subclasses down the chain and need not be an immediate subclass of the specified widget class. Composite widgets that need to restrict the class of the items they contain can use **XtIsSubclass** to find out if a widget belongs to the desired class of objects.

To check the subclass that a widget belongs to and generate a debugging error message, use **XtCheckSubclass**.

void XtCheckSubclass(*w*, *widget_class*, *message*)
    Widget *w*;
    WidgetClass *widget_class*;
    String *message*;

w   Specifies the widget.

widget_class   Specifies the widget class to test against.

message   Specifies the message that is to be used.

The **XtCheckSubclass** macro determines if the class of the specified widget is equal to or is a subclass of the specified widget class. The widget can be any number of subclasses down the chain and need not be an immediate subclass of the specified widget class. If the specified widget is not a subclass, **XtCheckSubclass** constructs an error message from the supplied message, the widget's actual class, and the expected class and calls **XtErrorMsg**. **XtCheckSubclass** should be used at the entry point of exported routines to ensure that the client has passed in a valid widget class for the exported operation.

XtCheckSubclass is only executed when the widget has been compiled with the compiler symbol DEBUG defined; otherwise, it is defined as the empty string and generates no code.

1.4.7. Superclass Chaining

While most fields in a widget class structure are self-contained, some fields are linked to their corresponding field in their superclass or subclass structures. With a linked field, the Intrinsics access it value only after accessing its corresponding superclass value (called downward superclass chaining) or before accessing its corresponding superclass value (called upward superclass chaining). The self-contained fields in a widget class are:

- class_name
- class_initialize
- widget_size
- realize
- visible_interest
- resize
- expose
- accept_focus
- compress_motion
- compress_exposure
- compress_enterleave
- set_values_almost
- tm_table
- version

With downward superclass chaining, the invocation of an operation first accesses the field from the **Core** class structure, then the subclass structure, and so on down the class chain to that widget's class structure. These superclass-to-subclass fields are:

- class_part_initialize
- get_values_hook
- initialize
- initialize_hook
- set_values
- set_values_hook
- resources

In addition, for subclasses of **Constraint**, the resources field of the **ConstraintClassPart** structure is chained from the **Constraint** class down to the subclass.

With upward superclass chaining, the invocation of an operation first accesses the field from the widget class structure, then the field from the superclass structure, and so on up the class chain to the **Core** class structure. The subclass-to-superclass fields are:

- destroy
- actions

1.4.8. Class Initialization: class_initialize and class_part_initialize Procedures

Many class records can be initialized completely at compile time. In some cases, however, a class may need to register type converters or perform other sorts of one-time initialization.

Because the C language does not have initialization procedures that are invoked automatically when a program starts up, a widget class can declare a class_initialize procedure that will be automatically called exactly once by the X Toolkit. A class initialization procedure pointer is of type **XtProc**:

```
typedef void (*XtProc)();
```

A widget class indicates that it has no class initialization procedure by specifying NULL in the class_initialize field.

In addition to having class initializations done exactly once, some classes need to perform additional initialization for fields in its part of the class record. These are performed not just for the particular class but for subclasses as well. This is done in the class's class part initialization procedure, which is stored in the class_part_initialize field. The class_part_initialize procedure pointer is of type **XtWidgetClassProc**:

```
typedef void (*XtWidgetClassProc)(WidgetClass);
```

During class initialization, the class part initialization procedure for the class and all its superclasses are called in superclass-to-subclass order on the class record. These procedures have the responsibility of doing any dynamic initializations necessary to their class's part of the record. The most common is the resolution of any inherited methods defined in the class. For example, if a widget class C has superclasses **Core**, **Composite**, A, and B, the class record for C first is passed to **Core**'s class_part_initialize record. This resolves any inherited core methods and compiles the textual representations of the resource list and action table that are defined in the class record. Next, the **Composite**'s class_part_initialize is called to initialize the composite part of C's class record. Finally, the class_part_initialize procedures for A, B, and C (in order) are called. For further information, see Section 1.4.9. Classes that do not define any new class fields or that need no extra processing for them can specify NULL in the class_part_initialize field.

All widget classes, whether they have a class initialization procedure or not, must start with their class_inited field **False**.

The first time a widget of a class is created, **XtCreateWidget** ensures that the widget class and all superclasses are initialized, in superclass to subclass order, by checking each class_inited field and if it is **False**, by calling the class_initialize and the class_part_initialize procedures for the class and all its superclasses. The Intrinsics then set the class_inited field to **True**. After the one-time initialization, a class structure is constant.

The following provides the class initialization procedure for Label.

```
static void ClassInitialize()
{
        XtQEleft   = XrmStringToQuark("left");
        XtQEcenter = XrmStringToQuark("center");
        XtQEright  = XrmStringToQuark("right");

        XtAddConverter(XtRString, XtRJustify, CvtStringToJustify, NULL, 0);
}
```

A class is initialized the first time a widget of that class or any subclass is created. If the class initialization procedure registers type converters, these type converters are not available until this first widget is created (see Section 9.6).

1.4.9. Inheritance of Superclass Operations

A widget class is free to use any of its superclass's self-contained operations rather than implementing its own code. The most frequently inherited operations are:

- expose
- realize
- insert_child
- delete_child

- geometry_manager
- set_values_almost

To inherit an operation *xyz*, specify the constant **XtInherit***Xyz* in your class record.

Every class that declares a new procedure in its widget class part must provide for inheriting the procedure in its class_part_initialize procedure. (The special chained operations initialize, set_values, and destroy declared in the **Core** record do not have inherit procedures. Widget classes that do nothing beyond what their superclass does specify NULL for chained procedures in their class records.)

Inheriting works by comparing the value of the field with a known, special value and by copying in the superclass's value for that field if a match occurs. This special value is usually the Intrinsics internal value **_XtInherit** cast to the appropriate type. (**_XtInherit** is a procedure that issues an error message if it is actually called.)

For example, the **Composite** class's private include file contains these definitions:

```
#define XtInheritGeometryManager ((XtGeometryHandler) _XtInherit)
#define XtInheritChangeManaged ((XtWidgetProc) _XtInherit)
#define XtInheritInsertChild ((XtArgsProc) _XtInherit)
#define XtInheritDeleteChild ((XtWidgetProc) _XtInherit)
```

The Composite's class_part_initialize procedure begins as follows:

```
static void CompositeClassPartInitialize(widgetClass)
        WidgetClass widgetClass;
{
        register CompositeWidgetClass wc = (CompositeWidgetClass) widgetClass;
        CompositeWidgetClass super = (CompositeWidgetClass) wc->core_class.superclass

        if (wc->composite_class.geometry_manager == XtInheritGeometryManager) {
          wc->composite_class.geometry_manager = super->composite_class.geometry_manager;
        }

        if (wc->composite_class.change_managed == XtInheritChangeManaged) {
          wc->composite_class.change_managed = super->composite_class.change_managed;
        }
        .
        .
        .
```

The inherit constants defined for **Core** are:

- **XtInheritRealize**
- **XtInheritResize**
- **XtInheritExpose**
- **XtInheritSetValuesAlmost**
- **XtInheritAcceptFocus**
- **XtInheritDisplayAccelerator**

The inherit constants defined for **Composite** are:

- **XtInheritGeometryManager**
- **XtInheritChangeManaged**
- **XtInheritInsertChild**
- **XtInheritDeleteChild**

1.4.10. Invocation of Superclass Operations

A widget class sometimes explicitly needs to call a superclass operation that usually is not chained. For example, a widget's expose procedure might call its superclass's expose and then perform a little more work of its own. **Composite** classes with fixed children can implement insert_child by first calling their superclass's insert_child procedure and then calling **XtManageChild** to add the child to the managed list.

Note that a method should call its own superclass method, not the widget's superclass method. That is, it should use its own class pointers only, not the widget's class pointers. This technique is referred to as *enveloping* the superclass's operation.

Chapter 2

Widget Instantiation

A collection of widget instances constitutes a widget tree. The shell widget returned by **XtAppCreateShell** is the root of the widget tree instance. The widgets with one or more children are the intermediate nodes of that tree, and the widgets with no children of any kind are the leaves of a widget tree. With the exception of pop-up children (see Chapter 5), this widget tree instance defines the associated X Window tree.

Widgets can be either composite or primitive. Both kinds of widgets can contain children, but the Intrinsics provide a set of management mechanisms for constructing and interfacing between composite widgets, their children, and other clients.

Composite widgets, subclasses of **Composite**, are containers for an arbitrary but implementation-defined collection of children, which may be instantiated by the composite widget itself, by other clients, or by a combination of the two. Composite widgets also contain methods for managing the geometry (layout) of any child widget. Under unusual circumstances, a composite widget may have zero children, but it usually has at least one. By contrast, primitive widgets that contain children typically instantiate specific children of known class themselves and do not expect external clients to do so. Primitive widgets also do not have general geometry management methods.

In addition, the Intrinsics recursively perform many operations (for example, realization and destruction) on composite widgets and all of their children. Primitive widgets that have children must be prepared to perform the recursive operations themselves on behalf of their children.

A widget tree is manipulated by several Intrinsics functions. For example, **XtRealizeWidget** traverses the tree downward and recursively realizes all pop-up widgets and children of composite widgets. **XtDestroyWidget** traverses the tree downward and destroys all pop-up widgets and children of composite widgets. The functions that fetch and modify resources traverse the tree upward and determine the inheritance of resources from a widget's ancestors. **XtMakeGeometryRequest** traverses the tree up one level and calls the geometry manager that is responsible for a widget child's geometry.

To facilitate up-traversal of the widget tree, each widget has a pointer to its parent widget. The **Shell** widget that **XtAppCreateShell** returns, however, has a parent pointer of NULL.

To facilitate down-traversal of the widget tree, each composite widget has a pointer to an array of children widgets, which includes all normal children created, not just the subset of children that are managed by the composite widget's geometry manager. Primitive widgets that instantiate children are entirely responsible for all operations that require downward traversal below themselves. In addition, every widget has a pointer to an array of pop-up children widgets.

2.1. Initializing the X Toolkit

Before an application can call any of the Intrinsics functions, it must initialize the X Toolkit by using:

- **XtToolkitInitialize**, which initializes the X Toolkit internals
- **XtCreateApplicationContext**, which initializes the per application state
- **XtDisplayInitialize** or **XtOpenDisplay**, which initializes the per display state
- **XtAppCreateShell**, which creates the initial widget

Multiple instances of X Toolkit applications may be implemented by a single program in a single address space. Each instance needs to be able to read input and dispatch events independently of any other instance. Further, an application may need multiple display connections or need to have widgets on multiple screens. To accommodate both requirements, the Intrinsics define application contexts, each of which provides the information needed to distinguish one application instance from another. The major component of an application context is a list of X **Display** pointers for that application. The application context type **XtAppContext** is opaque to clients.

To initialize the X Toolkit internals, use **XtToolkitInitialize**.

void XtToolkitInitialize()

The semantics of calling **XtToolkitInitialize** more than once are undefined.

To create an application context, use **XtCreateApplicationContext**.

XtAppContext XtCreateApplicationContext()

The **XtCreateApplicationContext** function returns an application context, which is an opaque type. Every application must have at least one application context.

To destroy an application context and close any displays in it, use **XtDestroyApplicationContext**.

void XtDestroyApplicationContext(*app_context*)
    XtAppContext *app_context*;

app_context Specifies the application context.

The **XtDestroyApplicationContext** function destroys the specified application context as soon as it is safe to do so. If called from with an event dispatch (for example, a callback procedure), **XtDestroyApplicationContext** does not destroy the application context until the dispatch is complete.

To get the application context for a given widget, use **XtWidgetToApplicationContext**.

XtAppContext XtWidgetToApplicationContext(*w*)
    Widget *w*;

w Specifies the widget for which you want the application context .

The **XtWidgetToApplicationContext** function returns the application context for the specified widget.

To initialize a display and add it to an application context, use **XtDisplayInitialize**.

void XtDisplayInitialize(*app_context*, *display*, *application_name*, *application_class*,
        options, *num_options*, *argc*, *argv*)
    XtAppContext *app_context*;
    Display **display*;
    String *application_name*;
    String *application_class*;
    XrmOptionDescRec **options*;
    Cardinal *num_options*;
    Cardinal **argc*;
    String **argv*;

app_context Specifies the application context.

display Specifies the display. Note that a display can be in at most one application context.

application_name
    Specifies the name of the application instance.

application_class
Specifies the class name of this application, which is usually the generic name for all instances of this application.

options Specifies how to parse the command line for any application-specific resources. The options argument is passed as a parameter to **XrmParseCommand**. For further information, see *Xlib – C Language X Interface*.

num_options Specifies the number of entries in the options list.

argc Specifies a pointer to the number of command line parameters.

argv Specifies the command line parameters.

The **XtDisplayInitialize** function builds the resource database, calls the Xlib **XrmParseCommand** function to parse the command line, and performs other per display initialization. After **XrmParseCommand** has been called, argc and argv contain only those parameters that were not in the standard option table or in the table specified by the options argument. If the modified argc is not zero, most applications simply print out the modified argv along with a message listing the allowable options. On UNIX-based systems, the application name is usually the final component of argv[0]. If the synchronize resource is **True** for the specified application, **XtDisplayInitialize** calls the Xlib **XSynchronize** function to put Xlib into synchronous mode for this display connection. If the reverseVideo resource is **True**, the Intrinsics exchange **XtDefaultForeground** and **XtDefaultBackground** for widgets created on this display. (See Section 9.6.1).

To open a display, initialize it, and add it to an application context, use **XtOpenDisplay**.

Display *XtOpenDisplay(*app_context*, *display_string*, *application_name*, *application_class*,
        options, *num_options*, *argc*, *argv*)
    XtAppContext *app_context*;
    String *display_string*;
    String *application_name*;
    String *application_class*;
    XrmOptionDescRec **options*;
    Cardinal *num_options*;
    Cardinal **argc*;
    String **argv*;

app_context Specifies the application context.

display_string Specifies the display string. Note that a display can be in at most one application context.

application_name
Specifies the name of the application instance.

application_class
Specifies the class name of this application, which is usually the generic name for all instances of this application.

options Specifies how to parse the command line for any application-specific resources. The options argument is passed as a parameter to **XrmParseCommand**. For further information, see *Xlib – C Language X Interface*.

num_options Specifies the number of entries in the options list.

argc Specifies a pointer to the number of command line parameters.

argv Specifies the command line parameters.

The **XtOpenDisplay** function calls **XOpenDisplay** the specified display name. If display_string is NULL, **XtOpenDisplay** uses the current value of the –display option specified in argv and if no display is specified in argv, uses the user's default display (on UNIX-based systems, this is the value of the DISPLAY environment variable).

If this succeeds, it then calls **XtDisplayInitialize** and pass it the opened display and the value of the –name option specified in argv as the application name. If no name option is specified, it uses the application name passed to **XtOpenDisplay**. If the application name is NULL, it uses the last component of argv[0]. **XtOpenDisplay** returns the newly opened display or NULL if it failed.

XtOpenDisplay is provided as a convenience to the application programmer.

To close a display and remove it from an application context, use **XtCloseDisplay**.

void XtCloseDisplay(*display*)
    Display **display*;

display Specifies the display.

The **XtCloseDisplay** function closes the specified display as soon as it is safe to do so. If called from within an event dispatch (for example, a callback procedure), **XtCloseDisplay** does not close the display until the dispatch is complete. Note that applications need only call **XtCloseDisplay** if they are to continue executing after closing the display; otherwise, they should call **XtDestroyApplicationContext** or just exit.

2.2. Loading the Resource Database

The **XtDisplayInitialize** function loads the application's resource database for this display/host/application combination from the following sources (in order):

- Application-specific class resource file on the local host
- Application-specific user resource file on the local host
- Resource property on the server or user preference resource file on the local host
- Per-host user environment resource file on the local host
- Application command line (argv)

Each resource database is kept on a per-display basis.

The application-specific class resource file name is constructed from the class name of the application. It points to a site-specific resource file that usually is installed by the site manager when the application is installed. On UNIX-based systems, this file usually is **/usr/lib/X11/app-defaults/***class*, where *class* is the application class name. This file is expected to be provided by the developer of the application and may be required for the application to function properly.

The application-specific user resource file name is constructed from the class name of the application and points to a user-specific resource file. This file is owned by the application and typically stores user customizations. On UNIX-based systems, this file name is constructed from the user's XAPPLRESDIR variable by appending *class* to it, where *class* is the application class name. If XAPPLRESDIR is not defined, it defaults to the user's home directory. If the resulting resource file exists, it is merged into the resource database. This file may be provided with the application or constructed by the user.

The server resource file is the contents of the X server's RESOURCE_MANAGER property that was returned by **XOpenDisplay**. If no such property exists for the display, the contents of the resource file in the user's home directory is used instead. On UNIX-based systems, the usual name for the user preference resource file is **.Xdefaults**. If the resulting resource file exists, it is merged into the resource database. The server resource file is constructed entirely by the user and contains both display-independent and display-specific user preferences.

If one exists, a user's environment resource file is then loaded and merged into the resource database. This file name is user and host specific. On UNIX-based systems, the user's environment resource file name is constructed from the value of the user's XENVIRONMENT variable for the full path of the file. If this environment variable does not exist, **XtDisplayInitialize** searches the user's home directory for the **.Xdefaults-***host* file, where *host* is the name of the machine on which the application is running. If the resulting resource file exists, it is merged into the resource database. The environment resource file is expected to contain process-specific resource specifications that are to supplement those user-preference specifications in the server resource file.

To obtain the resource database for a particular display, use **XtDatabase**.

```
XrmDatabase XtDatabase(display)
    Display *display;
```

display Specifies the display.

The **XtDatabase** function returns the fully merged resource database that was built by **XtDisplayInitialize** associated with the display that was passed in. If this display has not been initialized by **XtDisplayInitialize**, the results are not defined.

2.3. Parsing the Command Line

The **XtOpenDisplay** function first parses the command line for the following options:

–display Specifies the display name for **XOpenDisplay**, which overrides the display name passed to **XtDisplayInitialize**.

–name Sets the resource name prefix, which overrides the application name passed to **XtDisplayInitialize**.

XtDisplayInitialize has a table of standard command line options that are passed to **XrmParseCommand** for adding resources to the resource database, and it takes as a parameter additional application-specific resource abbreviations. The format of this table is:

```
typedef enum {
        XrmoptionNoArg,          /* Value is specified in OptionDescRec.value */
        XrmoptionIsArg,          /* Value is the option string itself */
        XrmoptionStickyArg,      /* Value is characters immediately following option */
        XrmoptionSepArg,         /* Value is next argument in argv */
        XrmoptionSkipArg,        /* Ignore this option and the next argument in argv */
        XrmoptionSkipLine        /* Ignore this option and the rest of argv */
} XrmOptionKind;

typedef struct {
        char *option;            /* Option name in argv */
        char *specifier;         /* Resource name (without application name) */
        XrmOptionKind argKind;   /* Which style of option it is */
        caddr_t value;           /* Value to provide if XrmoptionNoArg */
} XrmOptionDescRec, *XrmOptionDescList;
```

The standard table contains the following entries:

Option String	Resource Name	Argument Kind	Resource Value
–background	background	SepArg	next argument
–bd	borderColor	SepArg	next argument
–bg	background	SepArg	next argument
–borderwidth	borderWidth	SepArg	next argument
–bordercolor	borderColor	SepArg	next argument
–bw	borderWidth	SepArg	next argument
–display	display	SepArg	next argument
–fg	foreground	SepArg	next argument
–fn	font	SepArg	next argument
–font	font	SepArg	next argument

−foreground	foreground	SepArg	next argument
−geometry	geometry	SepArg	next argument
−iconic	iconic	NoArg	true
−name	name	SepArg	next argument
−reverse	reverseVideo	NoArg	on
−rv	reverseVideo	NoArg	on
+rv	reverseVideo	NoArg	off
−selectionTimeout	selectionTimeout	SepArg	next argument
−synchronous	synchronize	NoArg	on
+synchronous	synchronize	NoArg	off
−title	title	SepArg	next argument
−xrm	next argument	ResArg	next argument

Note that any unique abbreviation for an option name in the standard table or in the application table is accepted.

If reverseVideo is set, the values of **XtDefaultForeground** and **XtDefaultBackground** are exchanged. If synchronize is set, the Intrinsics put Xlib into synchronous mode for all connections.

The −xrm option provides a method of setting any resource in an application. The next argument should be a quoted string identical in format to a line in the user resources file. For example, to give a red background to all command buttons in an application named **xmh**, you can start it up as:

```
xmh −xrm 'xmh*Command.background: red'
```

When it parses the command line, **XtDisplayInitialize** merges the application option table with the standard option table before calling the Xlib **XrmParseCommand** function. An entry in the application table with the same name as an entry in the standard table overrides the standard table entry. If an option name is a prefix of another option name, both names are kept in the merged table.

2.4. Creating Widgets

The creation of widget instances is a three-phase process:

1. The widgets are allocated and initialized with resources and are optionally added to the managed subset of their parent.
2. All composite widgets are notified of their managed children in a bottom-up traversal of the widget tree.
3. The widgets create X windows that then get mapped.

To start the first phase, the application calls **XtCreateWidget** for all its widgets and adds some (usually, most or all) of its widgets to their respective parent's managed set by calling **XtManageChild**. To avoid an $O(n^2)$ creation process where each composite widget lays itself out each time a widget is created and managed, parent widgets are not notified of changes in their managed set during this phase.

After all widgets have been created, the application calls **XtRealizeWidget** on the top-level widget to start the second and third phases. **XtRealizeWidget** first recursively traverses the widget tree in a post-order (bottom-up) traversal and then notifies each composite widget with one or more managed children by means of its change_managed procedure.

Notifying a parent about its managed set involves geometry layout and possibly geometry negotiation. A parent deals with constraints on its size imposed from above (for example, when a user specifics the application window size) and suggestions made from below (for example, when a primitive child computes its preferred size). One difference between the two can cause geometry changes to ripple in both directions through the widget tree. The parent may force some of its children to change size and position and may issue geometry requests to its own parent in order to better accommodate all its children. You cannot predict where anything will go on the screen until this process finishes.

Consequently, in the first and second phases, no X windows are actually created because it is likely that they will get moved around after creation. This avoids unnecessary requests to the X server.

Finally, **XtRealizeWidget** starts the third phase by making a pre-order (top-down) traversal of the widget tree, allocates an X window to each widget by means of its realize procedure, and finally maps the widgets that are managed.

2.4.1. Creating and Merging Argument Lists

Many Intrinsics functions need to be passed pairs of resource names and values. These are passed as an **ArgList**, which contains:

```
typedef something XtArgVal;

typedef struct {
        String name;
        XtArgVal value;
} Arg, *ArgList;
```

Where *something* is a type large enough to contain caddr_t, char *, long, int *, or a pointer to a function.

If the size of the resource is less than or equal to the size of an **XtArgVal**, the resource value is stored directly in value; otherwise, a pointer to it is stored into value.

To set values in an **ArgList**, use **XtSetArg**.

```
XtSetArg(arg, name, value)
    Arg arg;
    String name;
    XtArgVal value;
```

arg	Specifies the name-value pair to set.
name	Specifies the name of the resource.
value	Specifies the value of the resource if it will fit in an **XtArgVal** or the address.

The **XtSetArg** function is usually used in a highly stylized manner to minimize the probability of making a mistake; for example:

```
        Arg args[20];
        int n;

        n = 0;
        XtSetArg(args[n], XtNheight, 100);          n++;
        XtSetArg(args[n], XtNwidth, 200);           n++;
        XtSetValues(widget, args, n);
```

Alternatively, an application can statically declare the argument list and use **XtNumber**:

```
        static Args args[] = {
                {XtNheight, (XtArgVal) 100},
                {XtNwidth, (XtArgVal) 200},
        };
        XtSetValues(Widget, args, XtNumber(args));
```

Note that you should not use auto-increment or auto-decrement within the first argument to **XtSetArg**. **XtSetArg** can be implemented as a macro that dereferences the first argument twice.

To merge two **ArgList** structures, use **XtMergeArgLists**.

ArgList XtMergeArgLists(*args1*, *num_args1*, *args2*, *num_args2*)
    ArgList *args1*;
    Cardinal *num_args1*;
    ArgList *args2*;
    Cardinal *num_args2*;

args1 Specifies the first **ArgList**.

num_args1 Specifies the number of arguments in the first argument list.

args2 Specifies the second **ArgList**.

num_args2 Specifies the number of arguments in the second argument list.

The **XtMergeArgLists** function allocates enough storage to hold the combined **ArgList** structures and copies them into it. Note that it does not check for duplicate entries. When it is no longer needed, free the returned storage by using **XtFree**.

2.4.2. Creating a Widget Instance

To create an instance of a widget, use **XtCreateWidget**.

Widget XtCreateWidget(*name*, *widget_class*, *parent*, *args*, *num_args*)
    String *name*;
    WidgetClass *widget_class*;
    Widget *parent*;
    ArgList *args*;
    Cardinal *num_args*;

name Specifies the resource name for the created widget, which is used for retrieving resources and, for that reason, should not be the same as any other widget that is a child of same parent.

widget_class Specifies the widget class pointer for the created widget.

parent Specifies the parent widget.

args Specifies the argument list to override the resource defaults.

num_args Specifies the number of arguments in the argument list.

The **XtCreateWidget** function performs much of the boilerplate operations of widget creation:

- Checks to see if the class_initialize procedure has been called for this class and for all superclasses and, if not, calls those necessary in a superclass-to-subclass order.
- Allocates memory for the widget instance.
- If the parent is a subclass of **constraintWidgetClass**, it allocates memory for the parent's constraints and stores the address of this memory into the constraints field.
- Initializes the core nonresource data fields (for example, parent and visible).
- Initializes the resource fields (for example, background_pixel) by using the resource lists specified for this class and all superclasses.
- If the parent is a subclass of **constraintWidgetClass**, it initializes the resource fields of the constraints record by using the constraint resource list specified for the parent's class and all superclasses up to **constraintWidgetClass**.
- Calls the initialize procedures for the widget by starting at the Core initialize procedure on down to the widget's initialize procedure.

- If the parent is a subclass of **compositeWidgetClass**, it puts the widget into its parent's children list by calling its parent's insert_child procedure. For further information, see Section 3.5.
- If the parent is a subclass of **constraintWidgetClass**, it calls the constraint initialize procedures, starting at **constraintWidgetClass** on down to the parent's constraint initialize procedure.

Note that you can determine the number of arguments in an argument list by using the **XtNumber** macro. For further information, see Section 11.1. (See also **XtCreateManagedWidget**.)

2.4.3. Creating an Application Shell Instance

An application can have multiple top-level widgets, which can potentially be on many different screens. An application uses **XtAppCreateShell** if it needs to have several independent windows. The **XtAppCreateShell** function creates a top-level widget that is the root of a widget tree.

```
Widget XtAppCreateShell(application_name, application_class, widget_class, display,
                args, num_args)
    String application_name;
    String application_class;
    WidgetClass widget_class;
    Display *display;
    ArgList args;
    Cardinal num_args;
```

application_name
Specifies the name of the application instance. If application_name is NULL, the application name passed to **XtDisplayInitialize** is used.

application_class
Specifies the class name of this application.

widget_class Specifies the widget class that the application top-level widget should be (normally, applicationShellWidgetClass) .

display Specifies the display from which to get the resources.

args Specifies the argument list in which to set in the WM_COMMAND property.

num_args Specifies the number of arguments in the argument list.

The **XtAppCreateShell** function saves the specified application name and application class for qualifying all widget resource specifiers. The application name and application class are used as the left-most components in all widget resource names for this application. **XtAppCreateShell** should be used to create a new logical application within a program or to create a shell on another display. In the first case, it allows the specification of a new root in the resource hierarchy. In the second case, it uses the resource database associated with the other display.

Note that the widget returned by **XtAppCreateShell** has the WM_COMMAND property set for session managers (see Chapter 4).

To create multiple top-level shells within a single (logical) application, you can use one of two methods:

- Designate one shell as the real top-level shell and create the others as pop-up children of it by using **XtCreatePopupShell**.
- Have all shells as pop-up children of an unrealized top-level shell.

The first method, which is best used when there is a clear choice for what is the main window, leads to resource specifications like the following:

xmail.geometry:...	(the main window)
xmail.read.geometry:...	(the read window)
xmail.compose.geometry:...	(the compose window)

The second method, which is best if there is no main window, leads to resource specifications like the following:

xmail.headers.geometry:...	(the headers window)
xmail.read.geometry:...	(the read window)
xmail.compose.geometry:...	(the compose window)

2.4.4. Widget Instance Initialization: the initialize Procedure

The initialize procedure pointer in a widget class is of type **XtInitProc**:

```
typedef void (*XtInitProc)(Widget, Widget);
    Widget request;
    Widget new;
```

request Specifies the widget with resource values as requested by the argument list, the resource database, and the widget defaults.

new Specifies a widget with the new values, both resource and nonresource, that are actually allowed.

An initialization procedure performs the following:

- Allocates space for and copies any resources that are referenced by address. For example, if a widget has a field that is a **String** it cannot depend on the characters at that address remaining constant but must dynamically allocate space for the string and copy it to the new space. (Note that you should not allocate space for or copy callback lists.)
- Computes values for unspecified resource fields. For example, if width and height are zero, the widget should compute an appropriate width and height based on other resources. This is the only time that a widget should ever directly assign its own width and height.
- Computes values for uninitialized nonresource fields that are derived from resource fields. For example, graphics contexts (GCs) that the widget uses are derived from resources like background, foreground, and font.

An initialization procedure also can check certain fields for internal consistency. For example, it makes no sense to specify a color map for a depth that does not support that color map.

Initialization procedures are called in superclass-to-subclass order. Most of the initialization code for a specific widget class deals with fields defined in that class and not with fields defined in its superclasses.

If a subclass does not need an initialization procedure because it does not need to perform any of the above operations, it can specify NULL for the initialize field in the class record.

Sometimes a subclass may want to overwrite values filled in by its superclass. In particular, size calculations of a superclass are often incorrect for a subclass and in this case, the subclass must modify or recalculate fields declared and computed by its superclass.

As an example, a subclass can visually surround its superclass display. In this case, the width and height calculated by the superclass initialize procedure are too small and need to be incremented by the size of the surround. The subclass needs to know if its superclass's size was calculated by the superclass or was specified explicitly. All widgets must place themselves into whatever size is explicitly given, but they should compute a reasonable size if no size is requested.

The request and new arguments provide the necessary information for how a subclass knows the difference between a specified size and a size computed by a superclass. The request widget is the widget as originally requested. The new widget starts with the values in the request, but it has been updated by all superclass initialization procedures called so far. A subclass initialize procedure can compare these two to resolve any potential conflicts.

In the above example, the subclass with the visual surround can see if the width and height in the request widget are zero. If so, it adds its surround size to the width and height fields in the new widget. If not, it must make do with the size originally specified.

The new widget will become the actual widget instance record. Therefore, the initialization procedure should do all its work on the new widget (the request widget should never be modified), and if it needs to call any routines that operate on a widget, it should specify new as the widget instance.

2.4.5. Constraint Widget Instance Initialization: the constraint_initialize Procedure

The constraint_initialize procedure pointer is of type **XtInitProc**. The values passed to the parent constraint initialization procedure are the same as those passed to the child's class widget initialization procedure.

The constraint initialization procedure should compute any constraint fields derived from constraint resources. It can make further changes to the widget to make the widget conform to the specified constraints, for example, changing the widget's size or position.

If a constraint class does not need a constraint initialization procedure, it can specify NULL for the initialize field of the **ConstraintClassPart** in the class record.

2.4.6. Nonwidget Data Initialization: the initialize_hook Procedure

The initialize_hook procedure pointer is of type **XtArgsProc**:

```
typedef void (*XtArgsProc)(Widget, ArgList, Cardinal *);
    Widget w;
    ArgList args;
    Cardinal *num_args;
```

w Specifies the widget.

args Specifies the argument list to override the resource defaults.

num_args Specifies the number of arguments in the argument list.

If this procedure is not NULL, it is called immediately after the corresponding initialize procedure or in its place if the initialize procedure is NULL.

The initialize_hook procedure allows a widget instance to initialize nonwidget data using information from the specified argument list. For example, the Text widget has subparts that are not widgets, yet these subparts have resources that can be specified by means of the resource file or an argument list. See also Section 9.4.

2.5. Realizing Widgets

To realize a widget instance, use **XtRealizeWidget**.

```
void XtRealizeWidget(w)
    Widget w;
```

w Specifies the widget.

If the widget is already realized, **XtRealizeWidget** simply returns. Otherwise, it performs the following:

- Binds all action names in the widget's translation table to procedures (see Section 10.1.2).
- Makes a post-order traversal of the widget tree rooted at the specified widget and calls the change_managed procedure of each composite widget that has one or more managed children.
- Constructs an **XSetWindowAttributes** structure filled in with information derived from the **Core** widget fields and calls the realize procedure for the widget, which adds any

widget-specific attributes and creates the X window.

- If the widget is not a subclass of **compositeWidgetClass**, **XtRealizeWidget** returns; otherwise, it continues and performs the following:
  - Descends recursively to each of the widget's managed children and calls the realize procedures. Primitive widgets that instantiate children are responsible for realizing those children themselves.
  - Maps all of the managed children windows that have mapped_when_managed **True**. (If a widget is managed but mapped_when_managed is **False**, the widget is allocated visual space but is not displayed. Some people seem to like this to indicate certain states.)

If the widget is a top-level shell widget (that is, it has no parent), and mapped_when_managed is **True**, **XtRealizeWidget** maps the widget window.

XtCreateWidget, **XtRealizeWidget**, **XtManageChildren**, **XtUnmanageChildren**, and **XtDestroyWidget** maintain the following invariants:

- If a widget is realized, then all its managed children are realized.
- If a widget is realized, then all its managed children that are also mapped_when_managed are mapped.

All Intrinsics functions and all widget routines should work with either realized or unrealized widgets.

To check whether or not a widget has been realized, use **XtIsRealized**.

Boolean XtIsRealized(*w*)
    Widget *w*;

w Specifies the widget.

The **XtIsRealized** function returns **True** if the widget has been realized, that is, if the widget has a nonzero X window ID.

Some widget procedures (for example, set_values) might wish to operate differently after the widget has been realized.

2.5.1. Widget Instance Window Creation: the realize Procedure

The realize procedure pointer in a widget class is of type **XtRealizeProc**:

typedef void (*XtRealizeProc)(Widget, XtValueMask *, XSetWindowAttributes *);
    Widget *w*;
    XtValueMask **value_mask*;
    XSetWindowAttributes **attributes*;

w Specifies the widget.

value_mask Specifies which fields in the attributes structure to use.

attributes Specifies the window attributes to use in the **XCreateWindow** call.

The realize procedure must create the widget's window.

The generic **XtRealizeWidget** function fills in a mask and a corresponding **XSetWindowAttributes** structure. It sets the following fields based on information in the widget Core structure:

- The background_pixmap (or background_pixel if background_pixmap is NULL) is filled in from the corresponding field.
- The border_pixmap (or border_pixel if border_pixmap is NULL) is filled in from the corresponding field.
- The event_mask is filled in based on the event handlers registered, the event translations specified, whether expose is non-NULL, and whether visible_interest is **True**.

- The bit_gravity is set to **NorthWestGravity** if the expose field is NULL.
- The do_not_propagate_mask is set to propagate all pointer and keyboard events up the window tree. A composite widget can implement functionality caused by an event anywhere inside it (including on top of children widgets) as long as children do not specify a translation for the event.

All other fields in attributes (and the corresponding bits in value_mask) can be set by the realize procedure.

Note that because realize is not a chained operation, the widget class realize procedure must update the **XSetWindowAttributes** structure with all the appropriate fields from non-**Core** superclasses.

A widget class can inherit its realize procedure from its superclass during class initialization. The realize procedure defined for **Core** calls **XtCreateWindow** with the passed value_mask and attributes and with windowClass and visual set to **CopyFromParent**. Both **CompositeWidgetClass** and **ConstraintWidgetClass** inherit this realize procedure, and most new widget subclasses can do the same (see Section 1.4.9).

The most common noninherited realize procedures set bit_gravity in the mask and attributes to the appropriate value and then create the window. For example, depending on its justification, Label sets bit_gravity to **WestGravity**, **CenterGravity**, or **EastGravity**. Consequently, shrinking it just moves the bits appropriately, and no **Expose** event is needed for repainting.

If a composite widget's children should be realized in a particular order (typically to control the stacking order), it should call **XtRealizeWidget** on its children itself in the appropriate order from within its own realize procedure.

Widgets that have children and that are not a subclass of **compositeWidgetClass** are responsible for calling **XtRealizeWidget** on their children, usually from within the realize procedure.

2.5.2. Window Creation Convenience Routine

Rather than call the Xlib **XCreateWindow** function explicitly, a realize procedure should call the Intrinsics analog **XtCreateWindow**, which simplifies the creation of windows for widgets.

void XtCreateWindow(*w*, *window_class*, *visual*, *value_mask*, *attributes*)
  Widget *w*;
  unsigned int *window_class*;
  Visual **visual*;
  XtValueMask *value_mask*;
  XSetWindowAttributes **attributes*;

w	Specifies the widget that is used to set the x,y coordinates and so on.
window_class	Specifies the Xlib window class (for example, **InputOutput**, **InputOnly**, or **CopyFromParent**).
visual	Specifies the visual type (usually **CopyFromParent**).
value_mask	Specifies which attribute fields to use.
attributes	Specifies the window attributes to use in the **XCreateWindow** call.

The **XtCreateWindow** function calls the Xlib **XCreateWindow** function with values from the widget structure and the passed parameters. Then, it assigns the created window to the widget's window field.

XtCreateWindow evaluates the following fields of the **Core** widget structure:

- depth
- screen
- parent -> core.window

- x
- y
- width
- height
- border_width

2.6. Obtaining Window Information from a Widget

The **Core** widget definition contains the screen and window IDs. The window field may be NULL for a while (see Sections 2.4 and 2.5).

The display pointer, the parent widget, screen pointer, and window of a widget are available to the widget writer by means of macros and to the application writer by means of functions.

```
Display *XtDisplay(w)
    Widget w;
```

w Specifies the widget.

XtDisplay returns the display pointer for the specified widget.

```
Widget XtParent(w)
    Widget w;
```

w Specifies the widget.

XtParent returns the parent widget for the specified widget.

```
Screen *XtScreen(w)
    Widget w;
```

w Specifies the widget.

XtScreen returns the screen pointer for the specified widget.

```
Window XtWindow(w)
    Widget w;
```

w Specifies the widget.

XtWindow returns the window of the specified widget.

Several window attributes are locally cached in the widget. Thus, they can be set by the resource manager and **XtSetValues** as well as used by routines that derive structures from these values (for example, depth for deriving pixmaps, background_pixel for deriving GCs, and so on) or in the **XtCreateWindow** call.

The x, y, width, height, and border_width window attributes are available to geometry managers. These fields are maintained synchronously inside the X Toolkit. When an **XConfigureWindow** is issued on the widget's window (on request of its parent), these values are updated immediately rather than sometime later when the server generates a **ConfigureNotify** event. (In fact, most widgets do not have **SubstructureNotify** turned on.) This ensures that all geometry calculations are based on the internally consistent toolkit world, rather than on either an inconsistent world updated by asynchronous **ConfigureNotify** events or a consistent but slow world in which geometry managers ask the server for window sizes whenever they need to lay out their managed children (see Chapter 6).

2.6.1. Unrealizing Widgets

To destroy the windows associated with a widget and its descendants, use **XtUnrealizeWidget**.

void XtUnrealizeWidget(*w*)
    Widget *w*;

w Specifies the widget.

The **XtUnrealizeWidget** function destroys the windows of an existing widget and all of its children (recursively down the widget tree). To recreate the windows at a later time, call **XtRealizeWidget** again. If the widget was managed, it will be unmanaged automatically before its window is freed.

2.7. Destroying Widgets

The Intrinsics provide support to:

- Destroy all the pop-up children of the widget being destroyed and destroy all children of composite widgets
- Remove (and unmap) the widget from its parent
- Call the callback procedures that have been registered to trigger when the widget is destroyed
- Minimize the number of things a widget has to deallocate when destroyed
- Minimize the number of **XDestroyWindow** calls

To destroy a widget instance, use **XtDestroyWidget**.

void XtDestroyWidget(*w*)
    Widget *w*;

w Specifies the widget.

The **XtDestroyWidget** function provides the only method of destroying a widget, including widgets that need to destroy themselves. It can be called at any time, including from an application callback routine of the widget being destroyed. This requires a two-phase destroy process in order to avoid dangling references to destroyed widgets.

In phase one, **XtDestroyWidget** performs the following:

- If the being_destroyed field of the widget is **True**, it returns immediately.
- Recursively descends the widget tree and sets the being_destroyed field to **True** for the widget and all children.
- Adds the widget to a list of widgets (the destroy list) that should be destroyed when it is safe to do so.

Entries on the destroy list satisfy the invariant that if w2 occurs after w1 on the destroy list then w2 is not a descendent of w1. (A descendant refers to both normal and pop-up children.)

Phase two occurs when all procedures that should execute as a result of the current event have been called (including all procedures registered with the event and translation managers), that is, when the current invocation of **XtDispatchEvent** is about to return or immediately if not in **XtDispatchEvent**.

In phase two, **XtDestroyWidget** performs the following on each entry in the destroy list:

- Calls the destroy callback procedures registered on the widget (and all descendants) in post-order (it calls children callbacks before parent callbacks).
- If the widget's parent is a subclass of **compositeWidgetClass** and if the parent is not being destroyed, it calls **XtUnmanageChild** on the widget and then calls the widget's parent's delete_child procedure (see Section 3.4).

- If the widget's parent is a subclass of **constraintWidgetClass**, it calls the constraint destroy procedure for the parent, then the parent's superclass, until finally it calls the constraint destroy procedure for **constraintWidgetClass**.
- Calls the destroy methods for the widget (and all descendants) in post-order. For each such widget, it calls the destroy procedure declared in the widget class, then the destroy procedure declared in its superclass, until finally it calls the destroy procedure declared in the Core class record.
- Calls **XDestroyWindow** if the widget is realized (that is, has an X window). The server recursively destroys all descendant windows.
- Recursively descends the tree and deallocates all pop-up widgets, constraint records, callback lists and, if the widget is a subclass of **compositeWidgetClass**, children.

2.7.1. Adding and Removing Destroy Callbacks

When a application needs to perform additional processing during the destruction of a widget, it should register a destroy callback procedure for the widget. The destroy callback procedures use thc mechanism described in Chapter 8. The destroy callback list is identified by the resource name XtNdestroyCallback.

For example, the following adds an application-supplied destroy callback procedure *ClientDestroy* with client data to a widget by calling **XtAddCallback**.

XtAddCallback(*w*, XtNdestroyCallback, *ClientDestroy*, *client_data*)

Similarly, the following removes the application-supplied destroy callback procedure *ClientDestroy* by calling **XtRemoveCallback**.

XtRemoveCallback(*w*, XtNdestroyCallback, *ClientDestroy*, *client_data*)

The *ClientDestroy* argument is of type **XtCallbackProc**:

```
typedef void (*XtCallbackProc)(Widget, caddr_t, caddr_t);
```

For further information, see Section 8.1.

2.7.2. Dynamic Data Deallocation: the destroy Procedure

The destroy procedure pointer in the **CoreClassPart** structure is of type **XtWidgetProc**:

```
typedef void (*XtWidgetProc)(Widget);
```

The destroy procedures are called in subclass-to-superclass order. Therefore, a widget's destroy procedure only should deallocate storage that is specific to the subclass and should not bother with the storage allocated by any of its superclasses. The destroy procedure should only deallocate resources that have been explicitly created by the subclass. Any resource that was obtained from the resource database or was passed in in an argument list was not created by the widget and, therefore, should not be destroyed by it. If a widget does not need to deallocate any storage, the destroy procedure entry in its widget class record can be NULL.

Deallocating storage includes but is not limited to:

- Calling **XtFree** on dynamic storage allocated with **XtMalloc**, **XtCalloc**, and so on
- Calling **XFreePixmap** on pixmaps created with direct X calls
- Calling **XtDestroyGC** on GCs allocated with **XtGetGC**
- Calling **XFreeGC** on GCs allocated with direct X calls
- Calling **XtRemoveEventHandler** on event handlers added with **XtAddEventHandler**
- Calling **XtRemoveTimeOut** on timers created with **XtAppAddTimeOut**
- Calling **XtDestroyWidget** for each child if the widget has children and is not a subclass of **compositeWidgetClass**

2.7.3. Dynamic Constraint Data Deallocation: the constraint destroy Procedure

The constraint destroy procedure identified in the **ConstraintClassPart** structure is called for a widget whose parent is a subclass of **constraintWidgetClass**. This constraint destroy procedure pointer is of type **XtWidgetProc**. The constraint destroy procedures are called in subclass-to-superclass order, starting at the widget's parent and ending at **constraintWidgetClass**. Therefore, a parent's constraint destroy procedure only should deallocate storage that is specific to the constraint subclass and not the storage allocated by any of its superclasses.

If a parent does not need to deallocate any constraint storage, the constraint destroy procedure entry in its class record can be NULL.

2.8. Exiting from an Application

All X Toolkit applications should terminate by calling **XtDestroyApplicationContext** and then exiting using the standard method for their operating system (typically, by calling **exit** for UNIX-based systems). The quickest way to make the windows disappear while exiting is to call **XtUnmapWidget** on each top-level shell widget. The X Toolkit has no resources beyond those in the program image, and the X server will free its resources when its connection to the application is broken.

Chapter 3

Composite Widgets and Their Children

Composite widgets (widgets that are a subclass of **compositeWidgetClass**) can have an arbitrary number of children. Consequently, they are responsible for much more than primitive widgets. Their responsibilities (either implemented directly by the widget class or indirectly by Intrinsics functions) include:

- Overall management of children from creation to destruction
- Destruction of descendants when the composite widget is destroyed
- Physical arrangement (geometry management) of a displayable subset of children (that is, the managed children)
- Mapping and unmapping of a subset of the managed children

Overall management is handled by the generic procedures **XtCreateWidget** and **XtDestroyWidget**. **XtCreateWidget** adds children to their parent by calling the parent's insert_child procedure. **XtDestroyWidget** removes children from their parent by calling the parent's delete_child procedure and ensures that all children of a destroyed composite widget also get destroyed.

Only a subset of the total number of children is actually managed by the geometry manager and, hence, possibly visible. For example, a multibuffer composite editor widget might allocate one child widget for each file buffer, but it only might display a small number of the existing buffers. Windows that are in this displayable subset are called managed windows and enter into geometry manager calculations. The other children are called unmanaged windows and, by definition, are not mapped.

Children are added to and removed from the managed set by using **XtManageChild**, **XtManageChildren**, **XtUnmanageChild**, and **XtUnmanageChildren**, which notify the parent to recalculate the physical layout of its children by calling the parent's change_managed procedure. The **XtCreateManagedWidget** convenience function calls **XtCreateWidget** and **XtManageChild** on the result.

Most managed children are mapped, but some widgets can be in a state where they take up physical space but do not show anything. Managed widgets are not mapped automatically if their map_when_managed field is **False**. The default is **True** and is changed by using **XtSetMappedWhenManaged**.

Each composite widget class has a geometry manager, which is responsible for figuring out where the managed children should appear within the composite widget's window. Geometry management techniques fall into four classes:

- Fixed boxes

  Fixed boxes have a fixed number of children that are created by the parent. All of these children are managed, and none ever make geometry manager requests.

- Homogeneous boxes

  Homogeneous boxes treat all children equally and apply the same geometry constraints to each child. Many clients insert and delete widgets freely.

- Heterogeneous boxes

  Heterogeneous boxes have a specific location where each child is placed. This location usually is not specified in pixels, because the window may be resized, but is expressed rather in terms of the relationship between a child and the parent or between the child and other specific children. Heterogeneous boxes are usually subclasses of **Constraint**.

- Shell boxes

  Shell boxes have only one child, which is exactly the size of the shell. The geometry manager must communicate with the window manager if it exists, and the box must also accept **ConfigureNotify** events when the window size is changed by the window manager.

3.1. Verifying the Class of a Composite Widget

To test if a given widget is a subclass of **Composite**, use **XtIsComposite**.

```
Boolean XtIsComposite(w)
    Widget w;
```

w Specifies the widget.

The **XtIsComposite** function is a convenience function that is equivalent to **XtIsSubclass** with **compositeWidgetClass** specified.

3.2. Addition of Children to a Composite Widget: the insert_child Procedure

To add a child to the parent's list of children, the **XtCreateWidget** function calls the parent's class routine insert_child. The insert_child procedure pointer in a composite widget is of type **XtWidgetProc**:

```
typedef void (*XtWidgetProc)(Widget);
```

Most composite widgets inherit their superclass's operation. Composite's insert_child routine calls the insert_position procedure and inserts the child at the specified position.

Some composite widgets define their own insert_child routine so that they can order their children in some convenient way, create companion controller widgets for a new widget, or limit the number or type of their children widgets.

If there is not enough room to insert a new child in the children array (that is, num_children = num_slots), the insert_child procedure must first reallocate the array and update num_slots. The insert_child procedure then places the child wherever it wants and increments the num_children field.

3.3. Insertion Order of Children: the insert_position Procedure

Instances of composite widgets need to specify about the order in which their children are kept. For example, an application may want a set of command buttons in some logical order grouped by function, and it may want buttons that represent file names to be kept in alphabetical order.

The insert_position procedure pointer in a composite widget instance is of type **XtOrderProc**:

```
typedef Cardinal (*XtOrderProc)(Widget);
    Widget w;
```

w Specifies the widget.

Composite widgets that allow clients to order their children (usually homogeneous boxes) can call their widget instance's insert_position procedure from the class's insert_child procedure to determine where a new child should go in its children array. Thus, a client of a composite class can apply different sorting criteria to widget instances of the class, passing in a different insert_position procedure when it creates each composite widget instance.

The return value of the insert_position procedure indicates how many children should go before the widget. Returning zero indicates that the widget should go before all other children, and returning num_children indicates that it should go after all other children. The default insert_position function returns num_children and can be overridden by a specific composite widget's resource list or by the argument list provided when the composite widget is created.

3.4. Deletion of Children: the delete_child Procedure

To remove the child from the parent's children array, the **XtDestroyWidget** function eventually causes a call to the composite parent's class delete_child procedure. The delete_child procedure pointer is of type **XtWidgetProc**:

```
typedef void (*XtWidgetProc)(Widget);
```

Most widgets inherit the delete_child procedure from their superclass. Composite widgets that create companion widgets define their own delete_child procedure to remove these companion widgets.

3.5. Adding and Removing Children from the Managed Set

The Intrinsics provide a set of generic routines to permit the addition of widgets to or the removal of widgets from a composite widget's managed set. These generic routines eventually call the widget's change_managed procedure. The change_managed procedure pointer is of type **XtWidgetProc**.

3.5.1. Managing Children

To add a list of widgets to the geometry-managed (and, hence, displayable) subset of its composite parent widget, the application must first create the widgets (**XtCreateWidget**) and then call **XtManageChildren**.

```
typedef Widget *WidgetList;
```

void XtManageChildren(*children*, *num_children*)
    WidgetList *children*;
    Cardinal *num_children*;

children Specifies a list of child widgets.

num_children Specifies the number of children.

The **XtManageChildren** function performs the following:

- Issues an error if the children do not all have the same parent or if the parent is not a subclass of **compositeWidgetClass**.
- Returns immediately if the common parent is being destroyed; otherwise, for each unique child on the list, **XtManageChildren** ignores the child if it already is managed or is being destroyed and marks it if not.
- If the parent is realized and after all children have been marked, it makes some of the newly managed children viewable:
  - Calls the change_managed routine of the widgets' parent.
  - Calls **XtRealizeWidget** on each previously unmanaged child that is unrealized.
  - Maps each previously unmanaged child that has map_when_managed **True**.

Managing children is independent of the ordering of children and independent of creating and deleting children. The layout routine of the parent should consider children whose managed field is **True** and should ignore all other children. Note that some composite widgets, especially fixed boxes, call **XtManageChild** from their insert_child procedure.

If the parent widget is realized, its change_managed procedure is called to notify it that its set of managed children has changed. The parent can reposition and resize any of its children. It moves each child as needed by calling **XtMoveWidget**, which first updates the x and y fields and then calls **XMoveWindow** if the widget is realized.

If the composite widget wishes to change the size or border width of any of its children, it calls **XtResizeWidget**, which first updates the **Core** fields and then calls the Xlib **XConfigureWindow** function if the widget is realized.

To add a single child to a parent widget's list of managed children, first create the child widget (**XtCreateWidget**) and then use **XtManageChild**.

void XtManageChild(*child*)
    Widget *child*;

child Specifies the child.

The **XtManageChild** function constructs a **WidgetList** of length one and calls **XtManageChildren**.

To create and manage a child widget in a single procedure, use **XtCreateManagedWidget**.

Widget XtCreateManagedWidget(*name, widget_class, parent, args, num_args*)
    String *name*;
    WidgetClass *widget_class*;
    Widget *parent*;
    ArgList *args*;
    Cardinal *num_args*;

name Specifies the text name for the created widget.

widget_class Specifies the widget class pointer for the created widget.

parent Specifies the parent widget.

args Specifies the argument list to override the resource defaults.

num_args Specifies the number of arguments in the argument list.

The **XtCreateManagedWidget** function is a convenience routine that calls **XtCreateWidget** and **XtManageChild**.

3.5.2. Unmanaging Children

To remove a list of children from a parent widget's managed list, use **XtUnmanageChildren**.

void XtUnmanageChildren(*children, num_children*)
    WidgetList *children*;
    Cardinal *num_children*;

children Specifies a list of child widgets.

num_children Specifies the number of children.

The **XtUnmanageChildren** function performs the following:

- Issues an error if the children do not all have the same parent or if the parent is not a subclass of **compositeWidgetClass**.
- Returns immediately if the common parent is being destroyed; otherwise, for each unique child on the list, **XtUnmanageChildren** performs the following:
  - Ignores the child if it already is unmanaged or is being destroyed and marks it if not.
  - If the child is realized, it makes it nonvisible by unmapping it.
- Calls the change_managed routine of the widgets' parent after all children have been marked if the parent is realized.

XtUnmanageChildren does not destroy the children widgets. Removing widgets from a parent's managed set is often a temporary banishment, and, some time later, you may manage the children again. To destroy widgets entirely, see Section 2.7.

To remove a single child from its parent's managed set, use **XtUnmanageChild**.

void XtUnmanageChild(*child*)
    Widget *child*;

child Specifies the child.

The **XtUnmanageChild** function constructs a widget list of length one and calls **XtUnmanageChildren**.

These generic functions are low-level routines that are used by generic composite widget building routines. In addition, composite widgets can provide widget-specific, high-level convenience procedures to let applications create and manage children more easily.

3.5.3. Determining if a Widget Is Managed

To determine the managed state of a given child widget, use **XtIsManaged**.

```
Boolean XtIsManaged(w)
    Widget w;
```

w Specifies the widget.

The **XtIsManaged** macro (for widget programmers) or function (for application programmers) returns **True** if the specified child widget is managed or **False** if it is not.

3.6. Controlling When Widgets Get Mapped

A widget is normally mapped if it is managed. However, this behavior can be overridden by setting the XtNmappedWhenManaged resource for the widget when it is created or by setting the map_when_managed field to **False**.

To change the value of a given widget's map_when_managed field, use **XtSetMappedWhenManaged**.

```
void XtSetMappedWhenManaged(w, map_when_managed)
    Widget w;
    Boolean map_when_managed;
```

w Specifies the widget.

map_when_managed
Specifies a Boolean value that indicates the new value of the map_when_managed field.

If the widget is realized and managed and if the new value of map_when_managed is **True**, **XtSetMappedWhenManaged** maps the window. If the widget is realized and managed and if the new value of map_when_managed is **False**, it unmaps the window. **XtSetMappedWhenManaged** is a convenience function that is equivalent to (but slightly faster than) calling **XtSetValues** and setting the new value for the mappedWhenManaged resource. As an alternative to using **XtSetMappedWhenManaged** to control mapping, a client may set mapped_when_managed to **False** and use **XtMapWidget** and **XtUnmapWidget** explicitly.

To map a widget explicitly, use **XtMapWidget**.

```
XtMapWidget(w)
    Widget w;
```

w Specifies the widget.

To unmap a widget explicitly, use **XtUnmapWidget**.

```
XtUnmapWidget(w)
    Widget w;
```

w Specifies the widget.

3.7. Constrained Composite Widgets

Constraint widgets are a subclass of **compositeWidgetClass**. Their name is derived from the fact that they may manage the geometry of their children based on constraints associated with each child. These constraints can be as simple as the maximum width and height the parent will allow the child to occupy or can be as complicated as how other children should change if this child is moved or resized. **Constraint** widgets let a parent define resources that are supplied for their children. For example, if the **Constraint** parent defines the maximum sizes for its children, these new size resources are retrieved for each child as if they were resources that were defined by the child widget. Accordingly, constraint resources may be included in the argument list or resource file just like any other resource for the child.

Constraint widgets have all the responsibilities of normal composite widgets and, in addition, must process and act upon the constraint information associated with each of their children.

To make it easy for widgets and the Intrinsics to keep track of the constraints associated with a child, every widget has a constraints field, which is the address of a parent-specific structure that contains constraint information about the child. If a child's parent is not a subclass of **constraintWidgetClass**, then the child's constraints field is NULL.

Subclasses of a **Constraint** widget can add additional constraint fields to their superclass. To allow this, widget writers should define the constraint records in their private .h file by using the same conventions as used for widget records. For example, a widget that needs to maintain a maximum width and height for each child might define its constraint record as follows:

```
typedef struct {
        Dimension max_width, max_height;
} MaxConstraintPart;

typedef struct {
        MaxConstraintPart max;
} MaxConstraintRecord, *MaxConstraint;
```

A subclass of this widget that also needs to maintain a minimum size would define its constraint record as follows:

```
typedef struct {
        Dimension min_width, min_height;
} MinConstraintPart;

typedef struct {
        MaxConstraintPart max;
        MinConstraintPart min;
} MaxMinConstraintRecord, *MaxMinConstraint;
```

Constraints are allocated, initialized, deallocated, and otherwise maintained insofar as possible by the Intrinsics. The constraint class record part has several entries that facilitate this. All entries in **ConstraintClassPart** are information and procedures that are defined and implemented by the parent, but they are called whenever actions are performed on the parent's children.

The **XtCreateWidget** function uses the constraint_size field to allocate a constraint record when a child is created. The constraint_size field gives the number of bytes occupied by a constraint record. **XtCreateWidget** also uses the constraint resources to fill in resource fields in the constraint record associated with a child. It then calls the constraint initialize procedure so that the parent can compute constraint fields that are derived from constraint resources and can possibly move or resize the child to conform to the given constraints.

The **XtGetValues** and **XtSetValues** functions use the constraint resources to get the values or set the values of constraints associated with a child. **XtSetValues** then calls the constraint set_values procedures so that a parent can recompute derived constraint fields and move or resize the child as appropriate.

The **XtDestroyWidget** function calls the constraint destroy procedure to deallocate any dynamic storage associated with a constraint record. The constraint record itself must not be deallocated by the constraint destroy procedure; **XtDestroyWidget** does this automatically.

Chapter 4

Shell Widgets

Shell widgets hold an application's top-level widgets to allow them to communicate with the window manager. Shells have been designed to be as nearly invisible as possible. Clients have to create them, but they should never have to worry about their sizes.

If a shell widget is resized from the outside (typically by a window manager), the shell widget also resizes its child widget automatically. Similarly, if the shell's child widget needs to change size, it can make a geometry request to the shell, and the shell negotiates the size change with the outer environment. Clients should never attempt to change the size of their shells directly.

The four types of public shells are:

OverrideShell	Used for shell windows that completely bypass the window manager (for example, pop-up menu shells).
TransientShell	Used for shell windows that can be manipulated by the window manager but are not allowed to be iconified separately (for example, Dialog boxes that make no sense without their associated application). They are iconified by the window manager only if the main application shell is iconified.
TopLevelShell	Used for normal top-level windows (for example, any additional top-level widgets an application needs).
ApplicationShell	Used by the window manager to define a separate application instance, which is the main top-level window of the application.

4.1. Shell Widget Definitions

Widgets negotiate their size and position with their parent widget, that is, the widget that directly contains them. Widgets at the top of the hierarchy do not have parent widgets. Instead, they must deal with the outside world. To provide for this, each top-level widget is encapsulated in a special widget, called a Shell.

Shell widgets, a subclass of the Composite widget, encapsulate other widgets and can allow a widget to avoid the geometry clipping imposed by the parent/child window relationship. They also can provide a layer of communication with the window manager.

The seven different types of shells are:

Shell	Provides the base class for shell widgets and the fields needed for all types of shells. Shell is a direct subclass of compositeWidgetClass.
OverrideShell	Used for shell windows that completely bypass the window manager and is a subclass of Shell.
WMShell	Contains fields needed by the common window manager protocol and is a subclass of Shell.
VendorShell	Contains fields used by vendor-specific window managers and is a subclass of WMShell.

TransientShell	Used for shell windows that can be manipulated by the window manager but that are not allowed to be iconified and is a subclass of **VendorShell**.
TopLevelShell	Used for normal top level windows and is a subclass of **VendorShell**.
ApplicationShell	Used for an application's top-level window and is a subclass of **TopLevelShell**.

Note that the classes **Shell**, **WMShell**, and **VendorShell** are internal and should not be instantiated or subclassed. Only **OverrrideShell**, **TransientShell**, **TopLevelShell**, and **ApplicationShell** are for public use.

4.1.1. ShellClassPart Definitions

None of the shell widget classes has any additional fields:

```
typedef struct { caddr_t extension; } ShellClassPart, OverrideShellClassPart,
        WMShellClassPart, VendorShellClassPart, TransientShellClassPart,
        TopLevelShellClassPart, ApplicationShellClassPart;
```

Shell widget classes have the (empty) shell fields immediately following the composite fields:

```
typedef struct _ShellClassRec {
        CoreClassPart core_class;
        CompositeClassPart composite_class;
        ShellClassPart shell_class;
} ShellClassRec;

typedef struct _OverrideShellClassRec {
        CoreClassPart core_class;
        CompositeClassPart composite_class;
        ShellClassPart shell_class;
        OverrideShellClassPart override_shell_class;
} OverrideShellClassRec;

typedef struct _WMShellClassRec {
        CoreClassPart core_class;
        CompositeClassPart composite_class;
        ShellClassPart shell_class;
        WMShellClassPart wm_shell_class;
} WMShellClassRec;

typedef struct _VendorShellClassRec {
        CoreClassPart core_class;
        CompositeClassPart composite_class;
        ShellClassPart shell_class;
        WMShellClassPart wm_shell_class;
        VendorShellClassPart vendor_shell_class;
} VendorShellClassRec;

typedef struct _TransientShellClassRec {
        CoreClassPart core_class;
        CompositeClassPart composite_class;
        ShellClassPart shell_class;
        WMShellClassPart wm_shell_class;
        VendorShellClassPart vendor_shell_class;
        TransientShellClassPart transient_shell_class;
} TransientShellClassRec;
```

```
typedef struct _TopLevelShellClassRec {
        CoreClassPart core_class;
        CompositeClassPart composite_class;
        ShellClassPart shell_class;
        WMShellClassPart wm_shell_class;
        VendorShellClassPart vendor_shell_class;
        TopLevelShellClassPart top_level_shell_class;
} TopLevelShellClassRec;

typedef struct _ApplicationShellClassRec {
        CoreClassPart core_class;
        CompositeClassPart composite_class;
        ShellClassPart shell_class;
        WMShellClassPart wm_shell_class;
        VendorShellClassPart vendor_shell_class;
        TopLevelShellClassPart top_level_shell_class;
        ApplicationShellClassPart application_shell_class;
} ApplicationShellClassRec;
```

The predefined class records and pointers for shells are:

```
extern ShellClassRec shellClassRec;
extern OverrideShellClassRec overrideShellClassRec;
extern WMShellClassRec wmShellClassRec;
extern VendorShellClassRec vendorShellClassRec;
extern TransientShellClassRec transientShellClassRec;
extern TopLevelShellClassRec topLevelShellClassRec;
extern ApplicationShellClassRec applicationShellClassRec;

extern WidgetClass shellWidgetClass;
extern WidgetClass overrideShellWidgetClass;
extern WidgetClass wmShellWidgetClass;
extern WidgetClass vendorShellWidgetClass;
extern WidgetClass transientShellWidgetClass;
extern WidgetClass topLevelShellWidgetClass;
extern WidgetClass applicationShellWidgetClass;
```

The following opaque types and opaque variables are defined for generic operations on widgets that are a subclass of **ShellWidgetClass**:

Types	Variables
ShellWidget	**shellWidgetClass**
OverrideShellWidget	**overrideShellWidgetClass**
WMShellWidget	**wmShellWidgetClass**
VendorShellWidget	**vendorShellWidgetClass**
TransientShellWidget	**transientShellWidgetClass**
TopLevelShellWidget	**topLevelShellWidgetClass**
ApplicationShellWidget	**applicationShellWidgetClass**
ShellWidgetClass	
OverrideShellWidgetClass	
WMShellWidgetClass	
VendorShellWidgetClass	
TransientShellWidgetClass	
TopLevelShellWidgetClass	
ApplicationShellWidgetClass	

4.1.2. ShellPart Definition

The various shells have the following additional fields defined in their widget records:

```
typedef struct {
        String geometry;
        XtCreatePopupChildProc create_popup_child_proc;
        XtGrabKind grab_kind;
        Boolean spring_loaded;
        Boolean popped_up;
        Boolean allow_shell_resize;
        Boolean client_specified;
        Boolean save_under;
        Boolean override_redirect;
        XtCallbackList popup_callback;
        XtCallbackList popdown_callback;
} ShellPart;

typedef struct { int empty; } OverrideShellPart;

typedef struct {
        String title;
        int wm_timeout;
        Boolean wait_for_wm;
        Boolean transient;
        XSizeHints size_hints;
        XWMHints wm_hints;
} WMShellPart;

typedef struct {
        int vendor_specific;
} VendorShellPart;

typedef struct { int empty; } TransientShellPart;

typedef struct {
        String icon_name;
        Boolean iconic;
} TopLevelShellPart;

typedef struct {
        char *class;
        XrmClass xrm_class;
        int argc;
        char **argv;
} ApplicationShellPart;
```

The full definitions of the various shell widgets have shell fields following composite fields:

```
typedef struct {
        CorePart core;
        CompositePart composite;
        ShellPart shell;
} ShellRec, *ShellWidget;

typedef struct {
        CorePart core;
        CompositePart composite;
        ShellPart shell;
        OverrideShellPart override;
} OverrideShellRec, *OverrideShellWidget;

typedef struct {
        CorePart core;
        CompositePart composite;
        ShellPart shell;
        WMShellPart wm;
} WMShellRec, *WMShellWidget;

typedef struct {
        CorePart core;
        CompositePart composite;
        ShellPart shell;
        WMShellPart wm;
        VendorShellPart vendor;
} VendorShellRec, *VendorShellWidget;

typedef struct {
        CorePart core;
        CompositePart composite;
        ShellPart shell;
        WMShellPart wm;
        VendorShellPart vendor;
        TransientShellPart transient;
} TransientShellRec, *TransientShellWidget;

typedef struct {
        CorePart core;
        CompositePart composite;
        ShellPart shell;
        WMShellPart wm;
        VendorShellPart vendor;
        TopLevelShellPart topLevel;
} TopLevelShellRec, *TopLevelShellWidget;

typedef struct {
        CorePart core;
        CompositePart composite;
        ShellPart shell;
        WMShellPart wm;
        VendorShellPart vendor;
        TopLevelShellPart topLevel;
        ApplicationShellPart application;
} ApplicationShellRec, *ApplicationShellWidget;
```

4.1.3. ShellPart Default Values

The default values for fields common to all classes of public shells (filled in by the **Shell** resource lists and the **Shell** initialize procedures) are:

Field	Default Value
geometry	NULL
create_popup_child_proc	NULL
grab_kind	(internal)
spring_loaded	(internal)
popped_up	(internal)
allow_shell_resize	**False**
client_specified	(internal)
save_under	**True** for **OverrideShell** and **TransientShell**, **False** otherwise
override_redirect	**True** for **OverrideShell**, **False** otherwise
popup_callback	NULL
popdown_callback	NULL

The geometry resource specifies the size and position and is usually done only from a command line or a defaults file. For further information, see *Xlib – C Language X Interface*. The create_popup_child_proc is called by the **XtPopup** procedure and is usually NULL. The allow_shell_resize field controls whether or not the widget contained by the shell is allowed to try to resize itself. If allow_shell_resize is **False**, any geometry requests always return **XtGeometryNo**. Setting save_under instructs the server to attempt to save the contents of windows obscured by the shell when it is mapped and to restore its contents automatically later. It is useful for pop-up menus. Setting override_redirect determines whether or not the shell window is visible to the window manager. If it is **True**, the window is immediately mapped without the manager's intervention. The popup and popdown callbacks are called during **XtPopup** and **XtPopdown**. For further information, see *Xlib – C Language X Interface*.

The default values for shell fields in **WMShell** and its subclasses are:

Field	Default Value
title	Icon name, if specified, otherwise the application's name
wm_timeout	Five seconds
wait_for_wm	**True**
transient	**True** for **TransientShell**, **False** otherwise
min_width	None
min_height	None
max_width	None
max_height	None
width_inc	None
height_inc	None
min_aspect_x	None
min_aspect_y	None
max_aspect_x	None
max_aspect_y	None
input	**False**
initial_state	Normal
icon_pixmap	None
icon_window	None

icon_x	None
icon_y	None
icon_mask	None
window_group	None

The title is a string to be displayed by the window manager. The wm_timeout resource limits the amount of time a shell is to wait for confirmation of a geometry request to the window manager. If none comes back within that time, the shell assumes the window manager is not functioning properly and sets wait_for_wm to be **False** (later events may reset this value). The wait_for_wm resource sets the initial state for this flag. When the flag is **False**, the shell does not wait for a response but relies on asynchronous notification. All other resources are for fields in the window manager hints and the window manager size hints. For further information, see *Xlib – C Language X Interface* and the *Inter-Client Communication Conventions Manual.*

TopLevel shells have the the following additional resources:

Field	Default Value
icon_name	Shell widget's name
iconic	**False**

The icon_name field is the string to display in the shell's icon, and the iconic field is an alternative way to set the initialState resource to indicate that a shell should be initially displayed as an icon.

Application shells have the following additional resources:

Field	Default Value
argc	0
argv	NULL

The argc and argv fields are used to initialize the standard property WM_COMMAND. See the *Inter-Client Communication Conventions Manual* for more information.

Chapter 5

Pop-Up Widgets

Pop-up widgets are used to create windows that are outside of the window hierarchy defined by the widget tree. Each pop-up child has a window that is a descendant of the root window so that the pop-up window is not clipped by the pop-up widget's parent window. Therefore, pop-ups are created and attached differently to their widget parent than from normal widget children.

A parent of a pop-up widget does not actively manage its pop-up children; in fact, it usually never notices them or operates upon them. The popup_list field in the **CorePart** structure contains the list of its pop-up children. This pop-up list exists mainly to provide the proper place in the widget hierarchy for the pop-up to get resources and to provide a place for **XtDestroyWidget** to look for all extant children.

A **Composite** widget can have both normal and pop-up children. A pop-up can be popped up from almost anywhere, not just by its parent. A child always refers to a normal, geometry-managed child on the children list, and a pop-up child always refers to a child on the pop-up list.

5.1. Pop-Up Widget Types

There are three kinds of pop-up widgets:

- Modeless pop-ups

  A modeless pop-up (for example, a modeless dialog box) is usually visible to the window manager and looks like any other application from the user's point of view. (The application itself is a special form of a modeless pop-up.)

- Modal pop-ups

  A modal pop-up (for example, a modal dialog box) may or may not be visible to the window manager and, except for events that occur in the dialog box, disables user-event processing by the application.

- Spring-loaded pop-ups

  A spring-loaded pop-up (for example, a menu) is not visible to the window manager and, except for events that occur in the menu, disables user-event processing by all applications.

Modal pop-ups and spring-loaded pop-ups are very similar and should be coded as if they are the same. In fact, the same widget (for example, a ButtonBox or Menu) can be used both as a modal pop-up and as a spring-loaded pop-up within the same application. The main difference is that spring-loaded pop-ups are brought up with the pointer and, because of the grab that the pointer button causes, require different processing by the Intrinsics. Further, button up takes down a spring-loaded pop-up no matter where the button up occurs.

Any kind of pop-up, in turn, can pop up other widgets. Modal and spring-loaded pop-ups can constrain user events to the most recent such pop-up or to any of the modal/spring-loaded pop-ups currently mapped.

Regardless of their type, all pop-up widget classes are responsible for communicating with the X window manager and, therefore, are subclasses of **Shell**.

5.2. Creating a Pop-Up Shell

For a widget to pop up, it must be the child of a pop-up widget shell. A pop-up shell is never allowed more than one child, referred to as the pop-up child. Both the shell and child taken together are referred to as the pop-up. When you need to use a pop-up, you always should specify the pop-up shell, not the pop-up child.

To create a pop-up shell, use **XtCreatePopupShell**.

Widget XtCreatePopupShell(*name*, *widget_class*, *parent*, *args*, *num_args*)
    String *name*;
    WidgetClass *widget_class*;
    Widget *parent*;
    ArgList *args*;
    Cardinal *num_args*;

name	Specifies the text name for the created shell widget.
widget_class	Specifies the widget class pointer for the created shell widget.
parent	Specifies the parent widget.
args	Specifies the argument list to override the resource defaults.
num_args	Specifies the number of arguments in the argument list.

The **XtCreatePopupShell** function ensures that the specified class is a subclass of **Shell** and, rather than using insert_child to attach the widget to the parent's children list, attaches the shell to the parent's pop-ups list directly.

A spring-loaded pop-up invoked from a translation table already must exist at the time that the translation is invoked, so the translation manager can find the shell by name. Pop-ups invoked in other ways can be created "on-the-fly" when the pop-up actually is needed. This delayed creation of the shell is particularly useful when you pop up an unspecified number of pop-ups. You can look to see if an appropriate unused shell (that is, not currently popped up) exists and create a new shell if needed.

5.3. Creating Pop-Up Children

Once a pop-up shell is created, the single child of the pop-up shell can be created in one of two ways:

- Static
- Dynamic

At startup, an application can create the child of the pop-up shell, which is appropriate for pop-up children that are composed of a fixed set of widgets. The application can change the state of the subparts of the pop-up child as the application state changes. For example, if an application creates a static menu, it can call **XtSetSensitive** (or, in general, **XtSetValues**) on any of the buttons that make up the menu. Creating the pop-up child early means that pop-up time is minimized, especially if the application calls **XtRealizeWidget** on the pop-up shell at startup. When the menu is needed, all the widgets that make up the menu already exist and need only be mapped. The menu should pop up as quickly as the X server can respond.

Alternatively, an application can postpone the creation of the child until it is needed, which minimizes application startup time and allows the pop-up child to reconfigure itself each time it is popped up. In this case, the pop-up child creation routine should poll the application to find out if it should change the sensitivity of any of its subparts.

Pop-up child creation does not map the pop-up, even if you create the child and call **XtRealizeWidget** on the pop-up shell.

All shells have pop-up and pop-down callbacks, which provide the opportunity either to make last-minute changes to a pop-up child before it is popped up or to change it after it is popped down. Note that excessive use of pop-up callbacks can make popping up occur more slowly.

5.4. Mapping a Pop-Up Widget

Pop-ups can be popped up through several mechanisms:

- A call to **XtPopup**

- One of the supplied callback procedures (for example, **XtCallbackNone**, **XtCallback-Nonexclusive**, or **XtCallbackExclusive**)
- The standard translation action **MenuPopup**

Some of these routines take an argument of type **XtGrabKind**, which is defined as:

typedef enum {XtGrabNone, XtGrabNonexclusive, XtGrabExclusive} XtGrabKind;

To map a pop-up from within an application, use **XtPopup**.

void XtPopup(*popup_shell*, *grab_kind*)
    Widget *popup_shell*;
    XtGrabKind *grab_kind*;

popup_shell Specifies the widget shell.

grab_kind Specifies the way in which user events should be constrained.

The **XtPopup** function performs the following:

- Calls **XtCheckSubclass** to ensure popup_shell is a subclass of **Shell**.
- Generates an error if the shell's popped_up field is already **True**.
- Calls the callback procedures on the shell's popup_callback list.
- Sets the shell popped_up field to **True**, the shell spring_loaded field to **False**, and the shell grab_kind field from grab_kind.
- If the shell's create_popup_child field is non-NULL, **XtPopup** calls it with popup_shell as the parameter.
- If grab_kind is either **XtGrabNonexclusive** or **XtGrabExclusive**, it calls:

  XtAddGrab(popup_shell, (grab_kind == XtGrabExclusive), False)

- Calls **XtRealizeWidget** with popup_shell specified.
- Calls **XMapWindow** with popup_shell specified.

To map a pop-up from a given widget's callback list, you also can use the **XtCallbackNone**, **XtCallbackNonexclusive**, or **XtCallbackExclusive** convenience routines.

void XtCallbackNone(*w*, *client_data*, *call_data*)
    Widget *w*;
    caddr_t *client_data*;
    caddr_t *call_data*;

w Specifies the widget.

client_data Specifies the pop-up shell.

call_data Specifies the callback data, which is not used by this procedure.

void XtCallbackNonexclusive(*w*, *client_data*, *call_data*)
    Widget *w*;
    caddr_t *client_data*;
    caddr_t *call_data*;

w Specifies the widget.

client_data Specifies the pop-up shell.

call_data Specifies the callback data, which is not used by this procedure.

void XtCallbackExclusive(*w*, *client_data*, *call_data*)
    Widget *w*;
    caddr_t *client_data*;
    caddr_t *call_data*;

w Specifies the widget.

client_data Specifies the pop-up shell.

call_data Specifies the callback data, which is not used by this procedure.

The **XtCallbackNone**, **XtCallbackNonexclusive**, and **XtCallbackExclusive** functions call **XtPopup** with the shell specified by the client data argument and grab_kind set as the name specifies. **XtCallbackNone**, **XtCallbackNonexclusive**, and **XtCallbackExclusive** specify **XtGrabNone**, **XtGrabNonexclusive**, and **XtGrabExclusive**, respectively. Each function then sets the widget that executed the callback list to be insensitive by using **XtSetSensitive**. Using these functions in callbacks is not required. In particular, an application must provide customized code for callbacks that create pop-up shells dynamically or that must do more than desensitizing the button.

To pop up a menu when a pointer button is pressed or when the pointer is moved into some window, use **MenuPopup**. From a translation writer's point of view, the definition for this translation action is:

void MenuPopup(*shell_name*)
    String *shell_name*;

shell_name Specifies the name of the widget shell to pop up.

MenuPopup is known to the translation manager, which must perform special actions for spring-loaded pop-ups. Calls to **MenuPopup** in a translation specification are mapped into calls to a nonexported action procedure, and the translation manager fills in parameters based on the event specified on the left-hand side of a translation.

If **MenuPopup** is invoked on **ButtonPress** (possibly with modifiers), the translation manager pops up the shell with grab_kind set to **XtGrabExclusive** and spring_loaded set to **True**. If **MenuPopup** is invoked on **EnterWindow** (possibly with modifiers), the translation manager pops up the shell with grab_kind set to **XtGrabNonexclusive** and spring_loaded set to **False**. Otherwise, the translation manager generates an error. When the widget is popped up, the following actions occur:

- Calls **XtCheckSubclass** to ensure popup_shell is a subclass of **Shell**.
- Generates an error if the shell's popped_up field is already **True**.
- Calls the callback procedures on the shell's popup_callback list.
- Sets the shell popped_up field to **True** and the shell grab_kind and spring_loaded fields appropriately.
- If the shell's create_popup_child field is non-NULL, it is called with popup_shell as the parameter.
- Calls:

  XtAddGrab(popup_shell, (grab_kind == XtGrabExclusive), spring_loaded)

- Calls **XtRealizeWidget** with popup_shell specified.
- Calls **XMapWindow** with popup_shell specified.

(Note that these actions are the same as those for **XtPopup**.) **MenuPopup** tries to find the shell by searching the widget tree starting at the parent of the widget in which it is invoked. If it finds a shell with the specified name in the pop-up children of that parent, it pops up the shell with the appropriate parameters. Otherwise, it moves up the parent chain as needed. If **MenuPopup** gets to the application widget and cannot find a matching shell, it generates an error.

5.5. Unmapping a Pop-Up Widget

Pop-ups can be popped down through several mechanisms:

- A call to **XtPopdown**
- The supplied callback procedure **XtCallbackPopdown**
- The standard translation action **MenuPopdown**

To unmap a pop-up from within an application, use **XtPopdown**.

```
void XtPopdown(popup_shell)
    Widget popup_shell;
```

popup_shell Specifies the widget shell to pop down.

The **XtPopdown** function performs the following:

- Calls **XtCheckSubclass** to ensure popup_shell is a subclass of **Shell**.
- Checks that popup_shell is currently popped_up; otherwise, it generates an error.
- Unmaps popup_shell's window.
- If popup_shell's grab_kind is either **XtGrabNonexclusive** or **XtGrabExclusive**, it calls **XtRemoveGrab**.
- Sets pop-up shell's popped_up field to **False**.
- Calls the callback procedures on the shell's popdown_callback list.

To pop down pop-up that have been popped up with one of the callback routines (**XtCallbackNone**, **XtCallbackNonexclusive**, **XtCallbackExclusive**), use the callback **XtCallbackPopdown**.

```
void XtCallbackPopdown(w, client_data, call_data)
    Widget w;
    caddr_t client_data;
    caddr_t call_data;
```

w Specifies the widget.

client_data Specifies a pointer to the **XtPopdownID** structure.

call_data Specifies the callback data, which is not used by this procedure.

The **XtCallbackPopdown** function casts the client data parameter to an **XtPopdownID** pointer:

```
typedef struct {
        Widget shell_widget;
        Widget enable_widget;
} XtPopdownIDRec, *XtPopdownID;
```

The shell_widget is the pop-up shell to pop down, and the enable_widget is the widget that was used to pop it up.

XtCallbackPopdown calls **XtPopdown** with the specified shell_widget and then calls **XtSetSensitive** to resensitize the enable_widget.

To pop down a spring-loaded menu when a pointer button is released or when the pointer is moved into some window, use **MenuPopdown**. From a translation writer's point of view, the definition for this translation action is:

void MenuPopdown(*shell_name*)
    String *shell_name*;

shell_name Specifies the name of the widget shell to pop down.

If a shell name is not given, **MenuPopdown** calls **XtPopdown** with the widget for which the translation is specified. If a shell_name is specified in the translation table, **MenuPopdown** tries to find the shell by looking up the widget tree starting at the parent of the widget in which it is invoked. If it finds a shell with the specified name in the pop-up children of that parent, it pops down the shell; otherwise, it moves up the parent chain as needed. If **MenuPopdown** gets to the application top-level shell widget and cannot find a matching shell, it generates an error.

Chapter 6

Geometry Management

A widget does not directly control its size and location; rather, its parent is responsible for controlling its size and location. Although the position of children is usually left up to their parent, the widgets themselves often have the best idea of their optimal sizes and, possibly, preferred locations.

To resolve physical layout conflicts between sibling widgets and between a widget and its parent, the Intrinsics provide the geometry management mechanism. Almost all **Composite** widgets have a geometry manager (geometry_manager field in the widget class record) that is responsible for the size, position, and stacking order of the widget's children. The only exception are fixed boxes, which create their children themselves and can ensure that their children will never make a geometry request.

6.1. Initiating Geometry Changes

Parents, children, and clients all initiate geometry changes differently. Because a parent has absolute control of its children's geometry, it changes the geometry directly by calling **XtMoveWidget**, **XtResizeWidget**, or **XtConfigureWidget**. A child must ask its parent for a geometry change by calling **XtMakeGeometryRequest** or **XtMakeResizeRequest** to convey its wishes to its parent. An application or other client code initiates a geometry change by calling **XtSetValues** on the appropriate geometry fields, thereby giving the widget the opportunity to modify or reject the client request before it gets propagated to the parent and the opportunity to respond appropriately to the parent's reply.

When a widget that needs to change its size, position, border width, or stacking depth asks its parent's geometry manager to make the desired changes, the geometry manager can do one of the following:

- Allow the request
- Disallow the request
- Suggest a compromise

When the geometry manager is asked to change the geometry of a child, the geometry manager may also rearrange and resize any or all of the other children that it controls. The geometry manager can move children around freely using **XtMoveWidget**. When it resizes a child (that is, changes width, height, or border_width) other than the one making the request, it should do so by calling **XtResizeWidget**. It can simultaneously move and resize a child with a single call to **XtConfigureWidget**.

Often, geometry managers find that they can satisfy a request only if they can reconfigure a widget that they are not in control of (in particular, when the **Composite** widget wants to change its own size). In this case, the geometry manager makes a request to its parent's geometry manager. Geometry requests can cascade this way to arbitrary depth.

Because such cascaded arbitration of widget geometry can involve extended negotiation, windows are not actually allocated to widgets at application startup until all widgets are satisfied with their geometry. For further information, see Sections 2.4 and 2.5.

Notes

1. The Intrinsics treatment of stacking requests is deficient in several areas. Stacking requests for unrealized widgets are granted but will have no effect. In addition, there is no way to do an **XtSetValues** that will generate a stacking geometry request.
2. After a successful geometry request (one that returned **XtGeometryYes**), a widget does not know whether or not its resize procedure has been called. Widgets should have resize procedures that can be called more than once without ill effects.

6.2. General Geometry Manager Requests

To make a general geometry manager request from a widget, use **XtMakeGeometryRequest**.

XtGeometryResult XtMakeGeometryRequest(*w*, *request*, *reply_return*)
    Widget *w*;
    XtWidgetGeometry **request*;
    XtWidgetGeometry **reply_return*;

w	Specifies the widget that is making the request.
request	Specifies the desired widget geometry (size, position, border width, and stacking order).
reply_return	Returns the allowed widget size or may be NULL if the requesting widget is not interested in handling **XtGeometryAlmost**.

Depending on the condition, **XtMakeGeometryRequest** performs the following:

- If the widget is unmanaged or the widget's parent is not realized, it makes the changes and returns **XtGeometryYes**.
- If the parent is not a subclass of **compositeWidgetClass** or the parent's geometry_manager is NULL, it issues an error.
- If the widget's being_destroyed field is **True**, it returns **XtGeometryNo**.
- If the widget x, y, width, height and border_width fields are all equal to the requested values, it returns **XtGeometryYes**; otherwise, it calls the parent's geometry_manager procedure with the given parameters.
- If the parent's geometry manager returns **XtGeometryYes** and if **XtCWQueryOnly** is not set in the request_mode and if the widget is realized, **XtMakeGeometryRequest** calls the **XConfigureWindow** Xlib function to reconfigure the widget's window (set its size, location, and stacking order as appropriate).
- If the geometry manager returns **XtGeometryDone**, the change has been approved and actually has been done. In this case, **XtMakeGeometryRequest** does no configuring and returns **XtGeometryYes**. **XtMakeGeometryRequest** never returns **XtGeometryDone**.

Otherwise, **XtMakeGeometryRequest** returns the resulting value from the parent's geometry manager.

Children of primitive widgets are always unmanaged; thus, **XtMakeGeometryRequest** always returns **XtGeometryYes** when called by a child of a primitive widget.

The return codes from geometry managers are:

```
typedef enum _XtGeometryResult {
        XtGeometryYes,
        XtGeometryNo,
        XtGeometryAlmost,
        XtGeometryDone
} XtGeometryResult;
```

The **XtWidgetGeometry** structure is quite similar but not identical to the corresponding Xlib structure:

```
typedef unsigned long XtGeometryMask;

typedef struct {
        XtGeometryMask request_mode;
        Position x, y;
        Dimension width, height;
        Dimension border_width;
        Widget sibling;
        int stack_mode;
} XtWidgetGeometry;
```

The request_mode definitions are from <X11/X.h>:

```
#define    CWX                  (1<<0)
#define    CWY                  (1<<1)
#define    CWWidth              (1<<2)
#define    CWHeight             (1<<3)
#define    CWBorderWidth        (1<<4)
#define    CWSibling            (1<<5)
#define    CWStackMode          (1<<6)
```

The Intrinsics also support the following value:

```
#define    XtCWQueryOnly        (1<<7)
```

XtCWQueryOnly indicates that the corresponding geometry request is only a query as to what would happen if this geometry request were made and that no widgets should actually be changed.

XtMakeGeometryRequest, like the **XConfigureWindow** Xlib function, uses request_mode to determine which fields in the **XtWidgetGeometry** structure you want to specify.

The stack_mode definitions are from <X11/X.h>:

```
#define    Above                0
#define    Below                1
#define    TopIf                2
#define    BottomIf             3
#define    Opposite             4
```

The Intrinsics also support the following value:

```
#define    XtSMDontChange       5
```

For definition and behavior of **Above**, **Below**, **TopIf**, **BottomIf**, and **Opposite**, see *Xlib – C Language X Interface*. **XtSMDontChange** indicates that the widget wants its current stacking order preserved.

6.3. Resize Requests

To make a simple resize request from a widget, you can use **XtMakeResizeRequest** as an alternative to **XtMakeGeometryRequest**.

```
XtGeometryResult XtMakeResizeRequest(w, width, height, width_return, height_return)
    Widget w;
    Dimension width, height;
    Dimension *width_return, *height_return
```

w Specifies the widget.

width
height Specify the desired widget width and height.

width_return
height_return Return the allowed widget width and height.

The **XtMakeResizeRequest** function, a simple interface to **XtMakeGeometryRequest**, creates a **XtWidgetGeometry** structure and specifies that width and height should change. The geometry manager is free to modify any of the other window attributes (position or stacking order) to satisfy the resize request. If the return value is **XtGeometryAlmost**, width_return and height_return contain a compromise width and height. If these are acceptable, the widget should immediately make an **XtMakeResizeRequest** and request that the compromise width and height be applied. If the widget is not interested in **XtGeometryAlmost** replies, it can pass NULL for width_return and height_return.

6.4. Potential Geometry Changes

Sometimes a geometry manager cannot respond to a geometry request from a child without first making a geometry request to the widget's own parent (the requestor's grandparent). If the request to the grandparent would allow the parent to satisfy the original request, the geometry manager can make the intermediate geometry request as if it were the originator. On the other hand, if the geometry manager already has determined that the original request cannot be completely satisfied (for example, if it always denies position changes), it needs to tell the grandparent to respond to the intermediate request without actually changing the geometry because it does not know if the child will accept the compromise. To accomplish this, the geometry manager uses **XtCWQueryOnly** in the intermediate request.

When **XtCWQueryOnly** is used, the geometry manager needs to cache enough information to exactly reconstruct the intermediate request. If the grandparent's response to the intermediate query was **XtGeometryAlmost**, the geometry manager needs to cache the entire reply geometry in the event the child accepts the parent's compromise.

If the grandparent's response was **XtGeometryAlmost**, it may also be necessary to cache the entire reply geometry from the grandparent when **XtCWQueryOnly** is not used. If the geometry manager is still able to satisfy the original request, it may immediately accept the grandparent's compromise and then act on the child's request. If the grandparent's compromise geometry is insufficient to allow the child's request and if the geometry manager is willing to offer a different compromise to the child, the grandparent's compromise should not be accepted until the child has accepted the new compromise.

Note that a compromise geometry returned with **XtGeometryAlmost** is guaranteed only for the next call to the same widget; therefore, a cache of size one is sufficient.

6.5. Child Geometry Management: the geometry_manager Procedure

The geometry_manager procedure pointer in a composite widget class is of type **XtGeometryHandler**:

```
typedef XtGeometryResult (*XtGeometryHandler)(Widget, XtWidgetGeometry *, XtWidgetGeometry *);
    Widget w;
    XtWidgetGeometry *request;
    XtWidgetGeometry *geometry_return;
```

A class can inherit its superclass's geometry manager during class initialization.

A bit set to zero in the request's mask field means that the child widget does not care about the value of the corresponding field. Then, the geometry manager can change it as it wishes. A bit set to 1 means that the child wants that geometry element changed to the value in the corresponding field.

If the geometry manager can satisfy all changes requested and if **XtCWQueryOnly** is not specified, it updates the widget's x, y, width, height, and border_width values appropriately. Then, it returns **XtGeometryYes**, and the value of the geometry_return argument is undefined. The widget's window is moved and resized automatically by **XtMakeGeometryRequest**.

Homogeneous composite widgets often find it convenient to treat the widget making the request the same as any other widget, possibly reconfiguring it as part of its layout process, unless **XtCWQueryOnly** is specified. If it does this, it should return **XtGeometryDone** to inform **XtMakeGeometryRequest** that it does not need to do the configuration itself.

Although **XtMakeGeometryRequest** resizes the widget's window (if the geometry manager returns **XtGeometryYes**), it does not call the widget class's resize procedure. The requesting widget must perform whatever resizing calculations are needed explicitly.

If the geometry manager chooses to disallow the request, the widget cannot change its geometry. The value of the geometry_return parameter is undefined, and the geometry manager returns **XtGeometryNo**.

Sometimes the geometry manager cannot satisfy the request exactly, but it may be able to satisfy a similar request. That is, it could satisfy only a subset of the requests (for example, size but not position) or a lesser request (for example, it cannot make the child as big as the request but it can make the child bigger than its current size). In such cases, the geometry manager fills in geometry_return with the actual changes it is willing to make, including an appropriate mask, and returns **XtGeometryAlmost**. If a bit in geometry_return->request_mode is zero, the geometry manager does not change the corresponding value if the geometry_return is used immediately in a new request. If a bit is one, the geometry manager does change that element to the corresponding value in geometry_return. More bits may be set in geometry_return than in the original request if the geometry manager intends to change other fields should the child accept the compromise.

When **XtGeometryAlmost** is returned, the widget must decide if the compromise suggested in geometry_return is acceptable. If it is, the widget must not change its geometry directly; rather, it must make another call to **XtMakeGeometryRequest**.

If the next geometry request from this child uses the geometry_return box filled in by an **XtGeometryAlmost** return and if there have been no intervening geometry requests on either its parent or any of its other children, the geometry manager must grant the request, if possible. That is, if the child asks immediately with the returned geometry, it should get an answer of **XtGeometryYes**. However, the user's window manager may affect the final outcome.

To return an **XtGeometryYes**, the geometry manager frequently rearranges the position of other managed children by calling **XtMoveWidget**. However, a few geometry managers may sometimes change the size of other managed children by calling **XtResizeWidget** or **XtConfigureWidget**. If **XtCWQueryOnly** is specified, the geometry manager must return how it would react to this geometry request without actually moving or resizing any widgets.

Geometry managers must not assume that the request and geometry_return arguments point to independent storage. The caller is permitted to use the same field for both, and the geometry manager must allocate its own temporary storage, if necessary.

6.6. Widget Placement and Sizing

To move a sibling widget of the child making the geometry request, use **XtMoveWidget**.

```
void XtMoveWidget(w, x, y)
    Widget w;
    Position x;
    Position y;
```

w Specifies the widget.

x
y Specify the new widget x and y coordinates.

The **XtMoveWidget** function returns immediately if the specified geometry fields are the same as the old values. Otherwise, **XtMoveWidget** writes the new x and y values into the widget and, if the widget is realized, issues an Xlib **XMoveWindow** call on the widget's window.

To resize a sibling widget of the child making the geometry request, use **XtResizeWidget**.

```
void XtResizeWidget(w, width, height, border_width)
    Widget w;
    Dimension width;
    Dimension height;
    Dimension border_width;
```

w Specifies the widget.

width
height
border_width Specify the new widget size.

The **XtResizeWidget** function returns immediately if the specified geometry fields are the same as the old values. Otherwise, **XtResizeWidget** writes the new width, height, and border_width values into the widget and, if the widget is realized, issues an **XConfigureWindow** call on the widget's window.

If the new width or height are different from the old values, **XtResizeWidget** calls the widget's resize procedure to notify it of the size change.

To move and resize the sibling widget of the child making the geometry request, use **XtConfigureWidget**.

```
void XtConfigureWidget(w, x, y, width, height, border_width)
    Widget w;
    Position x;
    Position y;
    Dimension width;
    Dimension height;
    Dimension border_width;
```

w Specifies the widget.

x
y Specify the new widget x and y coordinates.

width
height
border_width Specify the new widget size.

The **XtConfigureWidget** function returns immediately if the specified geometry fields are the same as the old values. Otherwise, **XtConfigureWidget** writes the new x, y, width, height, and border_width values into the widget and, if the widget is realized, makes an Xlib **XConfigureWindow** call on the widget's window.

If either the new width or height is different from its old value, **XtConfigureWidget** calls the widget's resize procedure to notify it of the size change; otherwise, it simply returns.

To resize a child widget that already has the new values of its width, height, and border width fields, use **XtResizeWindow**.

void XtResizeWindow(*w*)
    Widget *w*;

w Specifies the widget.

The **XtResizeWindow** function calls the **XConfigureWindow** Xlib function to make the window of the specified widget match its width, height, and border width. This request is done unconditionally because there is no way to tell if these values match the current values. Note that the widget's resize procedure is not called.

There are very few times to use **XtResizeWindow**; instead, you should use **XtResizeWidget**.

6.7. Preferred Geometry

Some parents may be willing to adjust their layouts to accommodate the preferred geometries of their children. They can use **XtQueryGeometry** to obtain the preferred geometry and, as they see fit, can use or ignore any portion of the response.

To query a child widget's preferred geometry, use **XtQueryGeometry**.

XtGeometryResult XtQueryGeometry(*w*, *intended*, *preferred_return*)
    Widget *w*;
    XtWidgetGeometry **intended*, **preferred_return*;

w Specifies the widget.

intended Specifies any changes the parent plans to make to the child's geometry or NULL.

preferred_return Returns the child widget's preferred geometry.

To discover a child's preferred geometry, the child's parent sets any changes that it intends to make to the child's geometry in the corresponding fields of the intended structure, sets the corresponding bits in intended.request_mode, and calls **XtQueryGeometry**.

XtQueryGeometry clears all bits in the preferred_return->request_mode and checks the query_geometry field of the specified widget's class record. If query_geometry is not NULL, **XtQueryGeometry** calls the query_geometry procedure and passes as arguments the specified widget, intended, and preferred_return structures. If the intended argument is NULL, **XtQueryGeometry** replaces it with a pointer to an **XtWidgetGeometry** structure with request_mode=0 before calling query_geometry.

The query_geometry procedure pointer is of type **XtGeometryHandler**.

typedef XtGeometryResult (*XtGeometryHandler)(Widget, XtWidgetGeometry *, XtWidgetGeometry *);
    Widget *w*;
    XtWidgetGeometry **request*;
    XtWidgetGeometry **geometry_return*;

The query_geometry procedure is expected to examine the bits set in request->request_mode, evaluate the preferred geometry of the widget, and store the result in geometry_return (setting the bits in geometry_return->request_mode corresponding to those geometry fields that it cares about). If the proposed geometry change is acceptable without modification, the query_geometry procedure should return **XtGeometryYes**. If at least one field in geometry_return is different from the corresponding field in request or if a bit was set in geometry_return that was not set in request, the query_geometry procedure should return **XtGeometryAlmost**. If the preferred geometry is identical to the current geometry, the query_geometry procedure should return

XtGeometryNo.

After calling the query_geometry procedure or if the query_geometry field is NULL, **XtQueryGeometry** examines all the unset bits in geometry_return->request_mode and sets the corresponding fields in geometry_return to the current values from the widget instance. If CWStackMode is not set, the stack_mode field is set to **XtSMDontChange**. **XtQueryGeometry** returns the value returned by the query_geometry procedure or **XtGeometryYes** if the query_geometry field is NULL.

Therefore, the caller can interpret a return of **XtGeometryYes** as not needing to evaluate the contents of reply and, more importantly, not needing to modify its layout plans. A return of **XtGeometryAlmost** means either that both the parent and the child expressed interest in at least one common field and the child's preference does not match the parent's intentions or that the child expressed interest in a field that the parent might need to consider. A return value of XtGeometryNo means that both the parent and the child expressed interest in a field and that the child suggests that the field's current value is its preferred value. In addition, whether or not the caller ignores the return value or the reply mask, it is guaranteed that the reply structure contains complete geometry information for the child.

Parents are expected to call **XtQueryGeometry** in their layout routine and wherever other information is significant after change_managed has been called. The changed_managed procedure may assume that the child's current geometry is its preferred geometry. Thus, the child is still responsible for storing values into its own geometry during its initialize procedure.

6.8. Size Change Management: the resize Procedure

A child can be resized by its parent at any time. Widgets usually need to know when they have changed size so that they can lay out their displayed data again to match the new size. When a parent resizes a child, it calls **XtResizeWidget**, which updates the geometry fields in the widget, configures the window if the widget is realized, and calls the child's resize procedure to notify the child. The resize procedure pointer is of type **XtWidgetProc**.

If a class need not recalculate anything when a widget is resized, it can specify NULL for the resize field in its class record. This is an unusual case and should occur only for widgets with very trivial display semantics. The resize procedure takes a widget as its only argument. The x, y, width, height and border_width fields of the widget contain the new values. The resize procedure should recalculate the layout of internal data as needed. (For example, a centered Label in a window that changes size should recalculate the starting position of the text.) The widget must obey resize as a command and must not treat it as a request. A widget must not issue an **XtMakeGeometryRequest** or **XtMakeResizeRequest** call from its resize procedure.

Chapter 7

Event Management

While X allows the reading and processing of events anywhere in an application, widgets in the X Toolkit neither directly read events nor grab the server or pointer. Widgets register procedures that are to be called when an event or class of events occurs in that widget.

A typical application consists of startup code followed by an event loop that reads events and dispatches them by calling the procedures that widgets have registered. The default event loop provided by the Intrinsics is **XtAppMainLoop**.

The event manager is a collection of functions to perform the following tasks:

- Add or remove event sources other than X server events (in particular, timer interrupts and file input).
- Query the status of event sources.
- Add or remove procedures to be called when an event occurs for a particular widget.
- Enable and disable the dispatching of user-initiated events (keyboard and pointer events) for a particular widget.
- Constrain the dispatching of events to a cascade of pop-up widgets.
- Call the appropriate set of procedures currently registered when an event is read.

Most widgets do not need to call any of the event handler functions explicitly. The normal interface to X events is through the higher-level translation manager, which maps sequences of X events (with modifiers) into procedure calls. Applications rarely use any of the event manager routines besides **XtAppMainLoop**.

7.1. Adding and Deleting Additional Event Sources

While most applications are driven only by X events, some applications need to incorporate other sources of input into the X Toolkit event handling mechanism. The event manager provides routines to integrate notification of timer events and file data pending into this mechanism.

The next section describes functions that provide input gathering from files. The application registers the files with the Intrinsics read routine. When input is pending on one of the files, the registered callback procedures are invoked.

7.1.1. Adding and Removing Input Sources

To register a new file as an input source for a given application, use **XtAppAddInput**.

XtInputId XtAppAddInput(*app_context*, *source*, *condition*, *proc*, *client_data*)
    XtAppContext *app_context*;
    int *source*;
    caddr_t *condition*;
    XtInputCallbackProc *proc*;
    caddr_t *client_data*;

app_context	Specifies the application context that identifies the application.
source	Specifies the source file descriptor on a UNIX-based system or other operating system dependent device specification.
condition	Specifies the mask that indicates a read, write, or exception condition or some operating system dependent condition.

proc Specifies the procedure that is to be called when input is available.

client_data Specifies the argument that is to be passed to the specified procedure when input is available.

The **XtAppAddInput** function registers with the Intrinsics read routine a new source of events, which is usually file input but can also be file output. Note that file should be loosely interpreted to mean any sink or source of data. **XtAppAddInput** also specifies the conditions under which the source can generate events. When input is pending on this source, the callback procedure is called.

The legal values for the condition argument are operating-system dependent. On a UNIX-based system, the condition is some union of **XtInputReadMask**, **XtInputWriteMask**, and **XtInputExceptMask**.

Callback procedure pointers that are used when there are file events are of type **XtInputCallbackProc**:

```
typedef void (*XtInputCallbackProc)(caddr_t, int *, XtInputId *);
        caddr_t client_data;
        int *source;
        XtInputId *id;
```

client_data Specifies the client data that was registered for this procedure in **XtAppAddInput**.

source Specifies the source file descriptor generating the event.

id Specifies the ID returned from the corresponding **XtAppAddInput** call.

To discontinue a source of input, use **XtRemoveInput**.

```
void XtRemoveInput(id)
    XtInputId id;
```

id Specifies the ID returned from the corresponding **XtAppAddInput** call.

The **XtRemoveInput** function causes the Intrinsics read routine to stop watching for input from the input source.

7.1.2. Adding and Removing Timeouts

The timeout facility notifies the application or the widget through a callback procedure that a specified time interval has elapsed. Timeout values are uniquely identified by an interval ID.

To create a timeout value, use **XtAppAddTimeOut**.

```
XtIntervalId XtAppAddTimeOut(app_context, interval, proc, client_data)
    XtAppContext app_context;
    unsigned long interval;
    XtTimerCallbackProc proc;
    caddr_t client_data;
```

app_context Specifies the application context for which the timer is to be set.

interval Specifies the time interval in milliseconds.

proc Specifies the procedure that is to be called when the time expires.

client_data Specifies the argument that is to be passed to the specified procedure when it is called.

The **XtAppAddTimeOut** function creates a timeout and returns an identifier for it. The timeout value is set to interval. The callback procedure is called when the time interval elapses, and then the timeout is removed.

Callback procedure pointer that are used when timeouts expire are of type **XtTimerCallback-Proc**:

```
typedef void (*XtTimerCallbackProc)(caddr_t, XtIntervalId *);
        caddr_t client_data;
        XtIntervalId *id;
```

client_data Specifies the client data that was registered for this procedure in **XtAppAddTimeOut**.

id Specifies the ID returned from the corresponding **XtAppAddTimeOut** call.

To clear a timeout value, use **XtRemoveTimeOut**.

```
void XtRemoveTimeOut(timer)
    XtIntervalId timer;
```

timer Specifies the ID for the timeout request to be destroyed.

The **XtRemoveTimeOut** function removes the timeout. Note that timeouts are automatically removed once they trigger.

7.2. Constraining Events to a Cascade of Widgets

Modal widgets are widgets that, except for the input directly to them, lock out user input to the application.

When a modal menu or modal dialog box is popped up using **XtPopup**, user events (keyboard and pointer events) that occur outside the modal widget should be delivered to the modal widget or ignored. In no case will user events be delivered to a widget outside the modal widget.

Menus can pop up submenus and dialog boxes can pop up further dialog boxes to create a pop-up cascade. In this case, user events may be delivered to one of several modal widgets in the cascade.

Display-related events should be delivered outside the modal cascade so that expose events and the like keep the application's display up to date. Any event that occurs within the cascade is delivered as usual. The user events that are delivered to the most recent spring-loaded shell in the cascade when they occur outside the cascade are called remap events and are **KeyPress**, **KeyRelease**, **ButtonPress**, and **ButtonRelease**. The user events that are ignored when they occur outside the cascade are **MotionNotify**, **EnterNotify**, and **LeaveNotify**. All other events are delivered normally.

XtPopup uses the **XtAddGrab** and **XtRemoveGrab** functions to constrain user events to a modal cascade and subsequently to remove a grab when the modal widget goes away. Usually you should have no need to call them explicitly.

To redirect user input to a modal widget, use **XtAddGrab**.

```
void XtAddGrab(w, exclusive, spring_loaded)
    Widget w;
    Boolean exclusive;
    Boolean spring_loaded;
```

w Specifies the widget to add to the modal cascade.

exclusive Specifies whether user events should be dispatched exclusively to this widget or also to previous widgets in the cascade.

spring_loaded Specifies whether this widget was popped up because the user pressed a pointer button.

The **XtAddGrab** function appends the widget (and associated parameters) to the modal cascade and checks that exclusive is **True** if spring_loaded is **True**. If these are not **True**, **XtAddGrab** generates an error.

The modal cascade is used by **XtDispatchEvent** when it tries to dispatch a user event. When at least one modal widget is in the widget cascade, **XtDispatchEvent** first determines if the event should be delivered. It starts at the most recent cascade entry and follows the cascade up to and including the most recent cascade entry added with the exclusive parameter **True**.

This subset of the modal cascade along with all descendants of these widgets comprise the active subset. User events that occur outside the widgets in this subset are ignored or remapped. Modal menus with submenus generally add a submenu widget to the cascade with exclusive **False**. Modal dialog boxes that need to restrict user input to the most deeply nested dialog box add a subdialog widget to the cascade with exclusive **True**. User events that occur within the active subset are delivered to the appropriate widget, which is usually a child or further descendant of the modal widget.

Regardless of where on the screen they occur, remap events are always delivered to the most recent widget in the active subset of the cascade that has spring_loaded **True**, if any such widget exists.

To remove the redirection of user input to a modal widget, use **XtRemoveGrab**.

```
void XtRemoveGrab(w)
    Widget w;
```

w Specifies the widget to remove from the modal cascade.

The **XtRemoveGrab** function removes widgets from the modal cascade starting at the most recent widget up to and including the specified widget. It issues an error if the specified widget is not on the modal cascade.

7.3. Focusing Events on a Child

To redirect keyboard input to a child of a **Composite** widget without calling **XSetInputFocus**, use **XtSetKeyboardFocus**.

```
XtSetKeyboardFocus(subtree, descendant)
    Widget subtree, descendant;
```

subtree Specifies the subtree of the hierarchy for which the keyboard focus is to be set.

descendant Specifies either the widget in the subtree structure which is to receive the keyboard event, or **None**. Note that it is not an error to specify **None** when no input focus was previously set.

If a future **KeyPress** or **KeyRelease** event occurs within the specified subtree, **XtSetKeyboard-Focus** causes **XtDispatchEvent** to remap and send the event to the specified descendant widget.

When there is no modal cascade, keyboard events can occur within a widget W in one of three ways:

- W has the X input focus.
- W has the keyboard focus of one of its ancestors, and the event occurs within the ancestor or one of the ancestor's descendants.
- No ancestor of W has a descendant within the keyboard focus, and the pointer is within W.

When there is a modal cascade, a widget W receives keyboard events if an ancestor of W is in the active subset of the modal cascade and one or more of the previous conditions is **True**.

When subtree or one of its descendants acquires the X input focus or the pointer moves into the subtree such that keyboard events would now be delivered to subtree, a **FocusIn** event is generated for the descendant if **FocusNotify** events have been selected by the descendant. Similarly, when W loses the X input focus or the keyboard focus for one of its ancestors, a **FocusOut** event is generated for descendant if **FocusNotify** events have been selected by the descendant.

The accept_focus procedure pointer is of type **XtAcceptFocusProc**:

```
typedef Boolean (*XtAcceptFocusProc)(Widget, Time);
      Widget w;
      Time *time;
```

w Specifies the widget.

time Specifies the X time of the event causing the accept focus.

Widgets that need the input focus can call **XSetInputFocus** explicitly. To allow outside agents to cause a widget to get the input focus, every widget exports an accept_focus procedure. The widget returns whether it actually took the focus or not, so that the parent can give the focus to another widget. Widgets that need to know when they lose the input focus must use the Xlib focus notification mechanism explicitly (typically by specifying translations for **FocusIn** and **FocusOut** events). Widgets that never want the input focus should set their accept_focus procedure pointer to NULL.

To call a widget's accept_focus procedure, use **XtCallAcceptFocus**.

```
Boolean XtCallAcceptFocus(w, time)
     Widget w;
     Time *time;
```

w Specifies the widget.

time Specifies the X time of the event that is causing the accept focus.

The **XtCallAcceptFocus** function calls the specified widget's accept_focus procedure, passing it the specified widget and time, and returns what the accept_focus procedure returns. If accept_focus is NULL, **XtCallAcceptFocus** returns **False**.

7.4. Querying Event Sources

The event manager provides several functions to examine and read events (including file and timer events) that are in the queue. The next three functions handle Intrinsics equivalents of the **XPending**, **XPeekEvent**, and **XNextEvent** Xlib calls.

To determine if there are any events on the input queue for a given application, use **XtAppPending**.

```
XtInputMask XtAppPending(app_context)
     XtAppContext app_context;
```

app_context Specifies the application context that identifies the application to check.

The **XtAppPending** function returns a nonzero value if there are events pending from the X server, timer pending, or other input sources pending. The value returned is a bit mask that is the OR of **XtIMXEvent**, **XtIMTimer**, and **XtIMAlternateInput** (see **XtAppProcessEvent**). If there are no events pending, **XtAppPending** flushes the output buffer and returns zero.

To return the value from the head of a given application's input queue without removing input from the queue, use **XtAppPeekEvent**.

```
Boolean XtAppPeekEvent(app_context, event_return)
     XtAppContext app_context;
     XEvent *event_return;
```

app_context Specifies the application context that identifies the application.

event_return Returns the event information to the specified event structure.

If there is an event in the queue, **XtAppPeekEvent** fills in the event and returns a nonzero value. If no X input is on the queue, **XtAppPeekEvent** flushes the output buffer and blocks until input is available (possibly calling some timeout callbacks in the process). If the input is an event, **XtAppPeekEvent** fills in the event and returns a nonzero value. Otherwise, the input is for an alternate input source, and **XtAppPeekEvent** returns zero.

To return the value from the head of a given application's input queue, use **XtAppNextEvent**.

void XtAppNextEvent(*app_context*, *event_return*)
    XtAppContext *app_context*;
    XEvent **event_return*;

app_context Specifies the application context that identifies the application.

event_return Returns the event information to the specified event structure.

If no input is on the X input queue, **XtAppNextEvent** flushes the X output buffer and waits for an event while looking at the other input sources and timeout values and calling any callback procedures triggered by them. This wait time can be used for background processing (see Section 7.8).

7.5. Dispatching Events

The Intrinsics provide functions that dispatch events to widgets or other application code. Every client interested in X events on a widget uses **XtAddEventHandler** to register which events it is interested in and a procedure (event handler) that is to be called when the event happens in that window. The translation manager automatically registers event handlers for widgets that use translation tables (see Chapter 10).

Applications that need direct control of the processing of different types of input should use **XtAppProcessEvent**.

void XtAppProcessEvent(*app_context*, *mask*)
    XtAppContext *app_context*;
    XtInputMask *mask*;

app_context Specifies the application context that identifies the application for which to process input.

mask Specifies what types of events to process. The mask is the bitwise inclusive OR of any combination of **XtIMXEvent**, **XtIMTimer**, and **XtIMAlternateInput**. As a convenience, the X Toolkit defines the symbolic name **XtIMAll** to be the bitwise inclusive OR of all event types.

The **XtAppProcessEvent** function processes one timer, alternate input, or X event. If there is nothing of the appropriate type to process, **XtAppProcessEvent** blocks until there is. If there is more than one type of thing available to process, it is undefined which will get processed. Usually, this procedure is not called by client applications (see **XtAppMainLoop**). **XtAppProcessEvent** processes timer events by calling any appropriate timer callbacks, alternate input by calling any appropriate alternate input callbacks, and X events by calling **XtDispatchEvent**.

When an X event is received, it is passed to **XtDispatchEvent**, which calls the appropriate event handlers and passes them the widget, the event, and client-specific data registered with each procedure. If there are no handlers for that event registered, the event is ignored and the dispatcher simply returns. The order in which the handlers are called is undefined.

Boolean XtDispatchEvent(*event*)
    XEvent **event*;

event Specifies a pointer to the event structure that is to be dispatched to the appropriate event handler.

The **XtDispatchEvent** function sends those events to the event handler functions that have been previously registered with the dispatch routine. **XtDispatchEvent** returns **True** if it dispatched the event to some handler and **False** if it found no handler to dispatch the event to. The most common use of **XtDispatchEvent** is to dispatch events acquired with the **XtAppNextEvent** procedure. However, it also can be used to dispatch user-constructed events. **XtDispatchEvent** also is responsible for implementing the grab semantics for **XtAddGrab**.

7.6. The Application Input Loop

To process input from a given application, use **XtAppMainLoop**.

void XtAppMainLoop(*app_context*)
    XtAppContext *app_context*;

app_context Specifies the application context that identifies the application.

The **XtAppMainLoop** function first reads the next incoming X event by calling **XtAppNextEvent** and then it dispatches the event to the appropriate registered procedure by calling **XtDispatchEvent**. This constitutes the main loop of X Toolkit applications, and, as such, it does not return. Applications are expected to exit in response to some user action. There is nothing special about **XtAppMainLoop**; it is simply an infinite loop that calls **XtAppNextEvent** and then **XtDispatchEvent**.

Applications can provide their own version of this loop, which tests some global termination flag or tests that the number of top-level widgets is larger than zero before circling back to the call to **XtAppNextEvent**.

7.7. Setting and Checking the Sensitivity State of a Widget

Many widgets have a mode in which they assume a different appearance (for example, are greyed out or stippled), do not respond to user events, and become dormant.

When dormant, a widget is considered to be insensitive. If a widget is insensitive, the Event Manager does not dispatch any events to the widget with an event type of **KeyPress**, **KeyRelease**, **ButtonPress**, **ButtonRelease**, **MotionNotify**, **EnterNotify**, **LeaveNotify**, **FocusIn**, or **FocusOut**.

A widget can be insensitive because its sensitive field is **False** or because one of its parents is insensitive, and, thus, the widget's ancestor_sensitive field also is **False**. A widget can but does not need to distinguish these two cases visually.

To set the sensitivity state of a widget, use **XtSetSensitive**.

void XtSetSensitive(*w*, *sensitive*)
    Widget *w*;
    Boolean *sensitive*;

w Specifies the widget.

sensitive Specifies a Boolean value that indicates whether the widget should receive keyboard and pointer events.

The **XtSetSensitive** function first calls **XtSetValues** on the current widget with an argument list specifying that the sensitive field should change to the new value. It then recursively propagates the new value down the managed children tree by calling **XtSetValues** on each child to set the ancestor_sensitive to the new value if the new values for sensitive and the child's ancestor_sensitive are not the same.

XtSetSensitive calls **XtSetValues** to change sensitive and ancestor_sensitive. Therefore, when one of these changes, the widget's set_values procedure should take whatever display actions are needed (for example, greying out or stippling the widget).

XtSetSensitive maintains the invariant that if parent has either sensitive or ancestor_sensitive **False**, then all children have ancestor_sensitive **False**.

To check the current sensitivity state of a given widget (which is usually done by parents), use **XtIsSensitive**.

```
Boolean XtIsSensitive(w)
    Widget w;
```

w Specifies the widget.

The **XtIsSensitive** function returns **True** or **False** to indicate whether or not user input events are being dispatched. If both core.sensitive and core.ancestor_sensitive are **True**, **XtIsSensitive** returns **True**; otherwise, it returns **False**.

7.8. Adding Background Work Procedures

The Intrinsics have limited support for background processing. Because most applications spend most of their time waiting for input, you can register an idle-time work procedure that will be called when the toolkit would otherwise block in **XtAppNextEvent** or **XtAppProcessEvent**. Work procedure pointers are of type **XtWorkProc**:

```
typedef Boolean (*XtWorkProc)(caddr_t);
    caddr_t client_data;
```

client_data Client data specified when the work proc was registered.

This procedure returns **True** if it is done, that is, the work procedure should be removed. Work procedures should be very judicious about how much they do. If they run for more than a small part of a second, response time is likely to suffer.

To register a work procedure for a given application, use **XtAppAddWorkProc**.

```
XtWorkProcId XtAppAddWorkProc(app_context, proc, client_data)
    XtAppContext app_context;
    XtWorkProc proc;
    caddr_t client_data;
```

app_context Specifies the application context that identifies the application.

proc Specifies the procedure that is to be called when the application is idle.

client_data Specifies the argument that is to be passed to the specified procedure when it is called.

The **XtAppAddWorkProc** function adds the specified work procedure for the application identified by app_context.

XtWorkProcId is an opaque unique identifier for this work procedure. Multiple work procedures can be registered, and the most recently added one is always the one that is called. However, if a work procedure adds another work procedure, the newly added one has lower priority than the current one.

To remove a work procedure, either return **True** from the procedure when it is called or use **XtRemoveWorkProc**.

```
void XtRemoveWorkProc(id)
    XtWorkProcId id;
```

id Specifies which work procedure to remove.

The **XtRemoveWorkProc** function explicitly removes the specified background work procedure.

7.9. X Event Filters

The event manager provides filters that can be applied to X user events. The filters, which screen out events that are redundant or are temporarily unwanted, handle the following:

- Pointer motion compression
- Enter/leave compression
- Exposure compression

7.9.1. Pointer Motion Compression

Widgets can have a hard time keeping up with pointer motion events. Further, they usually do not actually care about every motion event. To throw out redundant motion events, the widget class field compress_motion should be **True**. When a request for an event would return a motion event, the Intrinsics check if there are any other motion events immediately following the current one, and, if so, skip all but the last of them.

7.9.2. Enter/Leave Compression

To throw out pairs of enter and leave events that have no intervening events, as can happen when the user moves the pointer across a widget without stopping in it, the widget class field compress_enterleave should be **True**. These enter and leave events are not delivered to the client if they are found together in the input queue.

7.9.3. Exposure Compression

Many widgets prefer to process a series of exposure events as a single expose region rather than as individual rectangles. Widgets with complex displays might use the expose region as a clip list in a graphics context, and widgets with simple displays might ignore the region entirely and redisplay their whole window or might get the bounding box from the region and redisplay only that rectangle.

In either case, these widgets do not care about getting partial expose events. If the compress_exposure field in the widget class structure is **True**, the event manager calls the widget's expose procedure only once for each series of exposure events. In this case, all **Expose** events are accumulated into a region. When the final **Expose** event in a series (that is, the one with count zero) is received, the event manager replaces the rectangle in the event with the bounding box for the region and calls the widget's expose procedure, passing the modified exposure event and the region. (See *Xlib – C Language X Interface.*)

If compress_exposure is **False**, the event manager calls the widget's expose procedure for every exposure event, passing it the event and a region argument of NULL.

7.10. Widget Exposure and Visibility

Every primitive widget and some composite widgets display data on the screen by means of raw Xlib calls. Widgets cannot simply write to the screen and forget what they have done. They must keep enough state to redisplay the window or parts of it if a portion is obscured and then reexposed.

7.10.1. Redisplay of a Widget: the expose Procedure

The expose procedure pointer in a widget class is of type **XtExposeProc**:

typedef void (*XtExposeProc)(Widget, XEvent *, Region);
    Widget *w*;
    XEvent **event*;
    Region *region*;

w	Specifies the widget instance requiring redisplay.
event	Specifies the exposure event giving the rectangle requiring redisplay.
region	Specifies the union of all rectangles in this exposure sequence.

The redisplay of a widget upon exposure is the responsibility of the expose procedure in the widget's class record. If a widget has no display semantics, it can specify NULL for the expose field. Many composite widgets serve only as containers for their children and have no expose procedure.

Note

> If the expose procedure is NULL, **XtRealizeWidget** fills in a default bit gravity of **NorthWestGravity** before it calls the widget's realize procedure.

If the widget's compress_exposure class field is **False** (see Section 7.9.3), region always is NULL. If the widget's compress_exposure class field is **True**, the event contains the bounding box for region.

A small simple widget (for example, Label) can ignore the bounding box information in the event and redisplay the entire window. A more complicated widget (for example, Text) can use the bounding box information to minimize the amount of calculation and redisplay it does. A very complex widget uses the region as a clip list in a GC and ignores the event information. The expose procedure is responsible for exposure of all superclass data as well as its own.

However, it often is possible to anticipate the display needs of several levels of subclassing. For example, rather than separate display procedures for the widgets Label, Command, and Toggle, you could write a single display routine in Label that uses display state fields like the following:

```
Boolean invert
Boolean highlight
Dimension highlight_width
```

Label would have invert and highlight always **False** and highlight_width zero. Command would dynamically set highlight and highlight_width, but it would leave invert always **False**. Finally, Toggle would dynamically set all three. In this case, the expose procedures for Command and Toggle inherit their superclass's expose procedure. For further information, see Section 1.4.9.

7.10.2. Widget Visibility

Some widgets may use substantial computing resources to display data. However, this effort is wasted if the widget is not actually visible on the screen, that is, if the widget is obscured by another application or is iconified.

The visible field in the **Core** widget structure provides a hint to the widget that it need not display data. This field is guaranteed **True** by the time an **Expose** event is processed if the widget is visible but is usually **False** if the widget is not visible.

Widgets can use or ignore the visible hint. If they ignore it, they should have visible_interest in their widget class record set **False**. In such cases, the visible field is initialized **True** and never changes. If visible_interest is **True**, the event manager asks for **VisibilityNotify** events for the widget and updates the visible field accordingly.

7.11. X Event Handlers

Event handlers are procedures that are called when specified events occur in a widget. Most widgets need not use event handlers explicitly. Instead, they use the Intrinsics translation manager. Event handler procedure pointers are of the type **XtEventHandler**:

```
typedef void (*XtEventHandler)(Widget, caddr_t, XEvent *);
    Widget w;
    caddr_t client_data;
    XEvent *event;
```

w	Specifies the widget for which to handle events.
client_data	Specifies the client specific information registered with the event handler, which is usually NULL if the event handler is registered by the widget itself.

event Specifies the triggering event.

7.11.1. Event Handlers that Select Events

To register an event handler procedure with the dispatch mechanism, use **XtAddEventHandler**.

void XtAddEventHandler(*w*, *event_mask*, *nonmaskable*, *proc*, *client_data*)
    Widget *w*;
    EventMask *event_mask*;
    Boolean *nonmaskable*;
    XtEventHandler *proc*;
    caddr_t *client_data*;

w Specifies the widget for which this event handler is being registered.

event_mask Specifies the event mask for which to call this procedure.

nonmaskable Specifies a Boolean value that indicates whether this procedure should be called on the nonmaskable events (**GraphicsExpose**, **NoExpose**, **SelectionClear**, **SelectionRequest**, **SelectionNotify**, **ClientMessage**, and **MappingNotify**).

proc Specifies the procedure that is to be called.

client_data Specifies additional data to be passed to the client's event handler.

The **XtAddEventHandler** function registers a procedure with the dispatch mechanism that is to be called when an event that matches the mask occurs on the specified widget. If the procedure is already registered with the same client_data, the specified mask is ORed into the existing mask. If the widget is realized, **XtAddEventHandler** calls **XSelectInput**, if necessary.

To remove a previously registered event handler, use **XtRemoveEventHandler**.

void XtRemoveEventHandler(*w*, *event_mask*, *nonmaskable*, *proc*, *client_data*)
    Widget *w*;
    EventMask *event_mask*;
    Boolean *nonmaskable*;
    XtEventHandler *proc*;
    caddr_t *client_data*;

w Specifies the widget for which this procedure is registered.

event_mask Specifies the event mask for which to unregister this procedure.

nonmaskable Specifies a Boolean value that indicates whether this procedure should be removed on the nonmaskable events (**GraphicsExpose**, **NoExpose**, **SelectionClear**, **SelectionRequest**, **SelectionNotify**, **ClientMessage**, and **MappingNotify**).

proc Specifies the procedure that is to be removed.

client_data Specifies the client data registered.

The **XtRemoveEventHandler** function stops the specified procedure from receiving the specified events. The request is ignored if client_data does not match the value given in the call to **XtAddEventHandler**. If the widget is realized, **XtRemoveEventHandler** calls **XSelectInput**, if necessary. If the specified procedure has not been registered or if it has been registered with a different value of client_data, **XtRemoveEventHandler** returns without reporting an error.

To stop a procedure from receiving any events, which will remove it from the widget's event_table entirely, call **XtRemoveEventHandler** with an event_mask of **XtAllEvents** and with nonmaskable **True**.

7.11.2. Event Handlers that Do Not Select Events

On occasion, clients need to register an event handler procedure with the dispatch mechanism without causing the server to select for that event. To do this, use **XtAddRawEventHandler**.

void XtAddRawEventHandler(*w*, *event_mask*, *nonmaskable*, *proc*, *client_data*)
    Widget *w*;
    EventMask *event_mask*;
    Boolean *nonmaskable*;
    XtEventHandler *proc*;
    caddr_t *client_data*;

w Specifies the widget for which this event handler is being registered.

event_mask Specifies the event mask for which to call this procedure.

nonmaskable Specifies a Boolean value that indicates whether this procedure should be removed on the nonmaskable events (**GraphicsExpose**, **NoExpose**, **SelectionClear**, **SelectionRequest**, **SelectionNotify**, **ClientMessage**, and **MappingNotify**).

proc Specifies the procedure that is to be registered.

client_data Specifies additional data to be passed to the client's event handler.

The **XtAddRawEventHandler** function is similar to **XtAddEventHandler** except that it does not affect the widget's mask and never causes an **XSelectInput** for its events. Note that the widget might already have those mask bits set because of other nonraw event handlers registered on it.

To remove a previously registered raw event handler, use **XtRemoveRawEventHandler**.

void XtRemoveRawEventHandler(*w*, *event_mask*, *nonmaskable*, *proc*, *client_data*)
    Widget *w*;
    EventMask *event_mask*;
    Boolean *nonmaskable*;
    XtEventHandler *proc*;
    caddr_t *client_data*;

w Specifies the widget for which this procedure is registered.

event_mask Specifies the event mask for which to unregister this procedure.

nonmaskable Specifies a Boolean value that indicates whether this procedure should be removed on the nonmaskable events (**GraphicsExpose**, **NoExpose**, **SelectionClear**, **SelectionRequest**, **SelectionNotify**, **ClientMessage**, and **MappingNotify**).

proc Specifies the procedure that is to be registered.

client_data Specifies the client data registered.

The **XtRemoveRawEventHandler** function stops the specified procedure from receiving the specified events. Because the procedure is a raw event handler, this does not affect the widget's mask and never causes a call on **XSelectInput**.

7.11.3. Current Event Mask

To retrieve the event mask for a given widget, use **XtBuildEventMask**.

EventMask XtBuildEventMask(*w*)
    Widget *w*;

w Specifies the widget.

The **XtBuildEventMask** function returns the event mask representing the logical OR of all event masks for event handlers registered on the widget with **XtAddEventHandler** and all event translations, including accelerators, installed on the widget. This is the same event mask stored into the **XSetWindowAttributes** structure by **XtRealizeWidget** and sent to the server when event handlers and translations are installed or removed on the realized widget.

Chapter 8

Callbacks

Applications and other widgets (clients) often need to register a procedure with a widget that gets called under certain conditions. For example, when a widget is destroyed, every procedure on the widget's destroy_callbacks list is called to notify clients of the widget's impending doom.

Every widget has a destroy_callbacks list. Widgets can define additional callback lists as they see fit. For example, the Command widget has a callback list to notify clients when the button has been activated.

8.1. Using Callback Procedure and Callback List Definitions

Callback procedure fields for use in callback lists are of type **XtCallbackProc**:

```
typedef void (*XtCallbackProc)(Widget, caddr_t, caddr_t);
    Widget w;
    caddr_t client_data;
    caddr_t call_data;
```

w	Specifies the widget for which the callback is registered.
client_data	Specifies the data that the widget should pass back to the client when the widget executes the client's callback procedure.
call_data	Specifies any callback-specific data the widget wants to pass to the client. For example, when Scrollbar executes its thumbChanged callback list, it passes the new position of the thumb.

The client_data argument provides a way for the client registering the callback also to register client-specific data (for example, a pointer to additional information about the widget, a reason for invoking the callback, and so on). The client_data value should be NULL if all necessary information is in the widget. The call_data argument is a convenience to avoid having simple cases where the client could otherwise call **XtGetValues** or a widget-specific function to retrieve data from the widget. Widgets should generally avoid putting complex state information in call_data. The client can use the more general data retrieval methods, if necessary.

Whenever a client wants to pass a callback list as an argument in an **XtCreateWidget**, **XtSet-Values**, or **XtGetValues** call, it should specify the address of a null-terminated array of type **XtCallbackList**:

```
typedef struct {
        XtCallbackProc callback;
        caddr_t closure;
} XtCallbackRec, *XtCallbackList;
```

For example, the callback list for procedures A and B with client data clientDataA and clientDataB, respectively, is:

```
static XtCallbackRec callbacks[] = {
        {A, (caddr_t) clientDataA},
        {B, (caddr_t) clientDataB},
        {(XtCallbackProc) NULL, (caddr_t) NULL}
};
```

Although callback lists are passed by address in argument lists, the Intrinsics know about callback lists. Your widget initialize and set_values procedures should not allocate memory for the callback list. The Intrinsics automatically do this for you by using a different structure for their internal representation.

8.2. Identifying Callback Lists

Whenever a widget contains a callback list for use by clients, it also exports in its public .h file the resource name of the callback list. Applications and client widgets never access callback list fields directly. Instead, they always identify the desired callback list by using the exported resource name. All the callback manipulation functions described in this chapter check to see that the requested callback list is indeed implemented by the widget.

For the Intrinsics to find and correctly handle callback lists, they should be declared with a resource type of **XtRCallback**.

8.3. Adding Callback Procedures

To add a callback procedure to a given widget's callback list, use **XtAddCallback**.

void XtAddCallback(*w*, *callback_name*, *callback*, *client_data*)
    Widget *w*;
    String *callback_name*;
    XtCallbackProc *callback*;
    caddr_t *client_data*;

w	Specifies the widget.
callback_name	Specifies the callback list to which the procedure is to be appended.
callback	Specifies the callback procedure.
client_data	Specifies the argument that is to be passed to the specified procedure when it is invoked by **XtCallCallbacks** or NULL.

A callback will be invoked as many times as it occurs in the callback list.

To add a list of callback procedures to a given widget's callback list, use **XtAddCallbacks**.

void XtAddCallbacks(*w*, *callback_name*, *callbacks*)
    Widget *w*;
    String *callback_name*;
    XtCallbackList *callbacks*;

w	Specifies the widget.
callback_name	Specifies the callback list to which the procedure is to be appended.
callbacks	Specifies the null-terminated list of callback procedures and corresponding client data.

8.4. Removing Callback Procedures

To delete a callback procedure from a given widget's callback list, use **XtRemoveCallback**.

void XtRemoveCallback(*w*, *callback_name*, *callback*, *client_data*)
    Widget *w*;
    String *callback_name*;
    XtCallbackProc *callback*;
    caddr_t *client_data*;

w	Specifies the widget.
callback_name	Specifies the callback list from which the procedure is to be deleted.
callback	Specifies the callback procedure.
client_data	Specifies the client data to match on the registered callback procedure.

The **XtRemoveCallback** function removes a callback only if both the procedure and the client data match.

To delete a list of callback procedures from a given widget's callback list, use **XtRemoveCallbacks**.

```
void XtRemoveCallbacks(w, callback_name, callbacks)
    Widget w;
    String callback_name;
    XtCallbackList callbacks;
```

w	Specifies the widget.
callback_name	Specifies the callback list from which the procedures are to be deleted.
callbacks	Specifies the null-terminated list of callback procedures and corresponding client data.

To delete all callback procedures from a given widget's callback list and free all storage associated with the callback list, use **XtRemoveAllCallbacks**.

```
void XtRemoveAllCallbacks(w, callback_name)
    Widget w;
    String callback_name;
```

w	Specifies the widget.
callback_name	Specifies the callback list to be removed.

8.5. Executing Callback Procedures

To execute the procedures in a given widget's callback list, use **XtCallCallbacks**.

```
void XtCallCallbacks(w, callback_name, call_data)
    Widget w;
    String callback_name;
    caddr_t call_data;
```

w	Specifies the widget.
callback_name	Specifies the callback list to be executed.
call_data	Specifies a callback-list specific data value to pass to each of the callback procedure in the list.

If no data is needed (for example, the commandActivated callback list in Command needs only to notify its clients that the button has been activated), the call_data argument can be NULL. The call_data argument is the actual data if only one (32-bit) longword is needed or is the address of the data if more than one word is needed.

8.6. Checking the Status of a Callback List

To find out the status of a given widget's callback list, use **XtHasCallbacks**.

```
typedef enum {XtCallbackNoList, XtCallbackHasNone, XtCallbackHasSome} XtCallbackStatus;

XtCallbackStatus XtHasCallbacks(w, callback_name)
    Widget w;
    String callback_name;
```

w	Specifies the widget.
callback_name	Specifies the callback list to be checked.

The **XtHasCallbacks** function first checks to see if the widget has a callback list identified by callback_name. If the callback list does not exist, **XtHasCallbacks** returns **XtCallbackNoList**. If the callback list exists but is empty, it returns **XtCallbackHasNone**. If the callback list exists and has at least one callback registered, it returns **XtCallbackHasSome**.

Chapter 9

Resource Management

A resource is a field in the widget record with a corresponding resource entry in the resource list of the widget or any of its superclasses. This means that the field is settable by **XtCreateWidget** (by naming the field in the argument list), by an entry in the default resource files (by using either the name or class), and by **XtSetValues**. In addition, it is readable by **XtGetValues**. Not all fields in a widget record are resources. Some are for bookkeeping use by the generic routines (like managed and being_destroyed). Others can be for local bookkeeping, and still others are derived from resources (many graphics contexts and pixmaps).

Writers of widgets need to obtain a large set of resources at widget creation time. Some of the resources come from the argument list supplied in the call to **XtCreateWidget**, some from the resource database, and some from the internal defaults specified for the widget. Resources are obtained first from the argument list, then from the resource database for all resources not specified in the argument list, and lastly from the internal default, if needed.

9.1. Resource Lists

A resource entry specifies a field in the widget, the textual name and class of the field that argument lists and external resource files use to refer to the field and a default value that the field should get if no value is specified. The declaration for the **XtResource** structure is:

```
typedef struct {
        String resource_name;
        String resource_class;
        String resource_type;
        Cardinal resource_size;
        Cardinal resource_offset;
        String default_type;
        caddr_t default_address;
} XtResource, *XtResourceList;
```

The resource_name field contains the name used by clients to access the field in the widget. By convention, it starts with a lowercase letter and is spelled identically to the field name, except all underscores (_) are deleted and the next letter is replaced by its uppercase counterpart. For example, the resource name for background_pixel becomes backgroundPixel. Widget header files typically contain a symbolic name for each resource name. All resource names, classes, and types used by the Intrinsics are named in **<X11/StringDefs.h>**. The Intrinsics symbolic resource names begin with **XtN** and are followed by the string name (for example, XtNbackgroundPixel for backgroundPixel).

A resource class provides two functions:

- It isolates an application from different representations that widgets can use for a similar resource.
- It lets you specify values for several actual resources with a single name. A resource class should be chosen to span a group of closely related fields.

For example, a widget can have several pixel resources: background, foreground, border, block cursor, pointer cursor, and so on. Typically, the background defaults to white and everything else to black. The resource class for each of these resources in the resource list should be chosen so that it takes the minimal number of entries in the resource database to make background offwhite and everything else darkblue.

In this case, the background pixel should have a resource class of **Background** and all the other pixel entries a resource class of **Foreground**. Then, the resource file needs only two lines to change all pixels to offwhite or darkblue:

```
*Background:        offwhite
*Foreground:        darkblue
```

Similarly, a widget may have several resource fonts (such as normal and bold), but all fonts should have the class Font. Thus, changing all fonts simply requires only a single line in the default resource file:

```
*Font:  6x13
```

By convention, resource classes are always spelled starting with a capital letter. Their symbolic names are preceded with **XtC** (for example, XtCBackground).

The resource_type field is the physical representation type of the resource. By convention, it starts with an uppercase letter and is spelled identically to the type name of the field. The resource type is used when resources are fetched to convert from the resource database format (usually String) or the default resource format (almost anything, but often String) to the desired physical representation (see Section 9.6). The Intrinsics define the following resource types:

Resource Type	Structure or Field Type
XtRAcceleratorTable	XtAccelerators
XtRBoolean	Boolean
XtRBool	Bool
XtRCallback	XtCallbackList
XtRColor	XColor
XtRCursor	Cursor
XtRDimension	Dimension
XtRDisplay	Display*
XtRFile	FILE*
XtRFloat	float
XtRFont	Font
XtRFontStruct	XFontStruct *
XtRFunction	(*)()
XtRInt	int
XtRPixel	Pixel
XtRPixmap	Pixmap
XtRPointer	caddr_t
XtRPosition	Position
XtRShort	short
XtRString	char*
XtRTranslationTable	XtTranslations
XtRUnsignedChar	unsigned char
XtRWidget	Widget
XtRWindow	Window

The resource_size field is the size of the physical representation in bytes; you should specify it as "sizeof(*type*)" so that the compiler fills in the value. The resource_offset field is the offset in bytes of the field within the widget. You should use the **XtOffset** macro to retrieve this value. The default_type field is the representation type of the default resource value. If default_type is different from resource_type and the default_type is needed, the resource manager invokes a conversion procedure from default_type to resource_type. Whenever possible, the default type should be identical to the resource type in order to minimize widget creation time. However, there are sometimes no values of the type that the program can easily specify. In this case, it should be a value that the converter is guaranteed to work for (for example, **XtDefaultForeground** for a pixel resource). The default_address field is the address of the default resource value. The default is used if a resource is not specified in the argument list or in the resource database or if the conversion from the representation type stored in the resource database fails, which can happen for various reasons (for example, a misspelled entry in a resource file).

Two special representation types (**XtRImmediate** and **XtRCallProc**) are usable only as default resource types. **XtRImmediate** indicates that the value in the default_address field is the actual value of the resource rather than the address of the value. The value must be in correct representation type for the resource. No conversion is possible since there is no source representation type. **XtRCallProc** indicates that the value in the default_address field is a procedure variable. This procedure is automatically invoked with the widget, resource_offset, and a pointer to the **XrmValue** in which to store the result and is an **XtResourceDefaultProc**:

typedef void (*XtResourceDefaultProc)(Widget, int, XrmValue *)
    Widget *w*;
    int *offset*;
    XrmValue **value*;

w Specifies the widget whose resource is to be obtained.

offset Specifies the offset of the field in the widget record.

value Specifies the resource value to fill in.

The **XtResourceDefaultProc** procedure should fill in the addr field of the value with a pointer to the default data in its correct type.

Note

The default_address field in the resource structure is declared as a caddr_t. On some machine architectures, this may be insufficient to hold procedure variables.

To get the resource list structure for a particular class, use **XtGetResourceList**:

void XtGetResourceList(*class*, *resources_return*, *num_resources_return*);
    WidgetClass *class*;
    XtResourceList **resources_return*;
    Cardinal **num_resources_return*;

widget_class Specifies the widget class pointer for the created shell widget.

*resources_return*Specifies a pointer to where to store the returned resource list. The caller must free this storage using **XtFree** when done with it.

num_resources_return
    Specifies a pointer to where to store the number of entries in the resource list.

If it is called before the widget class is initialized (that is, before the first widget of that class has been created), **XtGetResourceList** returns the resource list as specified in the widget class record. If it is called after the widget class has been initialized, **XtGetResourceList** returns a merged resource list that contains the resources for all superclasses.

The routines **XtSetValues** and **XtGetValues** also use the resource list to set and get widget state. For further information, see Sections 9.7.1 and 9.7.2.

Here is an abbreviated version of the resource list in the Label widget:

```
/* Resources specific to Label */
static XtResource resources[] = {
{XtNforeground, XtCForeground, XtRPixel, sizeof(Pixel),
  XtOffset(LabelWidget, label.foreground), XtRString, XtDefaultForeground},
```

```
{XtNfont, XtCFont, XtRFontStruct, sizeof(XFontStruct *),
  XtOffset(LabelWidget, label.font),XtRString, XtDefaultFont},
{XtNlabel, XtCLabel, XtRString, sizeof(String),
  XtOffset(LabelWidget, label.label), XtRString, NULL},
                                                  .
                                                  .
                                                  .
}
```

The complete resource name for a field of a widget instance is the concatenation of the application shell name (from **XtAppCreateShell**), the instance names of all the widget's parents up to the **ApplicationShellWidget**, the instance name of the widget itself, and the resource name of the specified field of the widget. Likewise, the full resource class of a field of a widget instance is the concatenation of the application class (from **XtAppCreateShell**), the widget class names of all the widget's parents up to the **ApplicationShellWidget** (not the superclasses), the widget class name of the widget itself, and the resource name of the specified field of the widget.

9.2. Byte Offset Calculations

To determine the byte offset of a field within a structure, use **XtOffset**.

Cardinal XtOffset(*pointer_type*, *field_name*)
    Type *pointer_type*;
    Field *field_name*;

pointer_type Specifies a type that is declared as a pointer to the structure.

field_name Specifies the name of the field for which to calculate the byte offset.

The **XtOffset** macro is usually used to determine the offset of various resource fields from the beginning of a widget and can be used at compile time in static initializations.

9.3. Superclass to Subclass Chaining of Resource Lists

The **XtCreateWidget** function gets resources as a superclass-to-subclass operation. That is, the resources specified in **Core** resource list are fetched, then those in the subclass, and so on down to the resources specified for this widget's class. Within a class, resources are fetched in the order they are declared.

In general, if a widget resource field is declared in a superclass, that field is included in the superclass's resource list and need not be included in the subclass's resource list. For example, the **Core** class contains a resource entry for background_pixel. Consequently, the implementation of Label need not also have a resource entry for background_pixel. However, a subclass, by specifying a resource entry for that field in its own resource list, can override the resource entry for any field declared in a superclass. This is most often done to override the defaults provided in the superclass with new ones. At class initialization time, resource lists for that class are scanned from the superclass down to the class to look for resources with the same offset. A matching resource in a subclass will be reordered to override the superclass entry. (A copy of the superclass resource list is made to avoid affecting other subclasses of the superclass.)

9.4. Subresources

A widget does not do anything to get its own resources; instead, **XtCreateWidget** does this automatically before calling the class initialize procedure.

Some widgets have subparts that are not widgets but for which the widget would like to fetch resources. For example, the Text widget fetches resources for its source and sink. Such widgets call **XtGetSubresources** to accomplish this.

void XtGetSubresources(*w*, *base*, *name*, *class*, *resources*, *num_resources*, *args*, *num_args*)
    Widget *w*;
    caddr_t *base*;
    String *name*;
    String *class*;
    XtResourceList *resources*;
    Cardinal *num_resources*;
    ArgList *args*;
    Cardinal *num_args*;

w	Specifies the widget that wants resources for a subpart.
base	Specifies the base address of the subpart data structure where the resources should be written.
name	Specifies the name of the subpart.
class	Specifies the class of the subpart.
resources	Specifies the resource list for the subpart.
num_resources	Specifies the number of resources in the resource list.
args	Specifies the argument list to override resources obtained from the resource database.
num_args	Specifies the number of arguments in the argument list.

The **XtGetSubresources** function constructs a name/class list from the application name/class, the name/classes of all its ancestors, and the widget itself. Then, it appends to this list the name/class pair passed in. The resources are fetched from the argument list, the resource database, or the default values in the resource list. Then, they are copied into the subpart record. If args is NULL, num_args must be zero. However, if num_args is zero, the argument list is not referenced.

9.5. Obtaining Application Resources

To retrieve resources that are not specific to a widget but apply to the overall application, use **XtGetApplicationResources**.

void XtGetApplicationResources(*w*, *base*, *resources*, *num_resources*, *args*, *num_args*)
    Widget *w*;
    caddr_t *base*;
    XtResourceList *resources*;
    Cardinal *num_resources*;
    ArgList *args*;
    Cardinal *num_args*;

w	Specifies the widget that identifies the resource database to search. (The database is that associated with the display for this widget.)
base	Specifies the base address of the subpart data structure where the resources should be written.
resources	Specifies the resource list for the subpart.
num_resources	Specifies the number of resources in the resource list.
args	Specifies the argument list to override resources obtained from the resource database.
num_args	Specifies the number of arguments in the argument list.

The **XtGetApplicationResources** function first uses the passed widget, which is usually an application shell, to construct a resource name and class list, Then, it retrieves the resources from the argument list, the resource database, or the resource list default values. After adding base to each address, **XtGetApplicationResources** copies the resources into the address given in the resource list. If args is NULL, num_args must be zero. However, if num_args is zero, the argument list is not referenced. The portable way to specify application resources is to declare them as members of a structure and pass the address of the structure as the base argument.

9.6. Resource Conversions

The Intrinsics provide a mechanism for registering representation converters that are automatically invoked by the resource fetching routines. The Intrinsics additionally provide and registers several commonly used converters. This resource conversion mechanism serves several purposes:

- It permits user and application resource files to contain ASCII representations of nontextual values.
- It allows textual or other representations of default resource values that are dependent on the display, screen, or color map, and thus must be computed at run time.
- It caches all conversion source and result data. Conversions that require much computation or space (for example, string to translation table) or that require round trips to the server (for example, string to font or color) are performed only once.

9.6.1. Predefined Resource Converters

The Intrinsics define all the representations used in the **Core**, **Composite**, **Constraint**, and **Shell** widgets. It registers the following resource converters:

From **XtRString** to:

> **XtRAcceleratorTable**, **XtRBoolean**, **XtRBool**, **XtRCursor**, **XtRDimension**, **XtRDisplay**, **XtRFile**, **XtRFloat**, **XtRFont**, **XtRFontStruct**, **XtRInt**, **XtRPixel**, **XtRPosition**, **XtRShort**, **XtRTranslationTable**, and **XtRUnsignedChar**.

From **XtRColor**, to: **XtRPixel**.

From **XRInt**, to:

> **XtRBoolean**, **XtRBool**, **XtRColor**, **XtRDimension**, **XtRFloat**, **XtRFont**, **XtRPixel**, **XtRPixmap**, **XtRPosition**, **XtRShort**, and **XtRUnsignedChar**.

From **XtRPixel**, to: **XtRColor**.

The string to pixel conversion has two predefined constants that are guaranteed to work and contrast with each other (**XtDefaultForeground** and **XtDefaultBackground**). They evaluate the black and white pixel values of the widget's screen, respectively. For applications that run with reverse video, however, they evaluate the white and black pixel values of the widget's screen, respectively. Similarly, the string to font and font structure converters recognize the constant **XtDefaultFont** and evaluate this to the font in the screen's default graphics context.

9.6.2. New Resource Converters

Type converters use pointers to **XrmValue** structures (defined in <X11/Xresource.h>) for input and output values.

```
typedef struct {
        unsigned int size;
        caddr_t addr;
} XrmValue, *XrmValuePtr;
```

A resource converter procedure pointer is of type **XtConverter**:

```
typedef void (*XtConverter)(XrmValue *, Cardinal *, XrmValue *, XrmValue *);
    XrmValue *args;
    Cardinal *num_args;
    XrmValue *from;
    XrmValue *to;
```

args Specifies a list of additional **XrmValue** arguments to the converter if additional context is needed to perform the conversion or NULL. For example, the string-to-font converter needs the widget's screen, or the string to pixel converter needs the widget's screen and color map.

num_args Specifies the number of additional **XrmValue** arguments or zero.

from Specifies the value to convert.

to Specifies the descriptor to use to return the converted value.

Type converters should perform the following actions:

- Check to see that the number of arguments passed is correct.
- Attempt the type conversion.
- If successful, return a pointer to the data in the to parameter; otherwise, call **XtWarningMsg** and return without modifying the to argument.

Most type converters just take the data described by the specified from argument and return data by writing into the specified to argument. A few need other information, which is available in the specified argument list. A type converter can invoke another type converter, which allows differing sources that may convert into a common intermediate result to make maximum use of the type converter cache.

Note that the address written to->addr cannot be that of a local variable of the converter because this is not valid after the converter returns. It should be a pointer to a static variable, as in the following example where screenColor is returned.

The following is an example of a converter that takes a string and converts it to a Pixel:

```
static void CvtStringToPixel(args, num_args, fromVal, toVal)
    XrmValue *args;
    Cardinal        *num_args;
    XrmValue *fromVal;
    XrmValue *toVal;

    static XColor   screenColor;
    XColor          exactColor;
    Screen          *screen;
    Colormap        colormap;
    Status          status;
    char            message[1000];
    XrmQuark        q;
    String          params[1];
    Cardinal        num_params = 1;

    if (*num_args != 2)
        XtErrorMsg("cvtStringToPixel","wrongParameters","XtToolkitError",
            "String to pixel conversion needs screen and colormap arguments",
            (String *)NULL, (Cardinal *)NULL);

    screen = *((Screen **) args[0].addr);
    colormap = *((Colormap *) args[1].addr);

    LowerCase((char *) fromVal->addr, message);
```

```
    q = XrmStringToQuark(message);

    if (q == XtQExtdefaultbackground) { done(&screen->white_pixel, Pixel); return; }
    if (q == XtQExtdefaultforeground) { done(&screen->black_pixel, Pixel); return; }

    if ((char) fromVal->addr[0] == '#') {  /* some color rgb definition */

        status = XParseColor(DisplayOfScreen(screen), colormap, (String) fromVal->addr,
            &screenColor);
        if (status != 0) status = XAllocColor(DisplayOfScreen(screen), colormap, &screenColor);

    } else  /* some color name */

        status = XAllocNamedColor(DisplayOfScreen(screen), colormap, (String) fromVal->addr,
            &screenColor, &exactColor);

    if (status == 0) {

        params[0]=(String)fromVal->addr;
        XtWarningMsg("cvtStringToPixel","noColormap","XtToolkitError",
            "Cannot allocate colormap entry for \"%s\"", params, &num_params);

    } else {

        toVal->addr = (caddr_t)&screenColor.pixel;
        toVal->size = sizeof(Pixel);

    }
};
```

All type converters should define some set of conversion values that they are guaranteed to succeed on so these can be used in the resource defaults. This issue arises only with conversions, such as fonts and colors, where there is no string representation that all server implementations will necessarily recognize. For resources like these, the converter should define a symbolic constant (for example, **XtDefaultForeground**, **XtDefaultBackground**, or **XtDefaultFont**).

9.6.3. Issuing Conversion Warnings

The **XtStringConversionWarning** function is a convenience routine for new resource converters that convert from strings.

void XtStringConversionWarning(*src*, *dst_type*)
    String *src*, *dst_type*;

src Specifies the string that could not be converted.

dst_type Specifies the name of the type to which the string could not be converted.

The **XtStringConversionWarning** function issues a warning message with name ''conversionError'', type ''string'', class ''XtToolkitError, and the default message string ''Cannot convert "*src*" to type *dst_type*''.

9.6.4. Registering a New Resource Converter

To register a new converter, use **XtAppAddConverter**.

```
void XtAppAddConverter(app_context, from_type, to_type, converter, convert_args, num_args)
   XtAppContext app_context;
   String from_type;
   String to_type;
   XtConverter converter;
   XtConvertArgList convert_args;
   Cardinal num_args;
```

app_context	Specifies the application context.
from_type	Specifies the source type.
to_type	Specifies the destination type.
converter	Specifies the type converter procedure.
convert_args	Specifies how to compute the additional arguments to the converter or NULL.
num_args	Specifies the number of additional arguments to the converter or zero.

If the same from_type and to_type are specified in two calls to **XtAppAddConverter**, the second call overrides the first. For the few type converters that need additional arguments, the Intrinsics conversion mechanism provides a method of specifying how these arguments should be computed. The enumerated type **XtAddressMode** and the structure **XtConvertArgRec** specify how each argument is derived. These are defined in **<X11/Convert.h>**.

```
typedef enum {
        /* address mode                    parameter representation */
          XtAddress,                       /* address */
          XtBaseOffset,                    /* offset */
          XtImmediate,                     /* constant */
          XtResourceString,                /* resource name string */
          XtResourceQuark                  /* resource name quark */
} XtAddressMode;

typedef struct {
        XtAddressMode address_mode;
        caddr_t address_id;
        Cardinal size;
} XtConvertArgRec, *XtConvertArgList;
```

The address_mode field specifies how the address_id field should be interpreted. **XtAddress** causes address_id to be interpreted as the address of the data. **XtBaseOffset** causes address_id to be interpreted as the offset from the widget base. **XtImmediate** causes address_id to be interpreted as a constant. **XtResourceString** causes address_id to be interpreted as the name of a resource that is to be converted into an offset from widget base. **XtResourceQuark** is an internal compiled form of an **XtResourceString**. The size field specifies the length of the data in bytes.

The following provides the code that was used to register the CvtStringToPixel routine shown earlier:

```
static XtConvertArgRec colorConvertArgs[] = {
        {XtBaseOffset, (caddr_t) XtOffset(Widget, core.screen),  sizeof(Screen *)},
        {XtBaseOffset, (caddr_t) XtOffset(Widget, core.colormap),sizeof(Colormap)}
};

XtAddConverter(XtRString, XtRPixel, CvtStringToPixel,
   colorConvertArgs, XtNumber(colorConvertArgs));
```

The conversion argument descriptors colorConvertArgs and screenConvertArg are predefined. The screenConvertArg descriptor puts the widget's screen field into args[0]. The colorConvertArgs descriptor puts the widget's screen field into args[0], and the widget's colormap field into args[1].

Conversion routines should not just put a descriptor for the address of the base of the widget into args[0], and use that in the routine. They should pass in the actual values that the conversion depends on. By keeping the dependencies of the conversion procedure specific, it is more likely that subsequent conversions will find what they need in the conversion cache. This way the cache is smaller and has fewer and more widely applicable entries.

9.6.5. Resource Converter Invocation

All resource-fetching routines (for example, **XtGetSubresources**, **XtGetApplicationResources**, and so on) call resource converters if the user specifies a resource that is a different representation from the desired representation or if the widget's default resource value representation is different from the desired representation.

To invoke resource conversions, use **XtConvert** or **XtDirectConvert**.

void XtConvert(*w*, *from_type*, *from*, *to_type*, *to_return*)
  Widget *w*;
  String *from_type*;
  XrmValuePtr *from*;
  String *to_type*;
  XrmValuePtr *to_return*;

w	Specifies the widget to use for additional arguments (if any are needed).
from_type	Specifies the source type.
from	Specifies the value to be converted.
to_type	Specifies the destination type.
to_return	Returns the converted value.

void XtDirectConvert(*converter*, *args*, *num_args*, *from*, *to_return*)
  XtConverter *converter*;
  XrmValuePtr *args*;
  Cardinal *num_args*;
  XrmValuePtr *from*;
  XrmValuePtr *to_return*;

converter	Specifies the conversion procedure that is to be called.
args	Specifies the argument list that contains the additional arguments needed to perform the conversion (often NULL).
num_args	Specifies the number of additional arguments (often zero).
from	Specifies the value to be converted.
to_return	Returns the converted value.

The **XtConvert** function looks up the type converter registered to convert from_type to to_type, computes any additional arguments needed, and then calls **XtDirectConvert**. The **XtDirectConvert** function looks in the converter cache to see if this conversion procedure has been called with the specified arguments. If so, it returns a descriptor for information stored in the cache; otherwise, it calls the converter and enters the result in the cache.

Before calling the specified converter, **XtDirectConvert** sets the return value size to zero and the return value address to NULL. To determine if the conversion was successful, the client should check to_return.address for non-NULL.

9.7. Reading and Writing Widget State

Any resource field in a widget can be read or written by a client. On a write operation, the widget decides what changes it will actually allow and updates all derived fields appropriately.

9.7.1. Obtaining Widget State

To retrieve the current value of a resource associated with a widget instance, use **XtGetValues**.

```
void XtGetValues(w, args, num_args)
    Widget w;
    ArgList args;
    Cardinal num_args;
```

w Specifies the widget.

args Specifies the argument list of name/address pairs that contain the resource name and the address into which the resource value is to be stored. The resource names are widget-dependent.

num_args Specifies the number of arguments in the argument list.

The **XtGetValues** function starts with the resources specified for the core widget fields and proceeds down the subclass chain to the widget. The value field of a passed argument list should contain the address into which to store the corresponding resource value. It is the caller's responsibility to allocate and deallocate this storage according to the size of the resource representation type used within the widget.

If the widget's parent is a subclass of **constraintWidgetClass**, **XtGetValues** then fetches the values for any constraint resources requested. It starts with the constraint resources specified for **constraintWidgetClass** and proceeds down to the subclass chain to the parent's constraint resources. If the argument list contains a resource name that is not found in any of the resource lists searched, the value at the corresponding address is not modified. Finally, if the get_values_hook procedures are non-NULL, they are called in superclass-to-subclass order after all the resource values have been fetched by **XtGetValues**. This permits a subclass to provide nonwidget resource data to **XtGetValues**.

9.7.1.1. Widget Subpart Resource Data: the get_values_hook Procedure

Widgets that have subparts can return resource values from them for **XtGetValues** by supplying a get_values_hook procedure. The get_values_hook procedure pointer is of type **XtArgsProc**:

```
typedef void (*XtArgsProc)(Widget, ArgList, Cardinal *);
    Widget w;
    ArgList args;
    Cardinal *num_args;
```

w Specifies the widget whose nonwidget resource values are to be retrieved.

args Specifies the argument list that was passed to **XtCreateWidget**.

num_args Specifies the number of arguments in the argument list.

The widget should call **XtGetSubvalues** and pass in its subresource list and the arg and num_args parameters.

9.7.1.2. Widget Subpart State

To retrieve the current value of a nonwidget resource data associated with a widget instance, use **XtGetSubvalues**. For a discussion of nonwidget subclass resources, see Section 9.4.

void XtGetSubvalues(*base*, *resources*, *num_resources*, *args*, *num_args*)
    caddr_t *base*;
    XtResourceList *resources*;
    Cardinal *num_resources*;
    ArgList *args*;
    Cardinal *num_args*;

base	Specifies the base address of the subpart data structure where the resources should be retrieved.
resources	Specifies the nonwidget resources list.
num_resources	Specifies the number of resources in the resource list.
args	Specifies the argument list of name/address pairs that contain the resource name and the address into which the resource value is to be stored. The arguments and values passed in are dependent on the subpart. The storage for argument values that are pointed to by the argument list must be deallocated by the application when no longer needed.
num_args	Specifies the number of arguments in the argument list.

The **XtGetSubvalues** function obtains resource values from the structure identified by base.

9.7.2. Setting Widget State

To modify the current value of a resource associated with a widget instance, use **XtSetValues**.

void XtSetValues(*w*, *args*, *num_args*)
    Widget *w*;
    ArgList *args*;
    Cardinal *num_args*;

w	Specifies the widget.
args	Specifies the argument list of name/value pairs that contain the resources to be modified and their new values. The resources and values passed are dependent on the widget being modified.
num_args	Specifies the number of arguments in the argument list.

The **XtSetValues** function starts with the resources specified for the **Core** widget fields and proceeds down the subclass chain to the widget. At each stage, it writes the new value (if specified by one of the arguments) or the existing value (if no new value is specified) to a new widget data record. **XtSetValues** then calls the set_values procedures for the widget in superclass-to-subclass order. If the widget has any non-NULL set_values_hook fields, these are called immediately after the corresponding set_values procedure. This procedure permits subclasses to set nonwidget data for **XtSetValues**.

If the widget's parent is a subclass of **constraintWidgetClass**, **XtSetValues** also updates the widget's constraints. It starts with the constraint resources specified for **constraintWidgetClass** and proceeds down the subclass chain to the parent's class. At each stage, it writes the new value or the existing value to a new constraint record. It then calls the constraint set_values procedures from **constraintWidgetClass** down to the parent's class. The constraint set_values procedures are called with widget arguments, as for all set_values procedures, not just the constraint record arguments, so that they can make adjustments to the desired values based on full information about the widget.

XtSetValues determines if a geometry request is needed by comparing the current widget to the new widget. If any geometry changes are required, it makes the request, and the geometry manager returns **XtGeometryYes**, **XtGeometryAlmost**, or **XtGeometryNo**. If **XtGeometryYes**, **XtSetValues** calls the widget's resize procedure. If **XtGeometryNo**, **XtSetValues** resets the geometry fields to their original values. If **XtGeometryAlmost**, **XtSetValues** calls the set_values_almost procedure, which determines what should be done and writes new values for the geometry fields into the new widget. **XtSetValues** then repeats this process, deciding once more whether the geometry manager should be called.

Finally, if any of the set_values procedures returned **True**, **XtSetValues** causes the widget's expose procedure to be invoked by calling the Xlib **XClearArea** function on the widget's window.

9.7.2.1. Widget State: the set_values Procedure

The set_values procedure pointer in a widget class is of type **XtSetValuesFunc**:

```
typedef Boolean (*XtSetValuesFunc)(Widget, Widget, Widget);
    Widget current;
    Widget request;
    Widget new;
```

current Specifies a copy of the widget as it was before the **XtSetValues** call.

request Specifies a copy of the widget with all values changed as asked for by the **XtSetValues** call before any class set_values procedures have been called.

new Specifies the widget with the new values that are actually allowed.

The set_values procedure should recompute any field derived from resources that are changed (for example, many GCs depend on foreground and background). If no recomputation is necessary and if none of the resources specific to a subclass require the window to be redisplayed when their values are changed, you can specify NULL for the set_values field in the class record.

Like the initialize procedure, set_values mostly deals only with the fields defined in the subclass, but it has to resolve conflicts with its superclass, especially conflicts over width and height.

Sometimes a subclass may want to overwrite values filled in by its superclass. In particular, size calculations of a superclass are often incorrect for a subclass and in this case, the subclass must modify or recalculate fields declared and computed by its superclass.

As an example, a subclass can visually surround its superclass display. In this case, the width and height calculated by the superclass set_values procedure are too small and need to be incremented by the size of the surround. The subclass needs to know if its superclass's size was calculated by the superclass or was specified explicitly. All widgets must place themselves into whatever size is explicitly given, but they should compute a reasonable size if no size is requested. How does a subclass know the difference between a specified size and a size computed by a superclass?

The request and new parameters provide the necessary information. The request widget is the widget as originally requested. The new widget starts with the values in the request, but it has been updated by all superclass set_values procedures called so far. A subclass set_values procedure can compare these two to resolve any potential conflicts.

In the above example, the subclass with the visual surround can see if the width and height in the request widget are zero. If so, it adds its surround size to the width and height fields in the new widget. If not, it must make do with the size originally specified.

The new widget is the actual widget instance record. Therefore, the set_values procedure should do all its work on the new widget (the request widget should never be modified), and if it needs to call any routines that operate on a widget, it should specify new as the widget instance.

The widget specified by new starts with the values of that specified by request but has been modified by any superclass set_values procedures. A widget need not refer to the request widget, unless it must resolve conflicts between the current and new widgets. Any changes that the widget needs to make, including geometry changes, should be made in the new widget.

Finally, the set_values procedure must return a Boolean that indicates whether the widget needs to be redisplayed. Note that a change in the geometry fields alone does not require the set_values procedure to return **True**; the X server will eventually generate an **Expose** event, if necessary. After calling all the set_values procedures, **XtSetValues** forces a redisplay by calling the Xlib **XClearArea** function if any of the set_values procedures returned **True**. Therefore, a set_values procedure should not try to do its own redisplaying.

Set_values procedures should not do any work in response to changes in geometry because **XtSetValues** eventually will perform a geometry request, and that request might be denied. If the widget actually changes size in response to a **XtSetValues**, its resize procedure are called. Widgets should do any geometry-related work in their resize procedure.

Note that it is permissible to call **XtSetValues** before a widget is realized. Therefore, the set_values proc must not assume that the widget is realized.

9.7.2.2. Widget State: the set_values_almost Procedure

The set_values_almost procedure pointer in a widget class is of type **XtAlmostProc**:

```
typedef void (*XtAlmostProc)(Widget, Widget, XtWidgetGeometry *, XtWidgetGeometry *);
    Widget w;
    Widget new_widget_return;
    XtWidgetGeometry *request;
    XtWidgetGeometry *reply;
```

w Specifies the widget on which the geometry change is requested.

new_widget_return
Specifies the new widget into which the geometry changes are to be stored.

request Specifies the original geometry request that was sent to the geometry manager that returned **XtGeometryAlmost**.

reply Specifies the compromise geometry that was returned by the geometry manager that returned **XtGeometryAlmost**.

Most classes inherit this operation from their superclass by specifying **XtInheritSetValuesAlmost** in the class initialization. The **Core** set_values_almost procedure accepts the compromise suggested.

The set_values_almost procedure is called when a client tries to set a widget's geometry by means of a call to **XtSetValues**, and the geometry manager cannot satisfy the request but instead returns **XtGeometryAlmost** and a compromise geometry. The set_values_almost procedure takes the original geometry and the compromise geometry and determines whether the compromise is acceptable or a different compromise might work. It returns its results in the new_widget parameter, which is then sent back to the geometry manager for another try.

9.7.2.3. Widget State: the constraint set_values Procedure

The constraint set_values procedure pointer is of type **XtSetValuesFunc**. The values passed to the parent's constraint set_values procedure are the same as those passed to the child's class set_values procedure. A class can specify NULL for the set_values field of the **ConstraintPart** if it need not compute anything.

The constraint set_values procedure should recompute any constraint fields derived from constraint resource that are changed. Further, it should modify the widget fields as appropriate. For example, if a constraint for the maximum height of a widget is changed to a value smaller than the widget's current height, the constraint set_values procedure should reset the height field in the widget.

9.7.2.4. Widget Subpart State

To set the current value of a nonwidget resource associated with a widget instance, use **XtSetSubvalues**. For a discussion of nonwidget subclass resources, see Section 9.4.

void XtSetSubvalues(*base*, *resources*, *num_resources*, *args*, *num_args*)
    caddr_t *base*;
    XtResourceList *resources*;
    Cardinal *num_resources*;
    ArgList *args*;
    Cardinal *num_args*;

base	Specifies the base address of the subpart data structure where the resources should be written.
resources	Specifies the current nonwidget resources values.
num_resources	Specifies the number of resources in the resource list.
args	Specifies the argument list of name/value pairs that contain the resources to be modified and their new values. The resources and values passed are dependent on the subpart of the widget being modified.
num_args	Specifies the number of arguments in the argument list.

The **XtSetSubvalues** function stores resources into the structure identified by base.

9.7.2.5. Widget Subpart Resource Data: the set_values_hook Procedure

Widgets that have a subpart can set the resource values by using **XtSetValues** and supplying a set_values_hook procedure. The set_values_hook procedure pointer in a widget class is of type **XtArgsFunc**:

typedef Boolean (*XtArgsFunc)(Widget, Arglist, Cardinal *);
    Widget *w*;
    ArgList *args*;
    Cardinal **num_args*;

w	Specifies the widget whose nonwidget resource values are to be changed.
args	Specifies the argument list that was passed to **XtCreateWidget**.
num_args	Specifies the number of arguments in the argument list.

Chapter 10

Translation Management

Except under unusual circumstances, widgets do not hardwire the mapping of user events into widget behavior by using the event manager. Instead, they provide a default mapping of events into behavior that you can override.

The translation manager provides an interface to specify and manage the mapping of X Event sequences into widget-supplied functionality, for example, calling procedure *Abc* when the *y* key is pressed.

The translation manager uses two kinds of tables to perform translations:

- The action tables, which are in the widget class structure, specify the mapping of externally available procedure name strings to the corresponding procedure implemented by the widget class.
- A translation table, which is in the widget class structure, specifies the mapping of event sequence to procedure name strings.

You can override the translation table in the class structure for a specific widget instance by supplying a different translation table for the widget instance. The resource name is XtNtranslations.

10.1. Action Tables

All widget class records contain an action table. In addition, an application can register its own action tables with the translation manager so that the translation tables it provides to widget instances can access application functionality. The translation action_proc procedure pointer is of type **XtActionProc**:

```
typedef void (*XtActionProc)(Widget, XEvent *, String *, Cardinal *);
    Widget w;
    XEvent *event;
    String *params;
    Cardinal *num_params;
```

w	Specifies the widget that caused the action to be called.
event	Specifies the event that caused the action to be called. If the action is called after a sequence of events, then the last event in the sequence is used.
params	Specifies a pointer to the list of strings that were specified in the translation table as arguments to the action.
num_params	Specifies the number of arguments specified in the translation table.

```
typedef struct _XtActionsRec {
        String action_name;
        XtActionProc action_proc;
} XtActionsRec, *XtActionList;
```

The action_name field is the name that you use in translation tables to access the procedure. The action_proc field is a pointer to a procedure that implements the functionality.

For example, the Command widget has procedures to take the following actions:

- Set the command button to indicate it is activated
- Unset the button back to its normal mode
- Highlight the button borders

- Unhighlight the button borders
- Notify any callbacks that the button has been activated

The action table for the Command widget class makes these functions available to translation tables written for Command or any subclass. The string entry is the name used in translation tables. The procedure entry (often spelled identically to the string) is the name of the C procedure that implements that function:

```
XtActionsRec actionTable[] = {
        {"Set",           Set},
        {"Unset",         Unset},
        {"Highlight",     Highlight},
        {"Unhighlight",   Unhighlight}
        {"Notify",        Notify},
};
```

10.1.1. Action Table Registration

To declare an action table and register it with the translation manager, use **XtAppAddActions**.

void XtAppAddActions(*app_context*, *actions*, *num_actions*)
    XtAppContext *app_context*;
    XtActionList *actions*;
    Cardinal *num_actions*;

app_context Specifies the application context.

actions Specifies the action table to register.

num_args Specifies the number of entries in this action table.

If more than one action is registered with the same name, the most recently registered action is used. If duplicate actions exist in an action table, the first is used. The Intrinsics register an action table for **MenuPopup** and **MenuPopdown** as part of X Toolkit initialization.

10.1.2. Action Names to Procedure Translations

The translation manager uses a simple algorithm to convert the name of a procedure specified in a translation table into the actual procedure specified in an action table. When the widget is realized, the translation manager performs a search for the name in the following tables:

- The widget's class action table for the name
- The widget's superclass action table and on up the superclass chain
- The action tables registered with **XtAddActions** (from the most recently added table to the oldest table)

As soon as it finds a name, the translation manager stops the search. If it cannot find a name, the translation manager generates an error.

10.2. Translation Tables

All widget instance records contain a translation table, which is a resource with no default value. A translation table specifies what action procedures are invoked for an event or a sequence of events. A translation table is a string containing a list of translations from an event sequence into one or more action procedure calls. The translations are separated from one another by newline characters (ASCII LF). The complete syntax of translation tables is specified in Appendix B.

As an example, the default behavior of Command is:

- Highlight on enter window
- Unhighlight on exit window

- Invert on left button down
- Call callbacks and reinvert on left button up

The following illustrates the Command's default translation table:

```
static String defaultTranslations =
        "<EnterWindow>:Highlight()\n\
        <LeaveWindow>:Unhighlight()\n\
        <Btn1Down>:  Set()\n\
        <Btn1Up>:    Notify() Unset()";
```

The tm_table field of the **CoreClass** record should be filled in at static initialization time with the string containing the class's default translations. If a class wants to inherit its superclass's translations, it can store the special value **XtInheritTranslations** into tm_table. After the class initialization procedures have been called, the Intrinsics compile this translation table into an efficient internal form. Then, at widget creation time, this default translation table is used for any widgets that have not had their core translations field set by the resource manager or the initialize procedures.

The resource conversion mechanism automatically compiles string translation tables that are resources. If a client uses translation tables that are not resources, it must compile them itself using **XtParseTranslationTable**.

The Intrinsics use the compiled form of the translation table to register the necessary events with the event manager. Widgets need do nothing other than specify the action and translation tables for events to be processed by the translation manager.

10.2.1. Event Sequences

An event sequence is a comma separated list of X event descriptions that describes a specific sequence of X events to map to a set of program actions. Each X event description consists of three parts:

- The X event type
- A prefix consisting of the X modifier bits
- An event specific suffix

Various abbreviations are supported to make translation tables easier to read.

10.2.2. Action Sequences

Action sequences specify what program or widget actions to take in response to incoming X events. An action sequence of action procedure call specifications. Each action procedure call consists of the name of an action procedure and a parenthesized list of string parameters to pass to that procedure.

10.3. Translation Table Management

Sometimes an application needs to destructively or nondestructively add its own translations to a widget's translation. For example, a window manager provides functions to move a window. It usually may move the window when any pointer button is pressed down in a title bar, but it allows the user to specify other translations for the middle or right button down in the title bar, and it ignores any user translations for left button down.

To accomplish this, the window manager first should create the title bar and then should merge the two translation tables into the title bar's translations. One translation table contains the translations that the window manager wants only if the user has not specified a translation for a particular event (or event sequence). The other translation table contains the translations that the window manager wants regardless of what the user has specified.

Three Intrinsics functions support this merging:

XtParseTranslationTable	Compiles a translation table.
XtAugmentTranslations	Nondestructively merges a compiled translation table into a widget's compiled translation table.
XtOverrideTranslations	Destructively merges a compiled translation table into a widget's compiled translation table.

To compile a translation table, use **XtParseTranslationTable**.

XtTranslations XtParseTranslationTable(*table*)
    String *table*;

table Specifies the translation table to compile.

The **XtParseTranslationTable** function compiles the translation table into the opaque internal representation of type **XtTranslations**. Note that if an empty translation table is required for any purpose, one can be obtained by calling **XtParseTranslationTable** and passing an empty string.

To merge new translations into an existing translation table, use **XtAugmentTranslations**.

void XtAugmentTranslations(*w*, *translations*)
    Widget *w*;
    XtTranslations *translations*;

w Specifies the widget into which the new translations are to be merged.

translations Specifies the compiled translation table to merge in (must not be NULL).

The **XtAugmentTranslations** function nondestructively merges the new translations into the existing widget translations. If the new translations contain an event or event sequence that already exists in the widget's translations, the new translation is ignored.

To overwrite existing translations with new translations, use **XtOverrideTranslations**.

void XtOverrideTranslations(*w*, *translations*)
    Widget *w*;
    XtTranslations *translations*;

w Specifies the widget into which the new translations are to be merged.

translations Specifies the compiled translation table to merge in (must not be NULL).

The **XtOverrideTranslations** function destructively merges the new translations into the existing widget translations. If the new translations contain an event or event sequence that already exists in the widget's translations, the new translation is merged in and override the widget's translation.

To replace a widget's translations completely, use **XtSetValues** on the XtNtranslations resource and specifiy a compiled translation table as the value.

To make it possible for users to easily modify translation tables in their resource files, the string-to-translation-table resource type converter allows specifying whether the table should replace, augment, or override any existing translation table in the widget. As an option, you can specify a number sign (#) as the first character of the table followed by "replace" (default), "augment", or "override" to indicate whether to replace, augment, or override any existing table.

To completely remove existing translations, use **XtUninstallTranslations**.

void XtUninstallTranslations(*w*)
    Widget *w*;

w Specifies the widget from which the translations are to be removed.

The **XtUninstallTranslations** function causes the entire translation table for widget to be removed.

10.4. Using Accelerators

It is often convenient to be able to bind events in one widget to actions in another. In particular, it is often useful to be able to invoke menu actions from the keyboard. The Intrinsics provide a facility, called accelerators, that let you accomplish this. An accelerator is a translation table that is bound with its actions in the context of a particular widget. The accelerator table can then be installed on some destination widget. When an action in the destination widget would cause an accelerator action to be taken, rather than causing an action in the context of the destination, the actions are executed as though triggered by an action in the accelerator widget.

Each widget instance contains that widget's exported accelerator table. Each class of widget exports a method that takes a displayable string representation of the accelerators so that widgets can display their current accelerators. The representation is the accelerator table in canonical translation table form (see Appendix B). The display_accelerator procedure pointer is of type **XtStringProc**:

typedef void (*XtStringProc)(Widget, String);
    Widget *w*;
    String *string*;

w Specifies the widget that the accelerators are installed on.

string Specifies the string representation of the accelerators for this widget.

Accelerators can be specified in defaults files, and the string representation is the same as for a translation table. However, the interpretation of the #augment and #override directives apply to what will happen when the accelerator is installed, that is, whether or not the accelerator translations will override the translations in the destination widget. The default is #augment, which means that the accelerator translations have lower priority than the destination translations. The #replace directive is ignored for accelerator tables.

To parse an accelerator table, use **XtParseAcceleratorTable**.

XtAccelerators XtParseAcceleratorTable(*source*)
    String *source*;

source Specifies the accelerator table to compile.

The **XtParseAcceleratorTable** function compiles the accelerator table into the opaque internal representation.

To install accelerators from a widget on another widget, use **XtInstallAccelerators**.

void XtInstallAccelerators(*destination*, *source*)
    Widget *destination*;
    Widget *source*;

destination Specifies the widget on which the accelerators are to be installed.

source Specifies the widget from which the accelerators are to come.

The **XtInstallAccelerators** function installs the accelerators from source onto destination by augmenting the destination translations with the source accelerators. If the source display_accelerator method is non-NULL, **XtInstallAccelerators** calls it with the source widget and a string representation of the accelerator table, which indicates that its accelerators have been installed and that it should display them appropriately. The string representation of the accelerator table is its canonical translation table representation.

As a convenience for installing all accelerators from a widget and all its descendants onto one destination, use **XtInstallAllAccelerators**.

void XtInstallAllAccelerators(*destination*, *source*)
  Widget *destination*;
  Widget *source*;

destination Specifies the widget on which the accelerators are to be installed.

source Specifies the root widget of the widget tree from which the accelerators are to come.

The **XtInstallAllAccelerators** function recursively descends the widget tree rooted at source and installs the accelerators of each widget encountered onto destination. A common use is to call **XtInstallAllAccelerators** and pass the application main window as the source.

10.5. KeyCode-to-KeySym Conversions

The translation manager provides support for automatically translating key codes in incoming key events into KeySyms. KeyCode-to-KeySym-translator procedure pointers are of type **XtKeyProc**:

typedef void (*XtKeyProc)(Display *, KeyCode, Modifiers, Modifiers *, KeySym *);
  Display **display*;
  KeyCode *keycode*;
  Modifiers *modifiers*;
  Modifiers **modifiers_return*;
  KeySym **keysym_return*;

display Specifies the display that the KeyCode is from.

keycode Specifies the KeyCode to translate.

modifiers Specifies the modifiers to the KeyCode.

modifiers_return Returns a mask that indicates the subset of all modifiers that are examined by the key translator.

keysym_return Returns the resulting KeySym.

This procedure takes a KeyCode and modifiers and produces a KeySym. For any given key translator function, modifiers_return will be a constant that indicates the subset of all modifiers that are examined by the key translator.

To register a key translator, use **XtSetKeyTranslator**.

void XtSetKeyTranslator(*display*, *proc*)
  Display **display*;
  XtKeyProc *proc*;

display Specifies the display from which to translate the events.

proc Specifies the procedure that is to perform key translations.

The **XtSetKeyTranslator** function sets the specified procedure as the current key translator. The default translator is **XtTranslateKey**, an **XtKeyProc** that uses Shift and Lock modifiers with the interpretations defined by the core protocol. It is provided so that new translators can call it to get default KeyCode-to-KeySym translations and so that the default translator can be reinstalled.

To invoke the currently registered KeyCode-to-KeySym translator, use **XtTranslateKeycode**.

void XtTranslateKeycode(*display*, *keycode*, *modifiers*, *modifiers_return*, *keysym_return*)
  Display **display*;
  KeyCode *keycode*;
  Modifiers *modifiers*;
  Modifiers **modifiers_return*;
  KeySym **keysym_return*;

display Specifies the display that the KeyCode is from.

keycode Specifies the KeyCode to translate.

modifiers Specifies the modifiers to the KeyCode.

modifiers_return Returns a mask that indicates the modifiers actually used to generate the KeySym.

keysym_return Returns the resulting KeySym.

The **XtTranslateKeycode** function passes the specified arguments directly to the currently registered KeyCode to KeySym translator.

To handle capitalization of nonstandard KeySyms, the Intrinsics allow clients to register case conversion routines. Case converter procedure pointers are of type **XtCaseProc**:

typedef void (*XtCaseProc)(KeySym *, KeySym *, KeySym *);
  KeySym **keysym*;
  KeySym **lower_return*;
  KeySym **upper_return*;

keysym Specifies the KeySym to convert.

lower_return Specifies the lowercase equivalent for the KeySym.

upper_return Specifies the uppercase equivalent for the KeySym.

If there is no case distinction, this procedure should store the KeySym into both return values.

To register a case converter, use **XtRegisterCaseConverter**.

void XtRegisterCaseConverter(*display*, *proc*, *start*, *stop*)
  Display **display*;
  XtCaseProc *proc*;
  KeySym *start*;
  KeySym *stop*;

display Specifies the display from which the key events are to come.

proc Specifies the **XtCaseProc** that is to do the conversions.

start Specifies the first KeySym for which this converter is valid.

stop Specifies the last KeySym for which this converter is valid.

The **XtRegisterCaseConverter** registers the specified case converter. The start and stop arguments provide the inclusive range of KeySyms for which this converter is to be called. The new converter overrides any previous converters for KeySyms in that range. No interface exists to remove converters; you need to register an identity converter. When a new converter is registered, the Intrinsics refreshes the keyboard state if necessary. The default converter understands case conversion for all KeySyms defined in the core protocol.

To determine upper and lowercase equivalents for a KeySym, use **XtConvertCase**.

void XtConvertCase(*display*, *keysym*, *lower_return*, *upper_return*)
  Display **display*;
  KeySym *keysym*;
  KeySym **lower_return*;
  KeySym **upper_return*;

display	Specifies the display that the KeySym came from.
keysym	Specifies the KeySym to convert.
lower_return	Returns the lowercase equivalent of the KeySym.
upper_return	Returns the uppercase equivalent of the KeySym.

The **XtConvertCase** function calls the appropriate converter and returns the results. A user-supplied **XtKeyProc** may need to use this function.

Chapter 11

Utility Functions

The Intrinsics provide a number of utility functions that you can use to:

- Determine the number of elements in an array
- Translate strings to widget instances
- Manage memory usage
- Share graphics contexts
- Manipulate selections
- Merge exposure events into a region
- Translate widget coordinates
- Translate a window to a widget
- Handle errors

11.1. Determining the Number of Elements in an Array

To determine the number of elements in a fixed-size array, use **XtNumber**.

Cardinal XtNumber(*array*)
    ArrayVariable *array*;

array Specifies a fixed-size array.

The **XtNumber** macro returns the number of elements in the specified argument lists, resources lists, and other counted arrays.

11.2. Translating Strings to Widget Instances

To translate a widget name to widget instance, use **XtNameToWidget**.

Widget XtNameToWidget(*reference*, *names*);
    Widget *reference*;
    String *names*;

reference Specifies the widget from which the search is to start.

names Specifies the fully qualified name of the desired widget.

The **XtNameToWidget** function looks for a widget whose name is the first component in the specified names and that is a pop-up child of reference (or a normal child if reference is a subclass of **compositeWidgetClass**). It then uses that widget as the new reference and repeats the search after deleting the first component from the specified names. If it cannot find the specified widget, **XtNameToWidget** returns NULL.

Note that the names argument contains the name of a widget with respect to the specified reference widget and can contain more than one widget name (separated by periods) for widgets that are not direct children of the specified reference widget.

If more than one child of the reference widget matches the name, **XtNameToWidget** can return any of the children. The Intrinsics do not require that all children of a widget have unique names. If the specified names contain more than one component and if more than one child matches the first component, **XtNameToWidget** can return NULL if the single branch that it follows does not contain the named widget. That is, **XtNameToWidget** does not back up and follow other matching branches of the widget tree.

11.3. Managing Memory Usage

The Intrinsics memory management functions provide uniform checking for null pointers and error reporting on memory allocation errors. These functions are completely compatible with their standard C language runtime counterparts (**malloc**, **calloc**, **realloc**, and **free**) with the following added functionality:

- **XtMalloc**, **XtCalloc**, and **XtRealloc** give an error if there is not enough memory.
- **XtFree** simply returns if passed a NULL pointer.
- **XtRealloc** simply allocates new storage if passed a NULL pointer.

See the standard C library documentation on **malloc**, **calloc**, **realloc**, and **free** for more information.

To allocate storage, use **XtMalloc**.

char *XtMalloc(*size*);
    Cardinal *size*;

size Specifies the number of bytes desired.

The **XtMalloc** functions returns a pointer to a block of storage of at least the specified size bytes. If there is insufficient memory to allocate the new block, **XtMalloc** calls **XtErrorMsg**.

To allocate and initialize an array, use **XtCalloc**.

char *XtCalloc(*num*, *size*);
    Cardinal *num*;
    Cardinal *size*;

num Specifies the number of array elements to allocate.

size Specifies the size of an array element in bytes.

The **XtCalloc** function allocates space for the specified number of array elements of the specified size and initializes the space to zero. If there is insufficient memory to allocate the new block, **XtCalloc** calls **XtErrorMsg**.

To change the size of an allocated block of storage, use **XtRealloc**.

char *XtRealloc(*ptr*, *num*);
    char **ptr*;
    Cardinal *num*;

ptr Specifies a pointer to the old storage.

num Specifies number of bytes desired in new storage.

The **XtRealloc** function changes the size of a block of storage (possibly moving it). Then, it copies the old contents (or as much as will fit) into the new block and frees the old block. If there is insufficient memory to allocate the new block, **XtRealloc** calls **XtErrorMsg**. If ptr is NULL, **XtRealloc** allocates the new storage without copying the old contents; that is, it simply calls **XtMalloc**.

To free an allocated block of storage, use **XtFree**.

void XtFree(*ptr*);
    char **ptr*;

ptr Specifies a pointer to the block of storage that is to be freed.

The **XtFree** function returns storage and allows it to be reused. If ptr is NULL, **XtFree** returns immediately.

To allocate storage for a new instance of a data type, use **XtNew**.

```
type *XtNew(type);
    type;
```

type Specifies a previously declared data type.

XtNew returns a pointer to the allocated storage. If there is insufficient memory to allocate the new block, **XtNew** calls **XtErrorMsg**. **XtNew** is a convenience macro that calls **XtMalloc** with the following arguments specified:

```
((type *) XtMalloc((unsigned) sizeof(type))
```

To copy an instance of a string, use **XtNewString**.

```
String XtNewString(string);
    String string;
```

string Specifies a previously declared string.

XtNewString returns a pointer to the allocated storage. If there is insufficient memory to allocate the new block, **XtNewString** calls **XtErrorMsg**. **XtNewString** is a convenience macro that calls **XtMalloc** with the following arguments specified:

```
(strcpy(XtMalloc((unsigned) strlen(str) + 1), str))
```

11.4. Sharing Graphics Contexts

The Intrinsics provide a mechanism whereby cooperating clients can share a graphics context (GC), thereby reducing both the number of GCs created and the total number of server calls in any given application. The mechanism is a simple caching scheme, and all GCs obtained by means of this mechanism must be treated as read-only. If a changeable GC is needed, the Xlib **XCreateGC** function should be used instead.

To obtain a read-only, sharable GC, use **XtGetGC**.

```
GC XtGetGC(w, value_mask, values)
    Widget w;
    XtGCMask value_mask;
    XGCValues *values;
```

w Specifies the widget.

value_mask Specifies which fields of the values are specified.

values Specifies the actual values for this GC.

The **XtGetGC** function returns a sharable, read-only GC. The parameters to this function are the same as those for **XCreateGC** except that a widget is passed instead of a display. **XtGetGC** shares only GCs in which all values in the GC returned by **XCreateGC** are the same. In particular, it does not use the value_mask provided to determine which fields of the GC a widget considers relevant. The value_mask is used only to tell the server which fields should be filled in with widget data and which it should fill in with default values. For further information about value_mask and values, see **XCreateGC** in the *Xlib – C Language X Interface*.

To deallocate a shared GC when it is no longer needed, use **XtReleaseGC**.

```
void XtReleaseGC(w, gc)
    Widget w;
    GC gc;
```

w Specifies the widget.

gc Specifies the GC to be deallocated.

References to sharable GCs are counted and a free request is generated to the server when the last user of a given GC destroys it.

11.5. Managing Selections

Arbitrary widgets (possibly not all in the same application) can communicate with each other by means of the X Toolkit global selection mechanism, which is defined in the *Inter-Client Communication Conventions Manual.* The Intrinsics provide functions for providing and receiving selection data in one logical piece (atomic transfers). The actual transfer between the selection owner and the Intrinsics is not required to be atomic; the Intrinsics will break a too-large selection into smaller pieces for transport if necessary.

The next sections discuss how to:

- Set and get the selection timeout value
- Use atomic transfers

11.5.1. Setting and Getting the Selection Timeout Value

To set the Intrinsics selection timeout, use **XtAppSetSelectionTimeout**.

void XtAppSetSelectionTimeout(*app_context*, *timeout*)
  XtAppContext *app_context*;
  unsigned long *timeout*;

app_context Specifies the application context.

timeout Specifies the selection timeout in milliseconds.

To get the current selection timeout value, use **XtAppGetSelectionTimeout**.

unsigned long XtAppGetSelectionTimeout(*app_context*)
  XtAppContext *app_context*;

app_context Specifies the application context.

The **XtAppGetSelectionTimeout** function returns the current selection timeout value, in milliseconds. The selection timeout is the time within which the two communicating applications must respond to one another. The initial timeout value is set by the **selectionTimeout** application resource, or, if **selectionTimeout** is not specified, it defaults to five seconds.

11.5.2. Using Atomic Transfers

The next three three sections discuss:

- Atomic transfer procedures
- Getting the selection value
- Setting the selection owner

11.5.2.1. Atomic Transfer Procedures

The following procedures are to be used with atomic transfers. The first three are used by the selection owner, and the last one is used by the requestor.

```
typedef Boolean (*XtConvertSelectionProc)(Widget, Atom *, Atom *, Atom *,
            caddr_t *, unsigned long *, int *);
    Widget w;
    Atom *selection;
    Atom *target;
    Atom *type_return;
    caddr_t *value_return;
    unsigned long *length_return;
    int *format_return;
```

w Specifies the widget which currently owns this selection.

selection Specifies the atom that describes the type of selection requested (for example, **XA_PRIMARY** or **XA_SECONDARY**).

target Specifies the target type of the selection that has been requested, which indicates the desired information about the selection (for example, File Name, Text, Window).

type_return Specifies a pointer to an atom into which the property type of the converted value of the selection is to be stored. For instance, either file name or text might have property type **XA_STRING**.

value_return Specifies a pointer into which a pointer to the converted value of the selection is to be stored. The selection owner is responsible for allocating this storage. If the selection owner has provided an **XtSelectionDoneProc** for the selection, this storage is owned by the selection owner; otherwise, it is owned by the Intrinsics selection mechanism, which frees it by calling **XtFree** when it is done with it.

length_return Specifies a pointer into which the number of elements in value (each of size indicated by format) is to be stored.

format_return Specifies a pointer into which the size in bits of the data elements of the selection value is to be stored.

This procedure is called by the Intrinsics selection mechanism to get the value of a selection as a given type from the current selection owner. It returns **True** if the owner successfully converted the selection to the target type or **False** otherwise. If the procedure returns **False** the values of the return arguments are undefined. Each **XtConvertSelectionProc** should respond to target value **TARGETS** by returning a value containing the list of the targets they are prepared to convert their selection into.

```
typedef void (*XtLoseSelectionProc)(Widget, Atom *);
    Widget w;
    Atom *selection;
```

w Specifies the widget that has lost selection ownership.

selection Specifies the atom that describes the selection type.

This procedure is called by the Intrinsics selection mechanism to inform the specified widgets that it has lost the given selection. Note that this procedure does not ask the widget to lose the selection ownership.

```
typedef void (*XtSelectionDoneProc)(Widget, Atom *, Atom *);
    Widget w;
    Atom *selection;
    Atom *target;
```

w Specifies the widget that owns the converted selection.

selection Specifies the atom that describes the selection type that was converted.

target Specifies the target type to which the conversion was done.

This procedure is called by the Intrinsics selection mechanism to inform the selection owner when a selection requestor has successfully retrieved a selection value. If the selection owner has registered an **XtSelectionDoneProc**, it should expect it to be called once for each conversion that it performs but after the converted value has been successfully transferred to the requestor. If the selection owner has registered an **XtSelectionDoneProc**, it also owns the storage containing the converted selection value.

```
typedef void (*XtSelectionCallbackProc)(Widget, caddr_t, Atom *, Atom *, caddr_t, unsigned long *, int *);
    Widget w;
    caddr_t client_data;
    Atom *selection;
    Atom *type;
    caddr_t value;
    unsigned long *length;
    int *format;
```

w Specifies the widget that requested the selection value.

client_data Specifies a value passed in by the widget when it requested the selection.

selection Specifies the type of selection that was requested.

type Specifies the representation type of the selection value (for example, **XA_STRING**). Note that it is not the target that was requested but the type that is used to represent the target. The special X Toolkit atom **XT_CONVERT_FAIL** is used to indicate that the selection conversion failed because the selection owner did not respond within the Intrinsics's selection timeout interval.

value Specifies a pointer to the selection value. The requesting client owns this storage and is responsible for freeing it by calling **XtFree** when it is done with it.

length Specifies the number of elements in value.

format Specifies the size in bits of the data elements of value.

This procedure is called by the Intrinsics selection mechanism to deliver the requested selection to the requestor.

11.5.2.2. Getting the Selection Value

To obtain the selection value in a single, logical unit, use **XtGetSelectionValue** or **XtGetSelectionValues**.

```
void XtGetSelectionValue(w, selection, target, callback, client_data, time)
    Widget w;
    Atom selection;
    Atom target;
    XtSelectionCallbackProc callback;
    caddr_t client_data;
    Time time;
```

w Specifies the widget that is making the request.

selection Specifies the particular selection desired (that is, primary or secondary).

target Specifies the type of the information that is needed about the selection.

callback Specifies the callback procedure that is to be called when the selection value has been obtained. Note that this is how the selection value is communicated back to the client.

client_data Specifies the argument that is to be passed to the specified procedure when it is called.

time Specifies the timestamp that indicates when the selection is desired. This should be the timestamp of the event which triggered this request; the value **CurrentTime** is not acceptable.

The **XtGetSelectionValue** function requests the value of the selection that has been converted to the target type. The specified callback will be called some time after **XtGetSelectionValue** is called; in fact, it may be called before or after **XtGetSelectionValue** returns.

void XtGetSelectionValues(*w*, *selection*, *targets*, *count*, *callback*, *client_data*, *time*)
  Widget *w*;
  Atom *selection*;
  Atom **targets*;
  int *count*;
  XtSelectionCallbackProc *callback*;
  caddr_t *client_data*;
  Time *time*;

w Specifies the widget that is making the request.

selection Specifies the particular selection desired (that is, primary or secondary).

targets Specifies the types of information that is needed about the selection.

count Specifies the length of the targets and client_data lists.

callback Specifies the callback procedure that is to be called with each selection value obtained. Note that this is how the selection values are communicated back to the client.

client_data Specifies the client data (one for each target type) that is passed to the callback procedure when it is called for that target.

time Specifies the timestamp that indicates when the selection value is desired. This should be the timestamp of the event which triggered this request; the value **CurrentTime** is not acceptable.

The **XtGetSelectionValues** function is similar to **XtGetSelectionValue** except that it takes a list of target types and a list of client data and obtains the current value of the selection converted to each of the targets. The effect is as if each target were specified in a separate call to **XtGetSelectionValue**. The callback is called once with the corresponding client data for each target. **XtGetSelectionValues** does guarantee that all the conversions will use the same selection value becaues the ownership of the selection cannot change in the middle of the list, as would be when calling **XtGetSelectionValue** repeatedly.

11.5.2.3. Setting the Selection Owner

To set the selection owner when using atomic transfers, use **XtOwnSelection**.

Boolean XtOwnSelection(*w*, *selection*, *time*, *convert_proc*, *lose_selection*, *done_proc*)
  Widget *w*;
  Atom *selection*;
  Time *time*;
  XtConvertSelectionProc *convert_proc*;
  XtLoseSelectionProc *lose_selection*;
  XtSelectionDoneProc *done_proc*;

w Specifies the widget that wishes to become the owner.

selection Specifies an atom that describes the type of the selection (for example, **XA_PRIMARY**, **XA_SECONDARY**, or **XA_CLIPBOARD**).

time Specifies the timestamp that indicates when the selection ownership should commence. This should be the timestamp of the event that triggered ownership; the value **CurrentTime** is not acceptable.

convert_proc Specifies the procedure that is to be called whenever someone requests the current value of the selection.

lose_selection Specifies the procedure that is to be called whenever the widget has lost selection ownership or NULL if the owner is not interested in being called back.

done_proc Specifies the procedure that is called after the requestor has received the selection or NULL if the owner is not interested in being called back.

The **XtOwnSelection** function informs the Intrinsics selection mechanism that a widget believes it owns a selection. It returns **True** if the widget has successfully become the owner and **False** otherwise. The widget may fail to become the owner if some other widget has asserted ownership at a time later than this widget. Note that widgets can lose selection ownership either because someone else asserted later ownership of the selection or because the widget voluntarily gave up ownership of the selection. Also note that the lose_selection procedure is not called if the widget fails to obtain selection ownership in the first place.

Usually, the Intrinsics selection mechanism informs an application when one of its widgets has lost ownership of the selection. However, in response to some user actions (for example, when a user deletes the information selected), the application should explicitly inform the Intrinsics that it's widget no longer is to be the selection owner by using **XtDisownSelection**.

void XtDisownSelection(*w*, *selection*, *time*)
    Widget *w*;
    Atom *selection*;
    Time *time*;

w Specifies the widget that wishes to relinquish ownership.

selection Specifies the atom that specifies which selection it is giving up.

time Specifies the timestamp that indicates when the selection ownership is relinquished.

The **XtDisownSelection** function informs the Intrinsics selection mechanism that the specified widget is to lose ownership of the selection. If the widget does not currently own the selection either because it lost the selection or because it never had the selection to begin with, **XtDisownSelection** does nothing.

After a widget has called **XtDisownSelection**, its convert procedure is not called even if a request arrives later with a timestamp during the period that this widget owned the selection. However, its done procedure will be called if a conversion that started before the call to **XtDisownSelection** finishes after the call to **XtDisownSelection**.

11.6. Merging Exposure Events into a Region

The Intrinsics provide the **XtAddExposureToRegion** utility function that merges **Expose** and **GraphicsExpose** events into a region that clients can process at once rather than processing individual rectangles. (For further information about regions, see *Xlib – C Language X Interface*.)

To merge **Expose** and **GraphicsExpose** events into a region, use **XtAddExposureToRegion**.

void XtAddExposureToRegion(*event*, *region*)
    XEvent **event*;
    Region *region*;

event Specifies a pointer to the **Expose** or **GraphicsExpose** event.

region Specifies the region object (as defined in <X11/Xutil.h>).

The **XtAddExposureToRegion** function computes the union of the rectangle defined by the exposure event and the specified region. Then, it stores the results back in region. If the event argument is not an **Expose** or **GraphicsExpose** event, **XtAddExposureToRegion** returns without an error and without modifying region.

This function is used by the exposure compression mechanism (see Section 7.9.3).

11.7. Translating Widget Coordinates

To translate an x-y coordinate pair from widget coordinates to root coordinates, use **XtTranslateCoords**.

```
void XtTranslateCoords(w, x, y, rootx_return, rooty_return)
    Widget w;
    Position x, y;
    Position *rootx_return, *rooty_return;
```

w Specifies the widget.

x
y Specify the widget-relative x and y coordinates.

rootx_return
rooty_return Returns the root-relative x and y coordinates.

While **XtTranslateCoords** is similar to the Xlib **XTranslateCoordinates** function, it does not generate a server request because all the required information already is in the widget's data structures.

11.8. Translating a Window to a Widget

To translate a window and display pointer into a widget instance, use **XtWindowToWidget**.

```
Widget XtWindowToWidget(display, window)
    Display *display;
    Window window;
```

display Specifies the display on which the window is defined.

window Specify the window for which you want the widget.

11.9. Handling Errors

The Intrinsics let a client register procedures that are to be called whenever a fatal or nonfatal error occurs. These facilities are intended for both error reporting and logging and for error correction or recovery.

Two levels of interface are provided:

- A high-level interface that takes an error name and class and looks the error up in an error resource database
- A low-level interface that takes a simple string

The high-level functions construct a string to pass to the lower-level interface. On UNIX-based systems, the error database usually is **/usr/lib/X11/XtErrorDB**.

Note

> The application context specific error handling in not implemented on many systems. Most implementations will have just one set of error handlers. If they are set for different application contexts, the one performed last will prevail.

To obtain the error database (for example, to merge with an application or widget specific database), use **XtAppGetErrorDatabase**.

XrmDatabase *XtAppGetErrorDatabase(*app_context*)
    XtAppContext *app_context*;

app_context Specifies the application context.

The **XtAppGetErrorDatabase** function returns the address of the error database. The Intrinsics do a lazy binding of the error database and do not merge in the database file until the first call to **XtAppGetErrorDatbaseText**.

For a complete listing of all errors and warnings that can be generated by the Intrinsics, see Appendix D.

The high-level error and warning handler procedure pointers are of the type **XtErrorMsgHandler**:

typedef void (*XtErrorMsgHandler)(String, String, String, String, String *, Cardinal *);
    String *name*;
    String *type*;
    String *class*;
    String *defaultp*;
    String **params*;
    Cardinal **num_params*;

name	Specifies the name that is concatenated with the specified type to form the resource name of the error message.
type	Specifies the type that is concatenated with the name to form the resource name of the error message.
class	Specifies the resource class of the error message.
defaultp	Specifies the default message to use if no error database entry is found.
params	Specifies a pointer to a list of values to be substituted in the message.
num_params	Specifies the number of values in the parameter list.

The specified name can be a general kind of error, like invalidParameters or invalidWindow, and the specified type gives extra information. Standard **printf** notation is used to substitute the parameters into the message.

An error message handler can obtain the error database text for an error or a warning by calling **XtAppGetErrorDatabaseText**.

void XtAppGetErrorDatabaseText(*app_context*, *name*, *type*, *class*, *default*, *buffer_return*, *nbytes*, *database*)
    XtAppContext *app_context*;
    char **name*, **type*, **class*;
    char **default*;
    char **buffer_return*;
    int *nbytes*;
    XrmDatabase *database*;

app_context	Specifies the application context.
name *type*	Specifies the name and type that are concatenated to form the resource name of the error message.
class	Specifies the resource class of the error message.
default	Specifies the default message to use if an error database entry is not found.
buffer_return	Specifies the buffer into which the error message is to be returned.

nbytes Specifies the size of the buffer in bytes.

database Specifies the name of the alternative database that is to be used or NULL if the application's database is to be used.

The **XtAppGetErrorDatabaseText** returns the appropriate message from the error database or returns the specified default message if one is not found in the error database.

To register a procedure to be called on fatal error conditions, use **XtAppSetErrorMsgHandler**.

void XtAppSetErrorMsgHandler(*app_context*, *msg_handler*)
    XtAppContext *app_context*;
    XtErrorMsgHandler *msg_handler*;

app_context Specifies the application context.

msg_handler Specifies the new fatal error procedure, which should not return.

The default error handler provided by the Intrinsics constructs a string from the error resource database and calls **XtError**. Fatal error message handlers should not return. If one does, subsequent X Toolkit behavior is undefined.

To call the high-level error handler, use **XtAppErrorMsg**.

void XtAppErrorMsg(*app_context*, *name*, *type*, *class*, *default*, *params*, *num_params*)
    XtAppContext *app_context*;
    String *name*;
    String *type*;
    String *class*;
    String *default*;
    String **params*;
    Cardinal **num_params*;

app_context Specifies the application context.

name Specifies the general kind of error.

type Specifies the detailed name of the error.

class Specifies the resource class.

default Specifies the default message to use if an error database entry is not found.

params Specifies a pointer to a list of values to be stored in the message.

num_params Specifies the number of values in the parameter list.

The Intrinsics internal errors all have class **XtToolkitError**.

To register a procedure to be called on nonfatal error conditions, use **XtAppSetWarningMsgHandler**.

void XtAppSetWarningMsgHandler(*app_context*, *msg_handler*)
    XtAppContext *app_context*;
    XtErrorMsgHandler *msg_handler*;

app_context Specifies the application context.

msg_handler Specifies the new nonfatal error procedure, which usually returns.

The default warning handler provided by the Intrinsics constructs a string from the error resource database and calls **XtWarning**.

To call the installed high-level warning handler, use **XtAppWarningMsg**.

void XtAppWarningMsg(*app_context*, *name*, *type*, *class*, *default*, *params*, *num_params*)
XtAppContext *app_context*;
String *name*;
String *type*;
String *class*;
String *default*;
String **params*;
Cardinal **num_params*;

app_context	Specifies the application context.
name	Specifies the general kind of error.
type	Specifies the detailed name of the error.
class	Specifies the resource class.
default	Specifies the default message to use if an error database entry is not found.
params	Specifies a pointer to a list of values to be stored in the message.
num_params	Specifies the number of values in the parameter list.

The Intrinsics internal warninings all have class **XtToolkitError**.

The low-level error and warning handler procedure pointers are of type **XtErrorHandler**:

typedef void (*XtErrorHandler)(String);
String *message*;

message	Specifies the error message.

The error handler should display the message string in some appropriate fashion.

To register a procedure to be called on fatal error conditions, use **XtAppSetErrorHandler**.

void XtAppSetErrorHandler(*app_context*, *handler*)
XtAppContext *app_context*;
XtErrorHandler *handler*;

app_context	Specifies the application context.
handler	Specifies the new fatal error procedure, which should not return.

The default error handler provided by the Intrinsics is **_XtError**. On UNIX-based systems, it prints the message to standard error and terminates the application. Fatal error message handlers should not return. If one does, subsequent X Toolkit behavior is undefined.

To call the installed fatal error procedure, use **XtAppError**.

void XtAppError(*app_context*, *message*)
XtAppContext *app_context*;
String *message*;

app_context	Specifies the application context.
message	Specifies the message that is to be reported.

Most programs should use **XtAppErrorMsg**, not **XtAppError**, to provide for customization and internationalization of error messages.

To register a procedure to be called on nonfatal error conditions, use **XtAppSetWarningHandler**.

void XtAppSetWarningHandler(*app_context*, *handler*)
    XtAppContext *app_context*;
    XtErrorHandler *handler*;

app_context Specifies the application context.

handler Specifies the new nonfatal error procedure, which usually returns.

The default warning handler provided by the Intrinsics is **_XtWarning**. On UNIX-based systems, it prints the message to standard error and returns to the caller.

To call the installed nonfatal error procedure, use **XtAppWarning**.

void XtAppWarning(*app_context*, *message*)
    XtAppContext *app_context*;
    String *message*;

app_context Specifies the application context.

message Specifies the nonfatal error message that is to be reported.

Most programs should use **XtAppWarningMsg**, not **XtAppWarning**, to provide for customization and internationalization of warning messages.

Appendix A

Resource File Format

A resource file contains text representing the default resource values for an application or set of applications. The resource file is an ASCII text file that consists of a number of lines with the following EBNF syntax:

```
resourcefile    = {line "\n"}.
line            = (comment | production).
comment         = "!" string.
production      = resourcename ":" string.
resourcename    = ["*"] name {("." | "*") name}.
string          = {<any character not including eol>}.
name            = {"A"-"Z" | "a"-"z" | "0"-"9"}.
```

If the last character on a line is a backslash (\), that line is assumed to continue on the next line.

To include a newline character in a string, use ''\n''.

Appendix B

Translation Table Syntax

Notation

Syntax is specified in EBNF notation with the following conventions:

[a]   Means either nothing or ''a''
{ a }   Means zero or more occurrences of ''a''

All terminals are enclosed in double quotation masks ('' ''). Informal descriptions are enclosed in angle brackets (< >).

Syntax

The syntax of the translation table file is:

```
translationTable    = [ directive ] { production }
directive           = ( "#replace" | "#override" | "#augment" ) "\n"
production          = lhs ":" rhs "\n"
lhs                 = ( event | keyseq ) { "," (event | keyseq) }
keyseq              = """" keychar {keychar} """"
keychar             = [ "^" | "$" | "\" ] <ISO Latin 1 character>
event               = [modifier_list] "<"event_type">" [ "(" count["+"] ")" ] {detail}
modifier_list       = ( ["!" | ":"] {modifier} ) | "None"
modifier            = ["~"] modifier_name
count               = ("1" | "2" | "3" | "4" | ...)
modifier_name       = "@" <keysym> | <see ModifierNames table below>
event_type          = <see Event Types table below>
detail              = <event specific details>
rhs                 = { name "(" [params] ")" }
name                = namechar { namechar }
namechar            = { "a"-"z" | "A"-"Z" | "0"-"9" | "$" | "_" }
params              = string {"," string}.
string              = quoted_string | unquoted_string
quoted_string       = """ {<Latin 1 character>} """
unquoted_string     = {<Latin 1 character except space, tab, ",", newline, ")">}
```

It is often convenient to include newlines in a translation table to make it more readable. In C, indicate a newline with a ''\n'':

```
"<Btn1Down>: DoSomething()\n\
<Btn2Down>:  DoSomethingElse()"
```

Modifier Names

The modifier field is used to specify normal X keyboard and button modifier mask bits. Modifiers are legal on event types **KeyPress**, **KeyRelease**, **ButtonPress**, **ButtonRelease**, **MotionNotify**, **EnterNotify**, **LeaveNotify**, and their abbreviations. An error is generated when a translation table that contains modifiers for any other events is parsed.

- If the modifier_list has no entries and is not ''None'', it means ''don't care'' on all modifiers.

- If an exclamation point (!) is specified at the beginning of the modifier list, it means that the listed modifiers must be in the correct state and no other modifiers can be asserted.
- If any modifiers are specified and an exclamation point (!) is not specified, it means that the listed modifiers must be in the correct state and "don't care" about any other modifiers.
- If a modifier is preceded by a tilde (~), it means that that modifier must not be asserted.
- If "None" is specified, it means no modifiers can be asserted.
- If a colon (:) is specified at the beginning of the modifier list, it directs the Intrinsics to apply any standard modifiers in the event to map the event keycode into a keysym. The default standard modifiers are Shift and Lock, with the interpretation as defined in *X Window System Protocol, X Version 11*. The resulting keysym must exactly match the specified keysym, and the nonstandard modifiers in the event must match the modifier_list. For example, ":<Key>a" is distinct from ":<Key>A", and ":Shift<Key>A" is distinct from ":<Key>A".
- If a colon (:) is not specified, no standard modifiers are applied. Then, for example, "<Key>A" and "<Key>a" are equivalent.

In key sequences, a circumflex (^) is an abbreviation for the Control modifier, a dollar sign ($) is an abbreviation for Meta, and a backslash (\) can be used to quote any character, in particular a double quote ("), a circumflex (^), a dollar sign ($), and another backslash (\). Briefly:

No Modifiers:	None <event> detail
Any Modifiers:	<event> detail
Only these Modifiers:	! mod1 mod2 <event> detail
These modifiers and any others:	mod1 mod2 <event> detail

The use of "None" for a modifier_list is identical to the use of and exclamation point with no modifers.

Modifier	Abbreviation	Meaning
Ctrl	c	Control modifier bit
Shift	s	Shift modifier bit
Lock	l	Lock modifier bit
Meta	m	Meta key modifier (see below)
Hyper	h	Hyper key modifier (see below)
Super	su	Super key modifier (see below)
Alt	a	Alt key modifier (see below)
Mod1		Mod1 modifier bit
Mod2		Mod2 modifier bit
Mod3		Mod3 modifier bit
Mod4		Mod4 modifier bit
Mod5		Mod5 modifier bit
Button1		Button1 modifier bit
Button2		Button2 modifier bit
Button3		Button3 modifier bit
Button4		Button4 modifier bit
Button5		Button5 modifier bit
ANY		Any combination

A key modifier is any modifier bit whose corresponding keycode contains the corresponding left or right keysym. For example, "m" or "Meta" means any modifier bit mapping to a keycode whose keysym list contains XK_Meta_L or XK_Meta_R. Note that this interpretation is for each display, not global or even for each application context. The Control, Shift, and Lock modifier names refer explicitly to the corresponding modifier bits; there is no additional interpretation of keysyms for these modifiers.

Because it is possible to associate arbitrary keysyms with modifiers, the set of modifier key modifiers is extensible. The "@" <keysym> syntax means any modifier bit whose corresponding keycode contains the specified keysym.

A modifier_list/keysym combination in a translation matches a modifiers/keycode combination in an event in the following:

1. If a colon (:) is used, the Intrinsics call the display's **XtKeyProc** with the keycode and modifiers. To match, (modifiers & ~modifiers_return) must equal modifier_list, and keysym_return must equal the given keysym.
2. If (:) is not used, the Intrinsics mask off all don't-care bits from the modifiers. This value must be equal to modifier_list. Then, for each possible combination of don't-care modifiers in the modifier_list, the Intrinsics call the display's **XtKeyProc** with the keycode and that combination ORed with the cared-about modifier bits from the event. Keysym_return must match the keysym in the translation.

Event Types

The EventType field describes XEvent types. The following are the currently defined EventType values:

Type	Meaning
Key	**KeyPress**
KeyDown	
KeyUp	**KeyRelease**
BtnDown	**ButtonPress**
BtnUp	**ButtonRelease**
Motion	**MotionNotify**
PtrMoved	
MouseMoved	
Enter	**EnterNotify**
EnterWindow	
Leave	**LeaveNotify**
LeaveWindow	
FocusIn	**FocusIn**
FocusOut	**FocusOut**
Keymap	**KeymapNotify**
Expose	**Expose**
GrExp	**GraphicsExpose**
NoExp	**NoExpose**
Visible	**VisibilityNotify**
Create	**CreateNotify**
Destroy	**DestroyNotify**
Unmap	**UnmapNotify**
Map	**MapNotify**
MapReq	**MapRequest**
Reparent	**ReparentNotify**
Configure	**ConfigureNotify**
ConfigureReq	**ConfigureRequest**
Grav	**GravityNotify**
ResReq	**ResizeRequest**
Circ	**CirculateNotify**
CircReq	**CirculateRequest**

Type	Meaning
Prop	**PropertyNotify**
SelClr	**SelectionClear**
SelReq	**SelectionRequest**
Select	**SelectionNotify**
Clrmap	**ColormapNotify**
Message	**ClientMessage**
Mapping	**MappingNotify**

The supported abbreviations are:

Abbreviation	Meaning
Ctrl	**KeyPress** with control modifier
Meta	**KeyPress** with meta modifier
Shift	**KeyPress** with shift modifier
Btn1Down	**ButtonPress** with Btn1 detail
Btn1Up	**ButtonRelease** with Btn1 detail
Btn2Down	**ButtonPress** with Btn2 detail
Btn2Up	**ButtonRelease** with Btn2 detail
Btn3Down	**ButtonPress** with Btn3 detail
Btn3Up	**ButtonRelease** with Btn3 detail
Btn4Down	**ButtonPress** with Btn4 detail
Btn4Up	**ButtonRelease** with Btn4 detail
Btn5Down	**ButtonPress** with Btn5 detail
Btn5Up	**ButtonRelease** with Btn5 detail
BtnMotion	**MotionNotify** with any button modifier
Btn1Motion	**MotionNotify** with Button1 modifier
Btn2Motion	**MotionNotify** with Button2 modifier
Btn3Motion	**MotionNotify** with Button3 modifier
Btn4Motion	**MotionNotify** with Button4 modifier
Btn5Motion	**MotionNotify** with Button5 modifier

The Detail field is event specific and normally corresponds to the detail field of an X Event, for example, <Key>A. If no detail field is specified, then ANY is assumed.

A keysym can be specified as any of the standard keysym names, a hexadecimal number prefixed with "0x" or "0X", an octal number prefixed with "0" or a decimal number. A keysym expressed as a single digit is interpreted as the corresponding Latin 1 keysym, for example, "0" is the keysym XK_0. Other single character keysyms are treated as literal constants from Latin 1, for example, "!" is treated as 0x21. Standard keysym names are as defined in **<X11/keysymdef.h>** with the "XK_" prefix removed.

Canonical Representation

Every translation table has a unique, canonical text representation. This representation is passed to a widget's **display_accelerator** method to describe the accelerators installed on that widget. The canonical representation of a translation table file is (see also "Syntax"):

```
translationTable    = { production }
production          = lhs ":" rhs "\n"
lhs                 = event { "," event  }
event               = [modifier_list] "<"event_type">" [ "(" count["+"] ")" ] {detail}
modifier_list       = ["!" | ":"] {modifier}
```

```
modifier          = ["~"] modifier_name
count             = ("1" | "2" | "3" | "4" | ...)
modifier_name     = "@" <keysym> | <see canonical modifier names below>
event_type        = <see canonical event types below>
detail            = <event specific details>
rhs               = { name "(" [params] ")" }
name              = namechar { namechar }
namechar          = { "a"-"z" | "A"-"Z" | "0"-"9" | "$" | "_" }
params            = string {"," string}.
string            = quoted_string
quoted_string     = """ {<Latin 1 character>} """
```

The canonical modifier names are:

Ctrl	Button1
Shift	Button2
Lock	Button3
Mod1	Button4
Mod2	Button5
Mod3	
Mod4	
Mod5	

The canonical event types are:

KeyPress	**KeyRelease**
ButtonPress	**ButtonRelease**
MotionNotify	**EnterNotify**
LeaveNotify	**FocusIn**
FocusOut	**KeymapNotify**
Expose	**GraphicsExpose,**
NoExpose	**VisibilityNotify**
CreateNotify	**DestroyNotify**
UnmapNotify	**MapNotify**
MapRequest	**ReparentNotify**
ConfigureNotify	**ConfigureRequest**
GravityNotify	**ResizeRequest**
CirculateNotify	**CirculateRequest**
PropertyNotify	**SelectionClear**
SelectionRequest	**SelectionNotify**
ColormapNotify	**ClientMessage**

Examples

- Always put more specific events in the table before more general ones:

```
Shift <Btn1Down> : twas()\n\
<Btn1Down> : brillig()
```

- For double-click on Button 1 Up with Shift, use this specification:

```
Shift<Btn1Up>(2) : and()
```

This is equivalent to the following line with appropriate timers set between events:

```
Shift<Btn1Down>,Shift<Btn1Up>,Shift<Btn1Down>,Shift<Btn1Up> : and()
```

- For double-click on Button 1 Down with Shift, use this specification:

```
Shift<Btn1Down>(2) : the()
```

This is equivalent to the following line with appropriate timers set between events:

```
Shift<Btn1Down>,Shift<Btn1Up>,Shift<Btn1Down> : the()
```

- Mouse motion is always discarded when it occurs between events in a table where no motion event is specified:

```
<Btn1Down>,<Btn1Up> : slithy()
```

This is taken, even if the pointer moves a bit between the down and up events. Similarly, any motion event specified in a translation matches any number of motion events. If the motion event causes an action procedure to be invoked, the procedure is invoked after each motion event.

- If an event sequence consists of a sequence of events that is also a non-initial subsequence of another translation, it is not taken if it occurs in the context of the longer sequence. This occurs mostly in sequences like the following:

```
<Btn1Down>,<Btn1Up> : toves()\n\
<Btn1Up> :  did()
```

The second translation is taken only if the button release is not preceded by a button press or if there are intervening events between the press and the release. Be particularly aware of this when using the repeat notation, above, with buttons and keys because their expansion includes additional events, and when specifying motion events because they are implicitly included between any two other events. In particular, pointer motion and double-click translations cannot coexist in the same translation table.

- For single click on Button 1 Up with Shift and Meta, use this specification:

```
Shift Meta <Btn1Down>, Shift Meta<Btn1Up>: gyre()
```

- You can use a plus sign (+) to indicate "for any number of clicks greater than or equal to count"; for example:

```
Shift <Btn1Up>(2+) : and()
```

- To indicate **EnterNotify** with any modifiers, use this specification:

```
<Enter> : gimble()
```

- To indicate **EnterNotify** with no modifiers, use this specification:

```
None <Enter> : in()
```

- To indicate **EnterNotify** with Button 1 Down and Button 2 Up and don't care about the other modifiers, use this specification:

```
Button1 ~Button2 <Enter> : the()
```

- To indicate **EnterNotify** with Button1 Down and Button2 Down exclusively, use this specification:

! Button1 Button2 <Enter> : wabe()

You do not need to use a tilde (~) with an exclamation point (!).

Appendix C

Conversion Notes

In the X Version 10 and alpha release X Version 11 X Toolkit each widget class implemented an Xt<*Widget*>Create (for example, **XtLabelCreate**) function, in which most of the code was identical from widget to widget. In this X Toolkit, a single generic **XtCreateWidget** performs most of the common work and then calls the initialize procedure implemented for the particular widget class.

Each composite widget class also implemented the procedures Xt<*Widget*>Add and an Xt<*Widget*>Delete (for example, **XtButtonBoxAddButton** and **XtButtonBoxDeleteButton**). In the beta release X Version 11 X Toolkit, the composite generic procedures **XtManageChildren** and **XtUnmanageChildren** perform error-checking and screening out of certain children. Then, they call the change_managed procedure implemented for the widget's composite class. If the widget's parent has not yet been realized, the call on the change_managed procedure is delayed until realization time.

Old style calls can be implemented in the X Toolkit by defining one-line procedures or macros that invoke a generic routine. For example, you could define the macro **XtCreateLabel** as:

```
#define XtCreateLabel(name, parent, args, num_args) \
     ((LabelWidget) XtCreateWidget(name, labelWidgetClass,  parent, args, num_args))
```

Pop-up shells no longer automatically perform an **XtManageChild** on their child within their insert_child procedure. Creators of pop-up children need to call **XtManageChild** themselves.

As a convenience to people converting from earlier versions of the toolkit and for greater orthogonality, the following routines exist: **XtInitialize**, **XtMainLoop**, **XtNextEvent**, **XtProcessEvent**, **XtPeekEvent**, **XtPending**, **XtAddInput**, **XtAddTimeOut**, **XtAddWorkProc**, and **XtCreateApplicationShell**.

Widget XtInitialize(*shell_name*, *application_class*, *options*, *num_options*, *argc*, *argv*)
    String *shell_name*;
    String *application_class*;
    XrmOptionDescRec *options*[];
    Cardinal *num_options*;
    Cardinal **argc*;
    String *argv*[];

shell_name This parameter is ignored; therefore, you can specify NULL.

application_class
Specifies the class name of this application.

options Specifies how to parse the command line for any application-specific resources. The options argument is passed as a parameter to **XrmParseCommand**. For further information, see *Xlib – C Language X Interface*.

num_options Specifies the number of entries in options list.

argc Specifies a pointer to the number of command line parameters.

argv Specifies the command line parameters.

XtInitialize calls **XtToolkitInitialize** to initialize the toolkit internals, creates a default application context for use by the other convenience routines, then calls **XtOpenDisplay** with a display_string of NULL and an application_name of NULL, and finally calls **XtAppCreateShell** with an application_name of NULL and returns the created shell. The semantics of calling **XtInitialize** more than once are undefined. See **XtCreateApplicationContext**, **XtDisplayInitialize**, and **XtAppCreateShell** for more information.

void XtMainLoop()

XtMainLoop first reads the next incoming file, timer, or X event by calling **XtNextEvent**. Then, it dispatches this to the appropriate registered procedure by calling **XtDispatchEvent**. This can be used as the main loop of X Toolkit applications, and, as such, it does not return. Applications are expected to exit in response to some user action. This routine has been replaced by **XtAppMainLoop**.

There is nothing special about **XtMainLoop**. It is simply an infinite loop that calls **XtNextEvent** then **XtDispatchEvent**.

void XtNextEvent(*event_return*)
    XEvent **event_return*;

event_return Returns the event information to the specified event structure.

If no input is on the X input queue for the default application context, **XtNextEvent** flushes the X output buffer and waits for an event while looking at the other input sources and timeout values and calling any callback procedures triggered by them. This routine has been replaced by **XtAppNextEvent**. **XtInitialize** must be called before using this routine.

void XtProcessEvent(*mask*)
    XtInputMask *mask*;

mask Specifies the type of input to process.

XtProcessEvent processes one input event, timeout, or alternate input source (depending on the value of mask), waiting if necessary. It has been replaced by **XtAppProcessEvent**. **XtInitialize** must be called before using this function.

Boolean XtPeekEvent(*event_return*)
    XEvent **event_return*;

event_return Returns the event information to the specified event structure.

If there is an event in the queue for the default application context, **XtPeekEvent** fills in the event and returns a non-zero value. If no X input is on the queue, **XtPeekEvent** flushes the output buffer and blocks until input is available, possibly calling some timeout callbacks in the process. If the input is an event, **XtPeekEvent** fills in the event and returns a non-zero value. Otherwise, the input is for an alternate input source, and **XtPeekEvent** returns zero. This routine has been replaced by **XtAppPeekEvent**. **XtInitialize** must be called before using this routine.

Boolean XtPending()

The **XtPending** returns a nonzero value if there are events pending from the X server or other input sources in the default application context. If there are no events pending, it flushes the output buffer and returns a zero value. It has been replaced by **XtAppPending**. **XtInitialize** must be called before using this routine.

XtInputId XtAddInput(*source*, *condition*, *proc*, *client_data*)
  int *source*;
  caddr_t *condition*;
  XtInputCallbackProc *proc*;
  caddr_t *client_data*;

source Specifies the source file descriptor on a UNIX-based system or other operating system dependent device specification.

condition Specifies the mask that indicates either a read, write, or exception condition or some operating system dependent condition.

proc Specifies the procedure that is called when input is available.

client_data Specifies the parameter to be passed to proc when input is available.

The **XtAddInput** function registers with the X Toolkit default application context a new source of events, which is usually file input but can also be file output. (The word "file" should be loosely interpreted to mean any sink or source of data.) **XtAddInput** also specifies the conditions under which the source can generate events. When input is pending on this source in the default application context, the callback procedure is called. This routine has been replaced by **XtAppAddInput**. **XtInitialize** must be called before using this routine.

XtIntervalId XtAddTimeOut(*interval*, *proc*, *client_data*)
  unsigned long *interval*;
  XtTimerCallbackProc *proc*;
  caddr_t *client_data*;

interval Specifies the time interval in milliseconds.

proc Specifies the procedure to be called when time expires.

client_data Specifies the parameter to be passed to proc when it is called.

The **XtAddTimeOut** function creates a timeout in the default application context and returns an identifier for it. The timeout value is set to interval. The callback procedure will be called after the time interval elapses, after which the timeout is removed. This routine has been replaced by **XtAppAddTimeOut**. **XtInitialize** must be called before using this routine.

XtWorkProcId XtAddWorkProc(*proc*, *closure*)
  XtWorkProc *proc*;
  Opaque *closure*;

proc Procedure to call to do the work.

closure Client data to pass to proc when it is called.

This routine registers a work proc in the default application context. It has been replaced by **XtAppAddWorkProc**. **XtInitialize** must be called before using this routine.

Widget XtCreateApplicationShell(*name*, *widget_class*, *args*, *num_args*)
  String *name*;
  WidgetClass *widget_class*;
  ArgList *args*;
  Cardinal *num_args*;

name This parameter is ignored; therefore, you can specify NULL.

widget_class Specifies the widget class pointer for the created application shell widget. This will usually be **topLevelShellWidgetClass** or a subclass thereof.

args Specifies the argument list to override the resource defaults.

num_args Specifies the number of arguments in args.

XtCreateApplicationShell calls **XtAppCreateShell** with an application_name of NULL, the application_class passed to **XtInitialize** and the default application context created by **XtInitialize**. This routine has been replaced by **XtAppCreateShell**.

To register a new converter, use the procedure **XtAddConverter**.

void XtAddConverter(*from_type*, *to_type*, *converter*, *convert_args*, *num_args*)
  String *from_type*;
  String *to_type*;
  XtConverter *converter*;
  XtConvertArgList *convert_args*;
  Cardinal *num_args*;

from_type Specifies the source type.

to_type Specifies the destination type.

converter Specifies the type converter procedure.

convert_args Specifies how to compute the additional arguments to the converter or NULL.

num_args Specifies the number of additional arguments to the converter or zero.

For the few type converters that need additional arguments, the Intrinsics conversion mechanism provides a method of specifying how these arguments should be computed. The enumerated type **XtAddressMode** and the structure **XtConvertArgRec** specify how each argument is derived. These are defined in **<X11/Convert.h>**.

```
typedef enum {
        /* address mode parameter representation */
          XtAddress,                    /* address */
          XtBaseOffset,                 /* offset */
          XtImmediate,                  /* constant */
          XtResourceString,             /* resource name string */
          XtResourceQuark               /* resource name quark */
} XtAddressMode;

typedef struct {
        XtAddressMode address_mode;
        caddr_t address_id;
        Cardinal size;
} XtConvertArgRec, *XtConvertArgList;
```

The address_mode field specifies how the address_id field should be interpreted. **XtAddress** causes address_id to be interpreted as the address of the data. **XtBaseOffset** causes address_id to be interpreted as the offset from the widget base. **XtImmediate** causes address_id to be interpreted as a constant. **XtResourceString** causes address_id to be interpreted as the name of a resource that is to be converted into an offset from widget base. **XtResourceQuark** is an internal compiled form of an **XtResourceString**. The size field specifies the length of the data in bytes.

The following provides the code that was used to register the CvtStringToPixel routine shown earlier:

```
static XtConvertArgRec colorConvertArgs[] = {
        {XtBaseOffset, (caddr_t) XtOffset(Widget, core.screen),  sizeof(Screen *)},
        {XtBaseOffset, (caddr_t) XtOffset(Widget, core.colormap),sizeof(Colormap)}
};
```

```
XtAddConverter(XtRString, XtRPixel, CvtStringToPixel,
  colorConvertArgs, XtNumber(colorConvertArgs));
```

The conversion argument descriptors colorConvertArgs and screenConvertArg are predefined. The screenConvertArg descriptor puts the widget's screen field into args[0]. The colorConvertArgs descriptor puts the widget's screen field into args[0], and the widget's colormap field into args[1].

Conversion routines should not just put a descriptor for the address of the base of the widget into args[0], and use that in the routine. They should pass in the actual values that the conversion depends on. By keeping the dependencies of the conversion procedure specific, it is more likely that subsequent conversions will find what they need in the conversion cache. This way the cache is smaller and has fewer and more widely applicable entries.

To deallocate a shared GC when it is no longer needed, use **XtDestroyGC**.

void XtDestroyGC(*w*, *gc*)
    Widget *w*;
    GC *gc*;

w Specifies the widget.

gc Specifies the GC to be deallocated.

References to sharable GCs are counted and a free request is generated to the server when the last user of a given GC destroys it. Note that some earlier versions of **XtDestroyGC** had only a gc argument. Therefore, this function is not very portable, and you are encouraged to use **XtReleaseGC** instead.

To declare an action table and register it with the translation manager, use **XtAddActions**.

void XtAddActions(*actions*, *num_actions*)
    XtActionList *actions*;
    Cardinal *num_actions*;

actions Specifies the action table to register.

num_args Specifies the number of entries in this action table.

If more than one action is registered with the same name, the most recently registered action is used. If duplicate actions exist in an action table, the first is used. The Intrinsics register an action table for **MenuPopup** and **MenuPopdown** as part of X Toolkit initialization.

To set the Intrinsics selection timeout, use **XtSetSelectionTimeout**.

void XtSetSelectionTimeout(*timeout*)
    unsigned long *timeout*;

timeout Specifies the selection timeout in milliseconds.

To get the current selection timeout value, use **XtGetSelectionTimeout**.

unsigned long XtGetSelectionTimeout()

The selection timeout is the time within which the two communicating applications must respond to one another. If one of them does not respond within this interval, the Intrinsics aborts the selection request. The default value of the selection timeout is five seconds.

To obtain the error database (for example, to merge with an application or widget specific database), use **XtGetErrorDatabase**.

XrmDatabase *XtGetErrorDatabase()

The **XtGetErrorDatabase** function returns tha address of the error database. The Intrinsics do a lazy binding of the error database and do not merge in the database file until the first call to **XtGetErrorDatbaseText**.

For a complete listing of all errors and warnings that can be generated by the Intrinsics, see Appendix D.

An error message handler can obtain the error database text for an error or a warning by calling **XtGetErrorDatabaseText**.

void XtGetErrorDatabaseText(*name*, *type*, *class*, *default*, *buffer_return*, *nbytes*)
    char **name*, **type*, **class*;
    char **default*;
    char **buffer_return*;
    int *nbytes*;

name
type Specifies the name and type that are concatenated to form the resource name of the error message.

class Specifies the resource class of the error message.

default Specifies the default message to use if an error database entry is not found.

buffer_return Specifies the buffer into which the error message is to be returned.

nbytes Specifies the size of the buffer in bytes.

The **XtGetErrorDatabaseText** returns the appropriate message from the error database or returns the specified default message if one is not found in the error database.

To register a procedure to be called on fatal error conditions, use **XtSetErrorMsgHandler**.

void XtSetErrorMsgHandler(*msg_handler*)
    XtErrorMsgHandler *msg_handler*;

msg_handler Specifies the new fatal error procedure, which should not return.

The default error handler provided by the Intrinsics constructs a string from the error resource database and calls **XtError**. Fatal error message handlers should not return. If one does, subsequent X Toolkit behavior is undefined.

To call the high-level error handler, use **XtErrorMsg**.

void XtErrorMsg(*name*, *type*, *class*, *default*, *params*, *num_params*)
    String *name*;
    String *type*;
    String *class*;
    String *default*;
    String **params*;
    Cardinal **num_params*;

name Specifies the general kind of error.

type Specifies the detailed name of the error.

class Specifies the resource class.

default Specifies the default message to use if an error database entry is not found.

params Specifies a pointer to a list of values to be stored in the message.

num_params Specifies the number of values in the parameter list.

The Intrinsics internal errors all have class **XtToolkitError**.

To register a procedure to be called on nonfatal error conditions, use **XtSetWarningMsgHandler**.

void XtSetWarningMsgHandler(*msg_handler*)
    XtErrorMsgHandler *msg_handler*;

msg_handler Specifies the new nonfatal error procedure, which usually returns.

The default warning handler provided by the Intrinsics constructs a string from the error resource database and calls **XtWarning**.

To call the installed high-level warning handler, use **XtWarningMsg**.

void XtWarningMsg(*name*, *type*, *class*, *default*, *params*, *num_params*)
    String *name*;
    String *type*;
    String *class*;
    String *default*;
    String **params*;
    Cardinal **num_params*;

name Specifies the general kind of error.

type Specifies the detailed name of the error.

class Specifies the resource class.

default Specifies the default message to use if an error database entry is not found.

params Specifies a pointer to a list of values to be stored in the message.

num_params Specifies the number of values in the parameter list.

The Intrinsics internal warninings all have class **XtToolkitError**.

To register a procedure to be called on fatal error conditions, use **XtSetErrorHandler**.

void XtSetErrorHandler(*handler*)
    XtErrorHandler *handler*;

handler Specifies the new fatal error procedure, which should not return.

The default error handler provided by the Intrinsics is **_XtError**. On UNIX-based systems, it prints the message to standard error and terminates the application. Fatal error message handlers should not return. If one does, subsequent X Toolkit behavior is undefined.

To call the installed fatal error procedure, use **XtError**.

void XtError(*message*)
    String *message*;

message Specifies the message that is to be reported.

Most programs should use **XtErrorMsg**, not **XtError**, to provide for customization and internationalization of error messages.

To register a procedure to be called on nonfatal error conditions, use **XtSetWarningHandler**.

void XtSetWarningHandler(*handler*)
    XtErrorHandler *handler*;

handler Specifies the new nonfatal error procedure, which usually returns.

The default warning handler provided by the Intrinsics is **_XtWarning**. On UNIX-based systems, it prints the message to standard error and returns to the caller.

To call the installed nonfatal error procedure, use **XtWarning**.

void XtWarning(*message*)
    String *message*;

message Specifies the nonfatal error message that is to be reported.

Most programs should use **XtWarningMsg**, not **XtWarning**, to provide for customization and internationalization of warning messages.

Appendix D

Standard Errors and Warnings

All X Toolkit errors and warnings have class **XtToolkitError**. The following two tables summarize all of the errors and warnings that can be generated by the X Toolkit.

Error Messages

Name	Type	Default Message
allocError	calloc	Cannot perform calloc
allocError	malloc	Cannot perform malloc
allocError	realloc	Cannot perform realloc
communicationError	select	Select failed
internalError	shell	Shell's window manager interaction is broken
invalidArgCount	xtGetValues	Argument count > 0 on NULL argument list in XtGetValues
invalidArgCount	xtSetValues	Argument count > 0 on NULL argument list in XtSetValues
invalidClass	constraintSetValue	Subclass of Constraint required in CallConstraintSetValues
invalidClass	xtAppCreateShell	XtAppCreateShell requires non-NULL widget class
invalidClass	xtCreatePopupShell	XtCreatePopupShell requires non-NULL widget class
invalidClass	xtCreateWidget	XtCreateWidget requires non-NULL widget class
invalidClass	xtPopdown	XtPopdown requires a subclass of shellWidgetClass
invalidClass	xtPopup	XtPopup requires a subclass of shellWidgetClass
invalidDimension	xtCreateWindow	Widget %s has zero width and/or height
invalidDimension	shellRealize	Shell widget %s has zero width and/or height
invalidDisplay	xtInitialize	Can't Open display
invalidGeometryManager	xtMakeGeometryRequest	XtMakeGeometryRequest - parent has no geometry manger
invalidParameter	removePopupFromParent	RemovePopupFromParent requires non-NULL popuplist
invalidParameter	xtAddInput	invalid condition passed to XtAddInput
invalidParameters	xtMenuPopupAction	MenuPopup wants exactly one argument
invalidParameters	xtmenuPopdown	XtMenuPopdown called with num_params != 0 or 1
invalidParent	realize	Application shell is not a windowed widget?
invalidParent	xtCreatePopupShell	XtCreatePopupShell requires non-NULL parent
invalidParent	xtCreateWidget	XtCreateWidget requires non-NULL parent
invalidParent	xtMakeGeometryRequest	XtMakeGeometryRequest - NULL parent. Use SetValues instead
invalidParent	xtMakeGeometryRequest	XtMakeGeometryRequest - parent not composite
invalidParent	xtManageChildren	Attempt to manage a child when parent is not Composite
invalidParent	xtUnmanageChildren	Attempt to unmanage a child when parent is not Composite
invalidPopup	xtMenuPopup	Can't find popup in _XtMenuPopup
invalidPopup	xtMenuPopup	Can't find popup in _XtMenuPopup
invalidProcedure	inheritanceProc	Unresolved inheritance operation
invalidProcedure	realizeProc	No realize class procedure defined

invalidWindow	eventHandler	Event with wrong window
missingEvent	shell	Events are disappearing from under Shell
noAppContext	widgetToApplicationContext	Couldn't find ancestor with display information
noPerDisplay	closeDisplay	Couldn't find per display information
noPerDisplay	getPerDisplay	Couldn't find per display information
noSelectionProperties	freeSelectionProperty	internal error: no selection property context for display
nullProc	insertChild	NULL insert_child procedure
subclassMismatch	xtCheckSubclass	Widget class %s found when subclass of %s expected: %s
translationError	mergingTablesWithCycles	Trying to merge translation tables with cycles, and can't resolve this cycle.
wrongParameters	cvtIntOrPixelToXColor	Pixel to color conversion needs screen and colormap arguments
wrongParameters	cvtStringToCursor	String to cursor conversion needs screen argument
wrongParameters	cvtStringToFont	String to font conversion needs screen argument
wrongParameters	cvtStringToFontStruct	String to cursor conversion needs screen argument
wrongParameters	cvtStringToPixel	String to pixel conversion needs screen and colormap arguments

Warning Messages

Name	Type	Default Message
ambigiousParent	xtManageChildren	Not all children have same parent in XtManageChildren
ambigiousParent	xtUnmanageChildren	Not all children have same parent in XtUnmanageChil-dren
communicationError	windowManager	Window Manager is confused
conversionError	string	Cannot convert string "%s" to type "%s"
displayError	invalidDisplay	Can't find display structure
grabError	grabDestroyCallback	XtAddGrab requires exclusive grab if spring_loaded is TRUE
grabError	grabDestroyCallback	XtAddGrab requires exclusive grab if spring_loaded is TRUE
grabError	xtRemoveGrab	XtRemoveGrab asked to remove a widget not on the grab list
initializationError	xtInitialize	Initializing Resource Lists twice
invalidArgCount	getResources	argument count > 0 on NULL argument list
invalidCallbackList	xtAddCallbacks	Cannot find callback list in XtAddCallbacks
invalidCallbackList	xtCallCallback	Cannot find callback list in XtCallCallbacks
invalidCallbackList	xtOverrideCallback	Cannot find callback list in XtOverrideCallbacks
invalidCallbackList	xtRemoveAllCallback	Cannot find callback list in XtRemoveAllCallbacks
invalidCallbackList	xtRemoveCallbacks	Cannot find callback list in XtRemoveCallbacks
invalidChild	xtManageChildren	null child passed to XtManageChildren
invalidChild	xtUnmanageChildren	Null child passed to XtUnmanageChildren
invalidDepth	setValues	Can't change widget depth
invalidGeometry	xtMakeGeometryRequest	Shell subclass did not take care of geometry in XtSet-Values
invalidParameters	compileAccelerators	String to AcceleratorTable needs no extra arguments
invalidParameters	compileTranslations	String to TranslationTable needs no extra arguments
invalidParameters	mergeTranslations	MergeTM to TranslationTable needs no extra arguments
invalidParent	xtCopyFromParent	CopyFromParent must have non-NULL parent

invalidPopup	unsupportedOperation	Pop-up menu creation is only supported on ButtonPress or EnterNotify events.
invalidPopup	unsupportedOperation	Pop-up menu creation is only supported on ButtonPress or EnterNotify events.
invalidProcedure	deleteChild	null delete_child procedure in XtDestroy
invalidProcedure	inputHandler	XtRemoveInput: Input handler not found
invalidProcedure	set_values_almost	set_values_almost procedure shouldn't be NULL
invalidResourceCount	getResources	resource count > 0 on NULL resource list
invalidResourceName	computeArgs	Cannot find resource name %s as argument to conversion
invalidShell	xtTranslateCoords	Widget has no shell ancestor
invalidSizeOverride	xtDependencies	Representation size %d must match superclass's to override %s
invalidTypeOverride	xtDependencies	Representation type %s must match superclass's to override %s
invalidWidget	removePopupFromParent	RemovePopupFromParent,widget not on parent list
noColormap	cvtStringToPixel	Cannot allocate colormap entry for "%s"
registerWindowError	xtRegisterWindow	Attempt to change already registered window.
registerWindowError	xtUnregisterWindow	Attempt to unregister invalid window.
translation error	nullTable	Can't remove accelerators from NULL table
translation error	nullTable	Tried to remove non-existant accelerators
translationError	ambigiousActions	Overriding earlier translation manager actions.
translationError	mergingNullTable	Old translation table was null, cannot modify.
translationError	nullTable	Can't translate event thorugh NULL table
translationError	unboundActions	Actions not found: %s
translationError	xtTranslateInitialize	Intializing Translation manager twice.
translationParseError	showLine	... found while parsing '%s'
translationParseError	parseError	translation table syntax error: %s
translationParseError	parseString	Missing '´.
typeConversionError	noConverter	No type converter registered for '%s' to '%s' conversion.
versionMismatch	widget	Widget class %s version mismatch: widget %d vs. intrinsics %d.
wrongParameters	cvtIntToBool	Integer to Bool conversion needs no extra arguments
wrongParameters	cvtIntToBoolean	Integer to Boolean conversion needs no extra arguments
wrongParameters	cvtIntToFont	Integer to Font conversion needs no extra arguments
wrongParameters	cvtIntToPixel	Integer to Pixel conversion needs no extra arguments
wrongParameters	cvtIntToPixmap	Integer to Pixmap conversion needs no extra arguments
wrongParameters	cvtIntToShort	Integer to Short conversion needs no extra arguments
wrongParameters	cvtStringToBool	String to Bool conversion needs no extra arguments
wrongParameters	cvtStringToBoolean	String to Boolean conversion needs no extra arguments
wrongParameters	cvtStringToDisplay	String to Display conversion needs no extra arguments
wrongParameters	cvtStringToFile	String to File conversion needs no extra arguments
wrongParameters	cvtStringToInt	String to Integer conversion needs no extra arguments
wrongParameters	cvtStringToShort	String to Integer conversion needs no extra arguments
wrongParameters	cvtStringToUnsignedChar	String to Integer conversion needs no extra arguments
wrongParameters	cvtXColorToPixel	Color to Pixel conversion needs no extra arguments

Appendix E

StringDefs.h Header File

The **StringDefs.h** header file contains:

```
/* Resource names */

#define XtNaccelerators          "accelerators"
#define XtNallowHoriz            "allowHoriz"
#define XtNallowVert             "allowVert"
#define XtNancestorSensitive     "ancestorSensitive"
#define XtNbackground            "background"
#define XtNbackgroundPixmap      "backgroundPixmap"
#define XtNborderColor           "borderColor"
#define XtNborder                "borderColor"
#define XtNborderPixmap          "borderPixmap"
#define XtNborderWidth           "borderWidth"
#define XtNcallback              "callback"
#define XtNcolormap              "colormap"
#define XtNdepth                 "depth"
#define XtNdestroyCallback       "destroyCallback"
#define XtNeditType              "editType"
#define XtNfont                  "font"
#define XtNforceBars             "forceBars"
#define XtNforeground            "foreground"
#define XtNfunction              "function"
#define XtNheight                "height"
#define XtNhSpace                "hSpace"
#define XtNindex                 "index"
#define XtNinnerHeight           "innerHeight"
#define XtNinnerWidth            "innerWidth"
#define XtNinnerWindow           "innerWindow"
#define XtNinsertPosition        "insertPosition"
#define XtNinternalHeight        "internalHeight"
#define XtNinternalWidth         "internalWidth"
#define XtNjustify               "justify"
#define XtNknobHeight            "knobHeight"
#define XtNknobIndent            "knobIndent"
#define XtNknobPixel             "knobPixel"
#define XtNknobWidth             "knobWidth"
#define XtNlabel                 "label"
#define XtNlength                "length"
#define XtNlowerRight            "lowerRight"
#define XtNmappedWhenManaged     "mappedWhenManaged"
#define XtNmenuEntry             "menuEntry"
#define XtNname                  "name"
#define XtNnotify                "notify"
#define XtNorientation           "orientation"
#define XtNparameter             "parameter"
#define XtNpopupCallback         "popupCallback"
#define XtNpopdownCallback       "popdownCallback"
```

```
#define XtNreverseVideo         "reverseVideo"
#define XtNscreen               "screen"
#define XtNscrollProc           "scrollProc"
#define XtNscrollDCursor        "scrollDownCursor"
#define XtNscrollHCursor        "scrollHorizontalCursor"
#define XtNscrollLCursor        "scrollLeftCursor"
#define XtNscrollRCursor        "scrollRightCursor"
#define XtNscrollUCursor        "scrollUpCursor"
#define XtNscrollVCursor        "scrollVerticalCursor"
#define XtNselection            "selection"
#define XtNselectionArray       "selectionArray"
#define XtNsensitive            "sensitive"
#define XtNshown                "shown"
#define XtNspace                "space"
#define XtNstring               "string"
#define XtNtextOptions          "textOptions"
#define XtNtextSink             "textSink"
#define XtNtextSource           "textSource"
#define XtNthickness            "thickness"
#define XtNthumb                "thumb"
#define XtNthumbProc            "thumbProc"
#define XtNtop                  "top"
#define XtNtranslations         "translations"
#define XtNuseBottom            "useBottom"
#define XtNuseRight             "useRight"
#define XtNvalue                "value"
#define XtNvSpace               "vSpace"
#define XtNwidth                "width"
#define XtNwindow               "window"
#define XtNx                    "x"
#define XtNy                    "y"

/* Class types */

#define XtCAccelerators         "Accelerators"
#define XtCBackground           "Background"
#define XtCBoolean              "Boolean"
#define XtCBorderColor          "BorderColor"
#define XtCBorderWidth          "BorderWidth"
#define XtCCallback             "Callback"
#define XtCColormap             "Colormap"
#define XtCColor                "Color"
#define XtCCursor               "Cursor"
#define XtCDepth                "Depth"
#define XtCEditType             "EditType"
#define XtCEventBindings        "EventBindings"
#define XtCFile                 "File"
#define XtCFont                 "Font"
#define XtCForeground           "Foreground"
#define XtCFraction             "Fraction"
#define XtCFunction             "Function"
#define XtCHeight               "Height"
#define XtCHSpace               "HSpace"
#define XtCIndex                "Index"
```

```
#define XtCInterval             "Interval"
#define XtCJustify              "Justify"
#define XtCKnobIndent           "KnobIndent"
#define XtCKnobPixel            "KnobPixel"
#define XtCLabel                "Label"
#define XtCLength               "Length"
#define XtCMappedWhenManaged    "MappedWhenManaged"
#define XtCMargin               "Margin"
#define XtCMenuEntry            "MenuEntry"
#define XtCNotify               "Notify"
#define XtCOrientation          "Orientation"
#define XtCParameter            "Parameter"
#define XtCPixmap               "Pixmap"
#define XtCPosition             "Position"
#define XtCScreen               "Screen"
#define XtCScrollProc           "ScrollProc"
#define XtCScrollDCursor        "ScrollDownCursor"
#define XtCScrollHCursor        "ScrollHorizontalCursor"
#define XtCScrollLCursor        "ScrollLeftCursor"
#define XtCScrollRCursor        "ScrollRightCursor"
#define XtCScrollUCursor        "ScrollUpCursor"
#define XtCScrollVCursor        "ScrollVerticalCursor"
#define XtCSelection            "Selection"
#define XtCSensitive            "Sensitive"
#define XtCSelectionArray       "SelectionArray"
#define XtCSpace                "Space"
#define XtCString               "String"
#define XtCTextOptions          "TextOptions"
#define XtCTextPosition         "TextPosition"
#define XtCTextSink             "TextSink"
#define XtCTextSource           "TextSource"
#define XtCThickness            "Thickness"
#define XtCThumb                "Thumb"
#define XtCTranslations         "Translations"
#define XtCValue                "Value"
#define XtCVSpace               "VSpace"
#define XtCWidth                "Width"
#define XtCWindow               "Window"
#define XtCX                    "X"
#define XtCY                    "Y"

/* Representation types */

#define XtRAcceleratorTable     "AcceleratorTable"
#define XtRBoolean              "Boolean"
#define XtRCallback             "Callback"
#define XtRCallProc             "CallProc"
#define XtRColor                "Color"
#define XtRCursor               "Cursor"
#define XtRDimension            "Dimension"
#define XtRDisplay              "Display"
#define XtREditMode             "EditMode"
#define XtRFile                 "File"
#define XtRFont                 "Font"
```

```
#define XtRFontStruct           "FontStruct"
#define XtRFunction             "Function"
#define XtRGeometry             "Geometry"
#define XtRImmediate            "Immediate"
#define XtRInt                  "Int"
#define XtRJustify              "Justify"
#define XtRLongBoolean          "LongBoolean"
#define XtROrientation          "Orientation"
#define XtRPixel                "Pixel"
#define XtRPixmap               "Pixmap"
#define XtRPointer              "Pointer"
#define XtRPosition             "Position"
#define XtRShort                "Short"
#define XtRString               "String"
#define XtRStringTable          "StringTable"
#define XtRUnsignedChar         "UnsignedChar"
#define XtRTranslationTable     "TranslationTable"
#define XtRWindow               "Window"

/* Boolean enumeration constants */

#define XtEoff                  "off"
#define XtEfalse                "false"
#define XtEno                   "no"
#define XtEon                   "on"
#define XtEtrue                 "true"
#define XtEyes                  "yes"

/* Orientation enumeration constants */

#define XtEvertical             "vertical"
#define XtEhorizontal           "horizontal"

/* text edit enumeration constants */

#define XtEtextRead             "read"
#define XtEtextAppend           "append"
#define XtEtextEdit             "edit"

/* color enumeration constants */

#define XtExtdefaultbackground  "xtdefaultbackground"
#define XtExtdefaultforeground  "xtdefaultforeground"

/* font constant */

#define XtExtdefaultfont        "xtdefaultfont"
```

Index

Bitmap Distribution Format 2.1

Table of Contents

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1. Introduction

This document describes Bitmap Distribution Format (BDF), version 2.1. BDF is an X Consortium standard for font interchange, intended to be easily understood by both humans and computers.

2. File Format

Character bitmap information will be distributed in an USASCII encoded, human readable form. Each file is encoded in the printable characters (octal 40 through 176) of USASCII plus carriage return and linefeed. Each file consists of a sequence of variable-length lines. Each line is terminated by a carriage-return (octal 015) and line-feed (octal 012), or by just a line-feed.

The information about a particular family and face at one size and orientation will be contained in one file. The file begins with information pertaining to the face as a whole, followed by the information and bitmaps for the individual characters.

A font bitmap description file has the following general form, where each item is contained on a separate line of text in the file. Items on a line are separated by spaces.

1. The word STARTFONT followed by a version number indicating the exact file format used. The version described here is number **2.1**.
2. One or more lines beginning with the word COMMENT. These lines may be ignored by any program reading the file.
3. The word FONT followed by the full name of the font. Note that the name continues all the way to the end of the line, and may contain spaces.
4. The word SIZE followed by the **point size** of the characters, the **x resolution**, and the **y resolution** of the device for which these characters were intended.
5. The word FONTBOUNDINGBOX followed by the **width in x**, **height in y**, and the x and y displacement of the lower left corner from the **origin**. (See the examples in section 3).
6. Optionally the word STARTPROPERTIES followed by the number of properties (**p**) that follow.
7. Then come **p** lines consisting of a word for the **property name** followed by either an integer or string surrounded by double-quote (octal 042). Internal double-quotes characters are indicated by using two in a row.
8. Properties named FONT_ASCENT, FONT_DESCENT, and DEFAULT_CHAR should be provided to define the logical font-ascent and font-descent and the default-char for the font. These properties will be removed from the actual font properties in the binary form produced by a compiler. If these properties are not provided, a compiler may reject the font, or may compute (arbitrary) values for these properties.
9. The property section, if it exists, is terminated by ENDPROPERTIES.
10. The word CHARS followed by the number of character segments (**c**) that follow.
11. Then come **c** character segments of the form:

a. The word STARTCHAR followed by up to 14 characters (no blanks) of descriptive **name** of the glyph.

b. The word ENCODING followed by a positive integer representing the Adobe Standard Encoding value. If the character is *not* a member of the Adobe Standard Encoding, ENCODING is followed by -1 and an optional integer specifying the glyph index; if the glyph index is not specified, a compiler will typically ignore the character segment.

c. The word SWIDTH followed by the **scalable width** in x and y of character. Scalable widths are in units of 1/1000th of the size of the character. If the size of the character is *p* points, the width information must be scaled by *p*/1000 to get the width of the character in printer's points. This width information should be considered as a vector indication the position of the next character's origin relative to the origin of this character. To convert the scalable width to the width in device pixels, multiply SWIDTH times *p*/1000 times *r*/72 where *r* is the device resolution in pixels per inch. The result is a real number giving the ideal print width in device pixels. The actual device width must of course be an integral number of device pixels and is given in the next entry. The SWIDTH y value should always be zero for a standard X font.

d. The word DWIDTH followed by the width in x and y of the character in device units. Like the SWIDTH, this width information is a vector indicating the position of the next character's origin relative to the origin of this character. The DWIDTH y value should always be zero for a standard X font.

e. The word BBX followed by the **width** in x (*BBw*), **height** in y (*BBh*) and x and y displacement (*BBox, BBoy*) of the lower left corner from the **origin** of the character.

f. The optional word ATTRIBUTES followed by the attributes as 4 **hex-encoded** characters. The interpretation of these attributes is undefined in this document.

g. The word BITMAP.

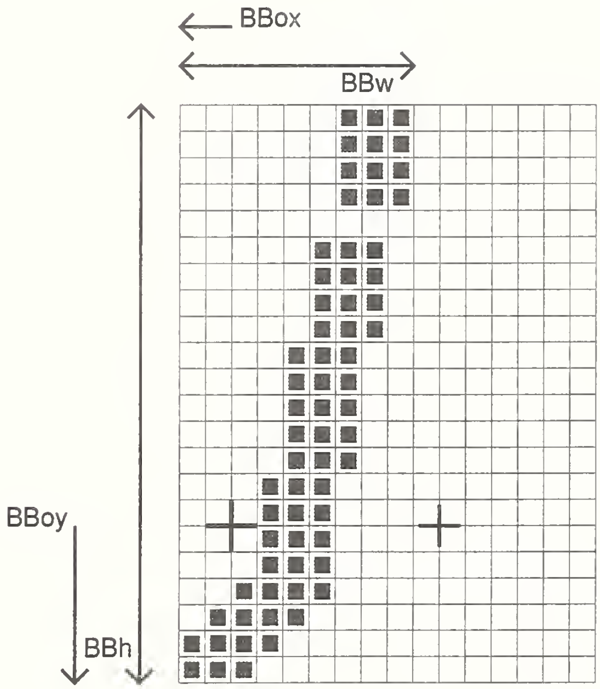
h. *h* lines of **hex-encoded bitmap**, padded on the right with zero's to the nearest byte (i.e., multiple of 8).

i. The word ENDCHAR.

12. The file is terminated with the word ENDFONT.

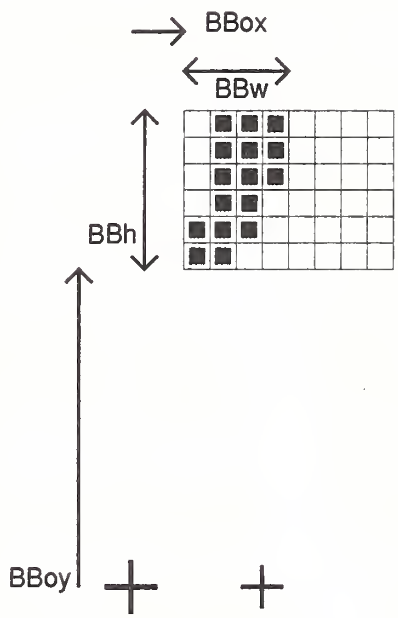
3. Metric Information

Figures 3-1 and 3-2 best illustrate the bitmap format and character metric information.



BBw = 9, BBh = 22, BBox = -2, BBoy = -6
Rounded character width = 8 0
''+'' = character origin and width

Figure 3-1: An example of a descender



BBh = 6, BBw = 4, BBox = +2, BBoy = +12
Rounded character width = 5 0

Figure 3-2: An example with the origin outside the bounding box

4. An Example File

Figure 4-1 is an abbreviated example of a bitmap file containing the specification of two characters (the j and quoteright in 3).[1]

```
STARTFONT 2.1
COMMENT This is a sample font in 2.1 format.
FONT Helvetica-Bold
SIZE 8 200 200
FONTBOUNDINGBOX 9 24 -2 -6
STARTPROPERTIES 2
MinSpace 4
Copyright "Copyright (c) 1987 Adobe Systems, Inc."
ENDPROPERTIES
CHARS 2
STARTCHAR j
ENCODING 106
SWIDTH 355 0
DWIDTH 8 0
BBX 9 22 -2 -6
BITMAP
0380
0380
0380
0380
0000
0700
0700
0700
0700
0E00
0E00
0E00
0E00
0E00
1C00
1C00
1C00
1C00
2C00
7800
F000
E000
ENDCHAR
STARTCHAR quoteright
ENCODING 39
SWIDTH 223 0
DWIDTH 5 0
BBX 4 5 2 12
ATTRIBUTES 01C0
BITMAP
70
70
60
E0
C0
ENDCHAR
ENDFONT
```

Figure 4-1: A short example file

[1]Helvetica® is a registered trademark of Allied Corporation.

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