NISTIR 5457

# Report on the Workshop on Advanced Digital Video in the National Information Infrastructure

## May 10-11, 1994
## Georgetown University Conference Center
## Washington, DC

July 1994

### WORKSHOP SPONSORS

- *National Institute of Standards and Technology*
- *Technology Policy Working Group*
  - *Information Infrastructure Task Force*
  - *Committee on Applications and Technology*
- *Electronics Industries Association*
- *Institute of Electrical and Electronics Engineers - USA*
- *Society of Motion Picture and Television Engineers*
- *Advanced Television Systems Committee*
- *Cross-Industry Working Team*

U. S. DEPARTMENT OF COMMERCE
Technology Administration
National Institute of Standards and Technology
Gaithersburg, MD 20899

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Prepared by the Workshop Program Committee:
Charles Fenlmore, Bruce Field, Howard Frank, Elden Georg, Michael Papillo,
Glenn Reitmeier, Will Stackhouse, and Craig Van Degrift

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Workshop on Advanced Digital Video
in the National Information Infrastructure

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# Summary Report on the Workshop on Advanced Digital Video in the National Information Infrastructure


By the Workshop Program Committee:

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Howard Frank, *Advanced Research Projects Agency*
Elden Georg, *Space Applications Corporation*
Michael Papillo, *Houston Associates, Inc.*
Glenn Reitmeier, *David Sarnoff Research Center*
Will Stackhouse, *Consultant*
Craig Van Degrift, *National Institute of Standards and Technology*


## INTRODUCTION

A workshop was held May 10-11, 1994, in Washington DC, to highlight technical issues for industry and government decision makers with respect to Advanced Digital Video (ADV) in the National Information Infrastructure (NII). The purpose of the workshop was to:

(1) define a vision of the role of digital video within the NII,
(2) identify the architectural, scaling, and performance issues in realizing this vision, and
(3) recommend the research, experiments, and steps to be taken to resolve these issues.

The workshop was attended by approximately 180 people from industry, government, and academia and consisted of talks and discussions by experts in information services, broadcasting, computing, consumer electronics, and government policy. Robert Kahn of the Corporation for National Research Initiatives, Michael Nelson from the Office of Science and Technology Policy, and D. Joseph Donahue, Senior Vice President for Technology and Business Development, Thomson Consumer Electronics, Inc. were among the many speakers at the Workshop. The discussions were facilitated by participants forming four breakout groups to focus on architectural considerations, modular decomposition and interoperability; display performance; image capture and display requirements; and digital delivery services.

In addition, there were three demonstrations of new video technology. The Grand Alliance demonstrated three of the proponent high-definition television systems (HDTV) that have been incorporated into the Grand Alliance proposal to the Federal Communications Commission for adoption as the U.S. broadcast standard. Nippon Television (NTV) demonstrated a 525-line, 16:9 widescreen, progressive-scan television camera which offers improved picture resolution compared to today's television standards. And, NIST demonstrated the Mosaic/World Wide Web information retrieval system on the Internet, a possible model for advanced information retrieval within the NII.

This summary by the Program Committee reports on some of the important ideas expressed by the speakers and the conclusions reached by the breakout groups. Discussion of an item in the KEY CONCEPTS section does not imply that the view was universally accepted by the workshop participants, rather that it was expressed by one or more of the speakers. The Recommendations are based on the plenary discussions including two straw polls. The Breakout Group *summaries* (starting on p. 5) are a synthesis by the Program Committee of the reports from each group. The Breakout Group *reports* (starting on p. 11) appear without editing by the Program Committee. Speakers' slides and other contributions from the participants appear as an appendix.

## KEY CONCEPTS

*Definition of the National Information Infrastructure*

> ***"A system to deliver to all Americans the information they need when they want it and where they want it – at an affordable price."***
> ***—Michael Nelson, OSTP***

The NII will be an amalgam of information networks, appliances, and services. It will consist of thousands of interconnected, interoperable communication networks, including terrestrial and satellite broadcasting, cable television networks, wired and wireless telephone systems, commercial computer network services, and the Internet and its successor. Computer systems, televisions, telephones, and other devices will all converge to serve as "information appliances" on the NII. Digital libraries, information services, and databases will be needed to provide the NII information content; users will buy content, not technology.

Content and useful applications will attract the usage necessary for NII success. The cultural industries, particularly motion pictures and television, can thus be seen as an essential part of the NII. It is critical that intellectual property rights associated with cultural items be protected by audit and control mechanisms at all service levels. Furthermore, the NII should be open to all information suppliers on an equitable basis.

NII applications will include distribution of entertainment programming, educational information, government data, manufacturing information, and access to health care. The production and distribution of entertainment programming today is a $37 billion information industry in the United States. Digital program delivery over interactive networks will permit additional cost-effective services such as video-on-demand and shopping at home. Electronic distribution of educational material will expose all students, even those in remote locations, to a high-quality education. Government, in part, is a vast information gathering and disbursing system. Electronic availability will facilitate access by business and the public to government reports, weather information, and other scientific data. Electronic "blueprints" and rapid communication between manufacturers and their suppliers are critical elements in improving manufacturing productivity. Health care may be improved by telemedicine and maintenance of on-line medical records. Telemedicine permits remote patient examination and diagnosis. Keeping appropriately-protected medical records on line permits immediate medical review by specialists, allows simplified billing procedures, and provides more complete research material for population studies.

The NII will be built, owned, and run by the private sector with hundreds or thousands of companies providing services. The role of the government is to ensure that these systems and services are interconnected and interoperable in order to provide competition and choice for the customer. The goal is to have a fully competitive marketplace in which *any* company may provide *any* service to *any* customer.

***Interoperable, extensible systems are required so that television and communications can evolve along the technology curve.***

Communications and video standards should describe an architecture which is flexible, extensible, and simple. A flexible architecture allows loose coupling between the components while focusing on key interworking points. If the architecture is structured correctly, then its performance can be optimized by improved engineering while still retaining maximal backward compatibility. System developers must plan for continuous deployment and renewal; system heterogeneity and migration will be the steady-state condition.

In an NII environment of diverse heterogeneous networks, interconnected systems will need commonality among high-level functions such as addressing, device and environment description, service performance description, property-rights-protection data, and transaction security. Lower level protocols of different individual network elements can be otherwise subjected to the standards of each industry, knowing that appropriate protocol conversions can be performed at network interconnect points. Two examples of these lower level protocols are the Asynchronous Transfer Mode (ATM) protocol (an accepted world standard for telephony) and the MPEG Systems Layer (an accepted world standard for multiplexing video, audio, and data for digital television broadcasting). Proposed technical approaches exist for efficiently mapping advanced digital video streams into ATM and handling the effect of "cell jitter" in applications where video and audio time synchronization are crucial, but industry agreements are still needed. Current video experiments are also being performed on the Internet to examine multi-casting techniques and the use of multiple service classes to handle applications with different timing requirements. Further work remains to accommodate network diversity, to determine requirements for various applications of video, and to define network management policies that accommodate video requirements.

Efficient general-purpose networking involves a flexible, loose coupling of sources with destinations so that a variety of sources can be connected to a variety of destinations via a variety of transmission paths. This decoupling means, for example, that image timing and colorimetry information must be conveyed in a device-independent manner. Using digital converters between existing standards is likely to be more cost-effective than requiring uniform standards for all types of imagery in the system.

Despite many common characteristics, the NII information appliance may develop along two paths: task-oriented computer systems, and entertainment-oriented digital television. Entertainment systems require a bright, large-screen display for multiple viewers while computer systems usually have a geometrically-accurate, small-screen display for a single viewer. This dual approach will provide NII services for different interests and needs, thus producing the quickest evolution of technology, services, and content. The architecture, however, must not force the technology along two paths, as applications may emerge to use the capabilities of both.

***An NII Goal is to transmit images and video as easily as a telephone transmits voice today.***

Video applications will likely set the maximum bit-rate requirements of the NII. High-definition, "studio-quality" video will need to be sent point-to-point in real time between studios, editing facilities, and archive locations. This may set the maximum bit rate required by any individual transaction in NII. Similarly, compressed high-definition television is likely to set the maximum bit-rate requirements of NII connections to the home.

The Grand Alliance HDTV System is an effective solution for delivering high-quality high-definition pictures and sound over a wide service area by terrestrial broadcast. The FCC's mandate to simulcast HDTV within the existing frequency allocations for television service requires low interference with existing NTSC service. This provision forces difficult tradeoffs among picture quality, sound quality, data rate, and HDTV coverage area, which must all be balanced in an overall HDTV system design. Entertainment television service further requires strict synchronization of video, audio and auxiliary data. The Grand Alliance system provides such capability and provides interoperability with other imaging media, e.g., motion picture film, NTSC television, and still images. While the Grand Alliance HDTV system will be useful in many NII applications beyond entertainment, there will clearly be a need for other advanced video standards. Applications in video production, medical, industrial, space, scientific, and defense industries may require higher resolution, different frame rates, or a different level of compression to meet quality or data rate requirements.

Existing technologies, on which present compression techniques are based, will be satisfactory for many NII applications. However, additional engineering will be required to develop a family of compression techniques to meet a wider range of quality and compression level requirements. The MPEG-2 standard, adopted by the Grand Alliance, could be a starting point for such a family of standards. As technology evolves and new methods are developed, equipment upgrades will be needed and should be considered in information appliance design. Today, cost-sensitive applications (i.e., consumer electronics) use specialized hardware that is not easily modified. For future information appliances, careful consideration should be given to including capabilities and required protocols to enable the transparent upgrade of functions, such as decompression or display, by downloading new software.

Video standards on the NII should decouple programming, distribution, and appliances. Traditionally, each information supplier has had its own distribution system with appliances tailored to the medium. In the NII, digital video will be carried by a variety of distribution channels, and will be easily repackaged and stored. This permits video suppliers and users to use a common distribution infrastructure that provides competition across all markets. The distribution infrastructure must ride the technology curve, with continuous deployment and renewal. Video should be scalable and extensible, e.g., encoded in a multi-resolution format that can be adapted to available resources. Achieving scalability without adversely affecting compression efficiency however represents an unsolved technical issue.

Compatibility and interconnectivity are of high priority in setting standards. Forcing premature obsolescence of consumer equipment should be avoided. Failure to do so may decrease the acceptability of the NII by consumers.

## BREAKOUT GROUP SUMMARIES

*Architectural Considerations, Modular Decomposition, and Interoperability*

The architecture discussion focused on the identification of "key long-lived reference points" in the conceptualization of the network. The reference points identified were: (1) digital appliance reference points (physical point of attachment; logical point of attachment; status/remote-control management protocols), (2) channel/network reference points (channel end points; coding within channels; channel address space naming), (3) software/program object reference points (naming protocols for all items transmitted over the network; media-specific data formats), and (4) reference points for third-party services supporting network management.

Rather than mandate a single standard at each reference point, industry should adopt a flexible architecture that assumes that the interfaces are constantly evolving and that most reference points will be realized by a variety of detailed standards. The principal requirement for NII interoperability is that a publicly documented interface be made available at each reference point. Market forces will then drive the implementation of converters and convergence of standards that facilitate the interoperability.

*Display Performance*

Display Performance addressed a contentious issue: is it possible to reconcile the demands for interlaced image capture with the superiority of progressive scan for display? There was no consensus on this question. There was anxiety that interlaced scanning may corrupt the whole advanced digital video system. It was recognized that one way to lower this anxiety is to assure that all film-sourced material (initially 60 - 70% of HDTV prime-time material) be transmitted in progressive scan. (This approach is supported by the Grand Alliance.) An additional requirement is that all HDTV material be transmitted at the full resolution of its particular format, that is any necessary filtering would be done at the receiver. Adopting these requirements would smooth the transition to higher quality systems.

Display performance associated with various technologies was felt to be properly handled by market competition. Government can accelerate the rate of innovation by facilitating interface standards, funding pilot programs using video in education and health care, and establishing regulations and policy in such areas as the protection of intellectual property rights.

*Image Capture and Display Requirements*

This breakout group focused on (1) identifying image capture and display requirements for various ADV/NII applications, and (2) the implications of decoupling capture and display devices from each other. Image capture devices were generally considered to be less of a gating technology for most applications than displays. The financial impact of conversions at the capture device are likely to be less significant than those at the receiving end.

Several video applications need display capabilities beyond that required for entertainment. Home shopping, medical imagery, and viewing of fine art require stringent color or detail fidelity. The decoupling of capture and display devices forces the use of a device-independent format for color information.

Point-to-point connectivity should allow video display devices and applications that use them to follow the technology curve. Nevertheless, the large installed base of standard NTSC television equipment must also be accommodated and will initially be the only video link to the NII for a large class of consumers.

*Advanced Delivery of Digital Video Services*

The Advanced Delivery of Digital Video Services breakout group addressed the requirements for delivering video services in the NII. The Internet was considered as a model for the delivery of NII services. It is ubiquitous in the U.S., has low barriers of entry for information users and providers, and is beginning to provide flexible search functionality. It is not well suited as a channel for digital video since it is bandwidth limited. It is also generally limited by an absence of network tools for traffic control, guaranteed delivery, privacy, security, and accountability.

Despite these limitations, the Internet serves as a model for the growth and evolution of digital services. It was suggested that government/industry cooperation can set goals for the NII, develop a minimal set of services now, and plan for the staged entry of added functionality. Government can also assist industry in developing network protocols. Government information services may catalyze the development of ADV-capable networks. Finally, the 1996 Olympic Games were identified as an opportunity for a demonstration project of HDTV and NII services which contain educational, health care, and entertainment elements, but copyright issues were cited as a serious barrier.

*Panel Discussion:*
*The Evolution of Standards: Is a New Approach Necessary?*

The standards panel viewed de facto standards as contradictory to the goal of interoperability. De facto standards lead to market fragmentation, higher cost to the end user, and confusion in the industry. There can be a financial reward for the originators of de facto standards because the traditional standards process often lags too far behind technological innovation. Also, the traditional standards process is slowed by a tendency to overspecify, a lack of focus on issues crucial to interoperability, and by the proliferation of standards organizations. In addition, those working on standards are usually volunteers whose time is shared with other "higher priority" tasks.

For the process of generating NII standards to be successful, the traditional standards process must be improved. It must be tightly focused on the network itself and how to assure the interoperability of its applications and transmission links. Critical interfaces must be identified and the resulting architecture must be "open." Those working on the process must be able to give it their primary attention and must be accountable to an agreed upon schedule. Government regulation should be applied only when it is in the public interest, e.g. to guarantee universal access.

## RECOMMENDATIONS

The following recommendations, while not the result of a formal decision process, nevertheless represent statements that were strongly supported in the plenary and breakout discussions.

- The United States should move forward on HDTV as quickly as possible as it can be a powerful driving force for the development of NII applications. The Grand Alliance Proposal for HDTV is the best available alternative and is superior to any system which involves digitizing NTSC signals. Digital NTSC systems would propagate interlaced transmission and continue the division between entertainment television and the computer/communications technologies.

- There will be continued controversy and disagreement over the desirability of an interlaced video format within the Grand Alliance System. Some believe that an all-progressive system is the only acceptable choice. The anxiety level would be reduced if the major broadcasting networks commit to broadcasting film-sourced material in unfiltered, progressive format. This approach is supported by the Grand Alliance, and there is an informal understanding that at least four networks (ABC, NBC, CBS, and PBS) are planning to broadcast film in progressive formats.

- There is a need for a long-term program involving government and industry to:
  - facilitate interface standards,
  - address intellectual property rights and information protection,
  - fund research and development in interoperable systems, and
  - establish pilot programs to apply advanced video technology in education, health care, and other areas of national importance.

- To serve the diverse needs of the NII, additional advanced digital video standards must be developed that complement the U.S. HDTV transmission standard. These should take into account and be interoperable with the U.S. HDTV standard.

- Standards should include both one- and two-way communications, provision for multicast video services, and internetworking cable, satellite, broadcast, common carrier, and packaged media. They should address the interconnection and interoperability of digital appliances and devices, digital networks and channels, software and programs, and third-party services. This will require identifying reference points (physical, management, and logical) and interfaces. Minimum service levels and staged criteria for interoperability and functionality should also be defined.

- Industry is encouraged to demonstrate a comprehensive "multimedia" event with integration of transport modes (e.g., ATM and broadcast), the use of multiple delivery networks (including the Internet), and the integration of text, graphics, and video. The Grand Alliance is encouraged to provide coverage, transmission, and display of both live and filmed programs so that both progressive and interlaced modes will be demonstrated.

## ACKNOWLEDGMENTS

The program committee wishes to thank all the speakers and breakout group chairmen as we recognize that the technical quality of the workshop is directly dependent on the efforts of the contributors. We also wish to thank the staff of the Georgetown University Conference Center and the NIST Conference Facilities for their many logistical contributions toward making the workshop run smoothly.

## WORKSHOP AGENDA

**Tuesday, May 10, 1994**

| | |
|---|---|
| 8:00 a.m. | Registration and Continental Breakfast |
| 8:45 a.m. | Welcome<br>**Charles Fenimore,** *NIST* and **Howard Frank,** *ARPA* |
| 9:00 a.m. | Visions and Services of the National Information Infrastructure<br>**Robert Kahn,** *Corporation for National Research Initiatives* |

NII Applications and the Value Added by Advanced Digital Video

| | |
|---|---|
| 9:45 a.m. | Production and Distribution of Entertainment<br>**Kenneth Davies,** *Canadian Broadcasting Corp.* |
| 10:05 a.m. | Educational Applications<br>**Connie Stout,** *University of Texas* |
| 10:25 a.m. | Coffee Break |
| 10:50 a.m. | Medical Applications<br>**Bijoy Khandheria,** *Mayo Foundation* |
| 11:10 a.m. | Commercial Applications - Manufacturers & Suppliers<br>**Michael Liebhold,** *Times Mirror* |

| | |
|---|---|
| 11:30 a.m. | NII Technical Requirements and Advanced Digital Video<br>**David Tennenhouse,** *MIT* |
| 12:00 p.m. | Lunch<br>An Administration Perspective<br>**Michael Nelson,** *Office of Science and Technology Policy* |
| 1:30 p.m. | The Grand Alliance Vision of High-definition Television (HDTV): Technical Capabilities of the GA Proposal with Respect to the NII Requirements<br>**Glenn Reitmeier,** *David Sarnoff Research Center* |
| 2:00 p.m. | Compression Technology<br>**Chong Lee,** *Qualcomm* |
| 2:25 p.m. | Advanced Digital Video over ATM Networks<br>**Jules Bellisio,** *Bellcore* |
| 2:45 p.m. | Advanced Digital Video over the Internet<br>**John Wroclawski,** *MIT* |
| 3:10 p.m. | Coffee break |

| | |
|---|---|
| 3:30 p.m. | Breakout groups<br>Architectural Considerations, Modular Decomposition, and Interoperability<br>Co-chairs: **David Staelin** and **David Tennenhouse,** *MIT*<br>Display Performance<br>Co-chairs: **William Schreiber,** *MIT,* and **Lance Glasser,** *ARPA*<br>Image Capture and Display Requirements<br>Co-chairs: **Barry Bronson,** *Hewlett-Packard Company* and **Craig Van Degrift,** *NIST*<br>Digital Delivery Services<br>Co-chairs: **Craig Tanner,** *Cable Labs,* and **Donald Mead,** *Hughes Aircraft Company* |
| 6:00-8:00 p.m. | Reception at the Georgetown University Conference Center |

**Wednesday, May 11**

| | |
|---|---|
| 8:00 a.m. | Continental Breakfast |
| 8:30 a.m. | Panel Discussion: The Evolution of Standards: Is a New Approach Necessary?<br>Moderator: **Will Stackhouse,** *Consultant*<br>Panelists: **Rex Buddenberg,** *Naval Postgraduate School;* **Karen Higginbottom,** *Apple Computer;* **Thomas Stanley,** *FCC;* and **Julius Szakolczay,** *Mitsubishi of America* |
| 9:30 a.m. | Coffee Break |
| 9:45 a.m. | Continued breakout groups; prepare report to plenary. |
| 12:00 p.m. | Lunch<br>What Will the Home Information Appliance Look Like?<br>**D. Joseph Donahue,** *Thomson Consumer Electronics, Inc.* |
| 1:30 p.m. | Presentation of Breakout Group reports |
| 2:30 p.m. | Discussion, summary, and action to be taken. |
| 4:00 p.m. | Adjourn |

**Thursday, May 12**

| | |
|---|---|
| 9:00 a.m.-12:00 p.m. | Optional tours of NIST labs:<br>Video Processing Laboratory/Princeton Engine<br>PDES Testbed or other demos of Mosaic/Internet services |

# Architecture Breakout Group Report

**"Interoperability Guidelines for the Home Information Infrastructure"**

*David L. Tennenhouse, MIT, and David Staelin, MIT*

## 1. INTRODUCTION

In the first of its two meetings the breakout group had a wide ranging discussion during which a number of NII-related issues were identified. Broadly speaking these issues could be classified under the following headings:

- NII vision
- Architecture
- User's perspective
- Digital video and the role of the Grand Alliance
- Integration
- Security and intellectual property issues
- Access modes
- Universal access

Experts on each issue were present, with a total attendance of about 40.

To start the second breakout session the group conducted a thought experiment in which a hypothetical user purchased a new information appliance (such as a display); took it home and connected it to their home information infrastructure; used the appliance to exchange video information with other appliances within the home; used the appliance to find and view video-based information from external sources at both low and high data rates; and used the appliance to produce locally generated video information for onwards transmission over the NII.

Based on the results of the first two activities, the group then identified a number of key NII-ATV *Reference Points* that were thought to be essential to NII interoperability. The remainder of this report presents: the context in which the reference points were identified; the individual reference points; and the group's recommendation as to how interoperability (at each reference point) should be achieved. These recommendations include the number of different standards believed to be appropriate for each of the reference points—*one*, a *few*, or *many*.

## 2. REFERENCE POINTS FOR NII INTEROPERABILITY

Figure 1 illustrates four broad classes of NII objects:

- *Digital Information Appliances.* The individual home and office devices that are purchased by individual users. These include any local networking equipment within the home or office;

- *Digital Information Channels.* The means of communication connecting homes and offices to each other and to service providers that provide application-specific services and switching such as television, telephony, etc.;

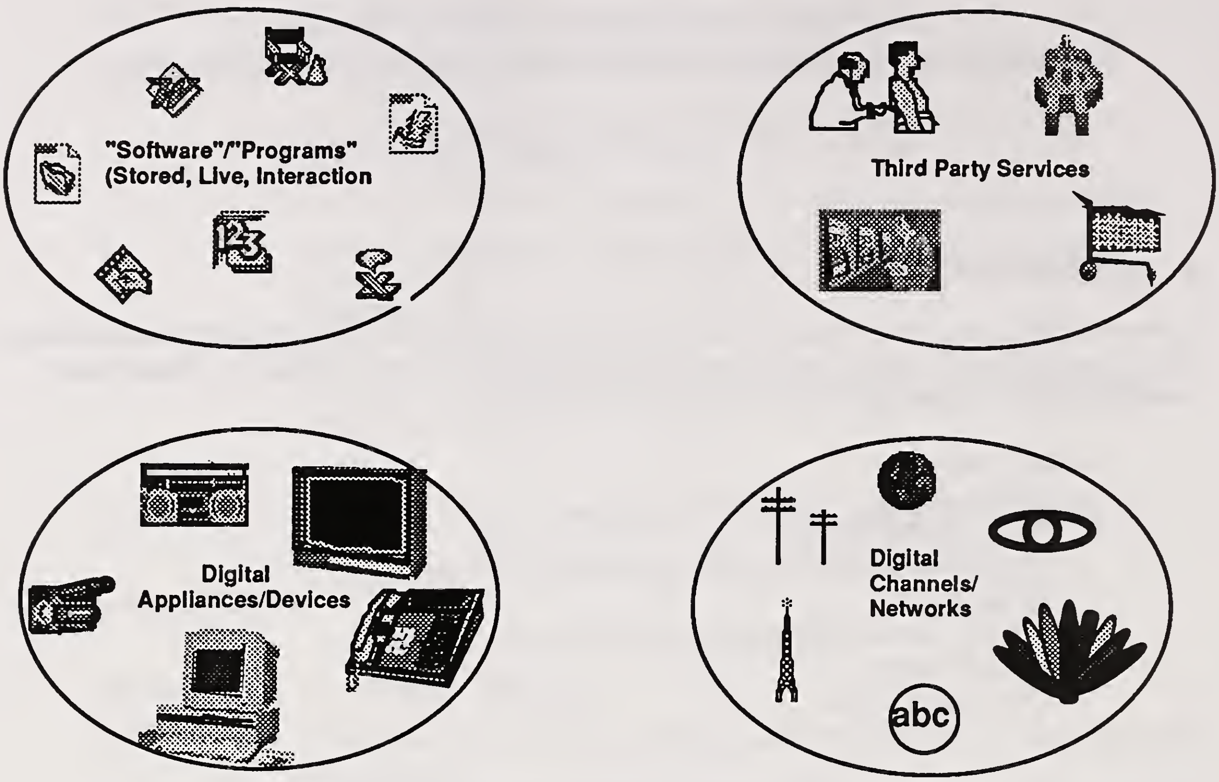



Figure 1. Four Classes of NII Objects

- *Third Party Services.* These include the primary information services themselves (e.g., sources of television programs, newspapers, stock tickers, etc.) and other services (such as authentication billing, etc.) that provide the *glue* that is essential to the smooth functioning of the NII; and

- *Software and Programs.* The information objects that flow over the channels and are *executed* at the service providers and at the customer-based appliances.

Within each of the "bubbles" of figure 1 a wide range of competitive solutions will emerge. Within some of the "bubbles" distinctive sub-architectures may be agreed upon by individual industries. For example, the television industry may develop one sub-architecture for digital broadcast channels while the telecommunications and cable industries each develop and deploy their own competing architectures. One approach may be to agree on a single unified architecture for the standardization of each class of components. However given the rapid pace of evolution within the underlying technologies such an architecture is likely to prove outdated long before it is deployed. Our approach is to allow each of the *converging* industries to continue to evolve at its own pace. NII interoperability is achieved by surrounding each class of objects with a set of *NII Reference Points*, as illustrated in figure 2.

NII Reference Points identify key interfaces that should be made public and interoperable. In a small number of cases a single standard for a reference point may be necessary. In other cases individual industries may agree on one or more standards that describe

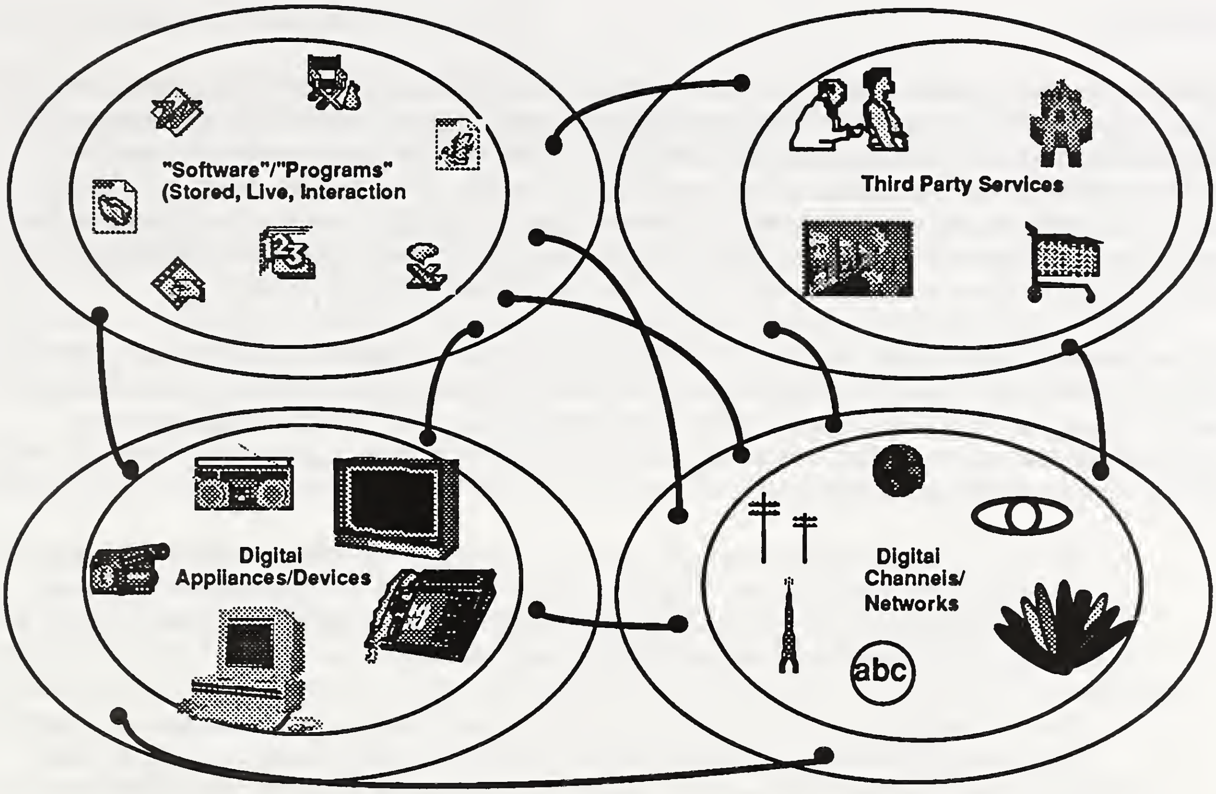



Figure 2. Reference Points for NII Interoperability

their interfaces at the reference point. Finally, there may be highly competitive reference points at which a large number of de facto interfaces are privately developed but whose specifications are published to facilitate interoperability. Once these interfaces are made public two scenarios for interoperability at a given reference point emerge:

- Conversion. Converters can be developed to facilitate interoperation between objects implementing different interfaces.

- Convergence. Over time, it is likely that the industries involved will converge on a relatively small number of standardized interfaces that are realized at a given reference point.

NII Reference Points facilitate interoperability among different implementations of objects of the same class (i.e., different types of devices, different types of digital channels, etc.). They also facilitate operability between objects of different classes, i.e., between appliances and channels, or between appliances and programs. Once the reference points are in place, a rich mesh of linkages can be developed to suit different NII requirements. For this reason the linkages shown in figure 2 are only illustrative—they are not meant to specify or constrain the relationships that might evolve in the future. For example, an information appliance that can be used within the home or office may also be used to manage digital channels or to support third party services.

**Summary**

NII interoperability efforts should focus on the identification of key long-lived reference points. Rather than mandate a single standard at each reference point, the NII should adopt a flexible architecture which assumes that the interfaces are constantly evolving and that most reference points will be realized by a variety of detailed standards. The principal requirement for NII interoperability is that a publicly documented interface be made available at each reference point. Market forces will then drive the implementation of the converters and/or convergence that facilitates the interoperability.

For each class of NII object the group identified a number of reference points. A total of thirteen reference points were identified at the meeting and this set is likely to evolve as the NII emerges. The following sections discuss the reference points and the group's deliberations concerning them. For each reference point the group considered the following development scenarios:

- Many. At a *many* reference point each vendor develops its own interface and publishes its specification. The reference point serves to delineate the broad functionality common across the interfaces without much restriction as to detail. Interoperability is achieved through converters.

- Few. At a *few* reference point a relatively small number of documented interfaces emerge either through a de facto (survival of the fittest) process or due to the adoption of different standards by different industries (e.g., Cable vs. Telco).

- One. A *singular* reference point is a point at which there is a need for a single NII-wide standard.

For the *one* and *few* reference points the group considered whether the emerging standards should be developed through an industry process or through a government initiated project (with industry involvement). The latter is exemplified by the cooperative manner in which the FCC and the television industry are developing an HDTV standard. Standards proposals are being developed and refined by the industry participants. The standard that finally emerges from this process will be *blessed* by the FCC.

## 3. DIGITAL APPLIANCE/DEVICE REFERENCE POINTS

### 3.1 Physical Point of Attachment (to the Home or Office Information Infrastructure)

This is the point at which undifferentiated bits are exchanged between the appliance and the Home Information Infrastructure (HII). For tethered appliances it is likely to coincide with a mechanical connector. A variety of digital coding techniques are likely to emerge.

*It was the consensus of the group that a few standards should be defined at this reference point through an industry-driven process.*

### 3.2 Management Reference Point

HII appliances should be self-describing and software-manageable. Each device should include a Management Information Base that: describes the device; permits its status to be monitored; and provides for the remote control of its configuration. An example of a standard that supports this functionality is the Simple Network Management Protocol (SNMP). The information made available at the management interface describes the logical interface to the appliance. It may also describe optional or advanced features of the physical interface. A minimal standard for the physical reference point might only support the exchange of bits for management purposes—the physical interface would be discovered through examination of the Management Information Base. The manufacturer, model number and serial number should also be available at this reference point.

*Although there is strong support for the definition of this reference point the group was split as to whether there should be a single NII-wide standard or a few industry-driven standards.*

### 3.3 Logical Point of Attachment

This is the point at which structured units of information are exchanged through the framing (i.e., packetization) of sequences of bits. The identification of the logical interface implemented by a specific device should be advertised at the management reference point.

*The logical reference point will be fluid and competitive with many competing implementations.*

*Note:* Conceptually, the digital appliance reference points provide for interoperability amongst appliances and interoperability between appliances and digital channels. In many cases this level of interoperability may be supported through a home/office Local Area Network. Although the HII architecture should provide this level of generality there is consensus that the engineering of individual products may *compress* the architecture.

## 4. DIGITAL CHANNEL/NETWORK REFERENCE POINTS

There are many *classes* of digital channels in the NII offering a range of services that support the exchange of bits. Examples of digital channels include ISDN, cable channels, digital broadcast (e.g., Grand Alliance HDTV), fiber to the home, digital satellite, digital cellular, etc.

### 4.1 Physical Point of Presence of the Digital Channel (at the Home/Office Information Infrastructure.)

Standards defined at this reference point describe the *raw* bit interface through which undifferentiated sequences of bits are exchanged at the channel end points.

*It was the consensus of the group that there should be one standard for each class of digital channel (i.e., each class of wide area network). The standard used by each class of channel should be defined through an industry-led process specific to that class of channel.*

### 4.2 Physical Reference Point — *Within* The Digital Channel(s)

This reference point describes the coding of bits transmitted within the channel itself (rather than at the end points). Two distinct cases emerge: digital channels involving an "enclosed" spectrum (twisted pair, cable, fiber, etc.); and "air" channels that use the shared free-space spectrum.

***Enclosed Spectrum.*** *The group was split by a vote of 13 to 9 in favor of a* ***few*** *standards versus a single NII-wide standard at this reference point. It was agreed that the standard(s) should be arrived at through an industry driven process.*

***Free Space Spectrum.*** *It was agreed that a* ***single*** *standard should be specified for each class (and band) of digital channel. The group was split as to whether these standards need to be "blessed" (14 in favor, 8 against) by some government agency.*

### 4.3 Channel Address Space Identifier

It was generally agreed that each class of digital channel would have its own address space through which the end points of digital channels are named. It was further agreed that there should be an NII-wide Address Space Identifier that could be used in conjunction with the class-specific addresses.

*There should be a* ***single*** *NII-wide standard for digital channel Address Space Identifiers. The standard should be approved and/or administered by some government agency.*

## 5. SOFTWARE/PROGRAM OBJECT REFERENCE POINTS

*Movies, data files, application software packages and live sports casts are all examples of software/program objects.*

### 5.1 Software Object Names

This is the point at which the object is assigned a name. The Universal Resource Locators (URL's) used within the World Wide Web are examples of object names. Third party services may be used to resolve object names into the names of related objects and/or the addresses of digital channel end points.

*It was agreed that a* ***few*** *different standards would emerge at this reference point through an industry-driven process.*

### 5.2 Software Object Name Space Identifiers

The Software Object Name Space Identifier is analogous to the digital channel address space identifier. The group was split as to whether or not an NII-wide identifier is required. The contrary position is that the user or program resolving an object name would have prior knowledge as to the standard and registration authority associated with that name.

*By a slim margin of 7 to 6 the group favored the establishment of a* ***single*** *NII-wide Software Object Name Space Identifier.*

### 5.3 Universal Label

The Universal Label allows each software object to be self describing, i.e., it is analogous to the Management Information Base of the digital appliances. The label has two parts. The Header identifies the type of object. The Descriptor, which constitutes the second part of the label, provides information concerning the object such as the copyright notice, conditions of use, instructions for payment of royalties, etc.

*A consensus emerged that there should be a single NII-wide standard for Universal Label Headers and this standard should be "blessed" by an appropriate government agency.*

*The group agreed that a few standards for Descriptors are likely to emerge through an industry led process.*

### 5.4 Media-specific Formats

Software objects incorporate and manipulate a range of media-specific formats which can be composed in a number of ways. It was generally agreed that although a wide variety of "data" formats would emerge, a somewhat narrower variety of "audio-visual" formats should be specified. The latter would include both compressed and uncompressed encodings for still images, video and audio information at a range of resolutions.

*A consensus emerged that there should be relatively few standards for audio-visual media encodings and that these standards should be arrived at through an industry driven process.*

*The group was of the opinion that many different data encodings would emerge through a highly competitive process.*

## 6.0 REFERENCE POINTS FOR THIRD PARTY SERVICES

Third party services may be provided by independent service providers or by a "primary" party i.e., a digital channel provider. These services are identified by Software Object Names.

Example of third party services are:

- Directories
- Navigation
- Payment/Settlement
- Encryption Key Distribution
- Service Integration/Management
- Brokerage
- Trusted Third Party Services

Trusted third parties include services provided by trustees, escrow agents, and authentication agents. It was noted that the operation of many third party services would be dependent on authentication. Therefore the specification of the reference point for authentication agents may be a matter of some urgency.

*It was generally agreed that there would be at least a few and possibly many, standards at each of the third party reference points. These standards will be developed through an industry-driven process.*

## Display Performance Breakout Group

*Lance Glasser, ARPA*

The Display Performance Breakout Session grappled with both near- and long-term issues critical to integrating the NII and HDTV. Integration is in the government's interest in its responsibilities related to the delivery of high-quality public services, such as education and health care. Mike Nelson articulated the government interest in his address. Likewise, business is also interested in the eventual integration of entertainment, computing, and communications, because such an integration creates an environment in which the invention of new "killer applications" would most likely arise. It is through the discovery of new services that customers will be induced to spend a larger fraction of their income on information technology. While the shape of these services cannot be predicted today, one can increase the likelihood that these services are discovered by assuring the creation of an interoperable and extensible infrastructure.

For the near-term issue, we focused on the interlaced vs. progressive-scan controversy. While there appears to be no way to ever reach consensus on the issue, we attempted to bring the sides closer together. Given the level of emotional energy involved, it is difficult to find a middle ground since trust seems to have been stripped away after dozens of skirmishes over many years.

All agreed that progressive scan is generally superior and should be a long-term goal. The present Grand Alliance (GA) proposal has 5 progressive modes and 1 interlaced format. The opponents of including interlaced scan have two levels of concern. The first is the concern that the existence of the interlaced mode will drive out the other modes, causing the entire system to sink to a common denominator which is incompatible with text and graphics. The second level of concern dealt with the quality of the display image presented to the consumer. Here, not only is interlaced vs. progressive mode in the transmission channel an issue, but so is the internal (or native) representation of the TV set, the types of filtering used, and even the number of pixels on the screen, the type of phosphors, and a myriad of other determinants of image quality. It seems quite unlikely that the government will, in the present climate, enforce a lower bound on the quality of product that the consumer can buy.

It was also postulated that the increased use of standard resolution digital is closing the window of opportunity for high-resolution TV. There was a sense that if we had to move forward now, then the GA scheme was the best opportunity, though not everyone agreed that the GA system, as presented, was what they wanted.

The approach of the breakout group was to try a problem-solving approach that addressed each of the concerns mentioned above. In order to address the possibility that only interlaced material would be in the channel, the group sought a way to guarantee significant amounts of progressive scan material in the channel. The theory is that if progressive scan material is in the channel, competition in the receiver design will assure that the customers will get an opportunity to choose sets that display progressive material with high quality. Conversely, it also assures that some of the HDTV sets will not be able to effectively display text and graphics.

The obvious way to assure copious amounts of progressive scan material in the channel is to assure that all film material will be transmitted in full-resolution progressive scan.

This is to be over 60% of the material transmitted during prime time. At the meeting we obtained indications of intent from PBS, CBS, and NBC to do this. Follow up needs to be done.

Competition in the receiver: Filtering in the receiver rather than in the source assures a smoother transition path to higher quality pictures. In addition, it is recommended that set producers incorporate vertical low-pass filters for the interlaced mode, assuming this mode makes it through the FCC process, so that interlaced cameras can be upgraded to full resolution. A public testing process should be put in place that helps consumers learn whether the set they are thinking of buying is "NII-compatible," i.e., whether it can deliver good quality text and graphics to the screen. Thus one needs receiver labeling as to scan parameters.

The Olympics: The possibility of a demonstration of the GA system at the Olympics in Atlanta generated a great deal of controversy. We agreed that if this demonstration goes forward, it should exercise at least two modes of the system with one of the modes containing full-resolution progressive-scan material. As a practical matter this material would probably have to be derived from pre-shot film, but there is considerable opportunity for such material during an Olympic-coverage program.

Long-term, the public goods aspects of NII and HDTV suggest that the government should examine the issues of the convergence of entertainment delivery and other services by using more mechanisms than just regulation. For instance, possible components of a long-range program might include:

- Facilitating interface standards
- Regulation
- Policy (e.g., Intellectual Property Protection)
- R&D
- Pilot programs to use high-resolution video for
    - Education
    - Health care

**MINORITY REPORT -** *William F. Schreiber, MIT*

I was co-chair of this session, along with Lance Glasser of ARPA. We had a long discussion of the interlace/progressive scan issue, and, as usual, reached no conclusion. As the group was so one-sided in its opinions on this issue, I decided to submit a minority report. All statements herein are my own opinion.

The effect of interlace on picture quality is much larger than most TV people think. This conviction grows out of my experience at MIT in our TV project. We made a demo in which an image of full vertical resolution was displayed both interlaced and proscan. The former flickered so much that our Sony visitors thought there was something wrong with the monitor. Note that standard NTSC cameras have very poor vertical resolution so that the effect is usually much smaller. (This is because tube cameras discharge the entire target every field, and CCD cameras discharge two lines at a time.) However, in the future, we shall have video sources that do not have these limitations. The computer industry has given up interlace for this reason. Our sponsors from ABC, NBC, CBS, PBS, Kodak, 3M, Harris, HBO, and Tektronix had never seen such flicker.

I think my opinion in this matter is not extreme. It fairly represents opinion in the non-TV imaging industries. For example, I do not believe the NII will die if interlace is used. However, there will be a significant reduction in legibility of small characters as well as very annoying interline flicker. Interoperability is also made more difficult with interlace.

I am concerned that interlace will drive out progressive scan, just as bad money drives out good under Gresham's Law. Since the Grand Alliance allows a 1080-line interlaced format as well as a number of proscan formats, I believe the former will be used since it is somewhat cheaper.

Note that the Grand Alliance has significantly raised the price of the receivers by allowing so many formats. It appears that one of the main reasons for doing this was that none of the "cooperating" companies was willing to allow their format to be dropped, so all were kept. Although there is talk of migration to 1080-line proscan, this will not be possible if 1080-line interlaced receivers are already in use, since the latter will flicker unacceptably when the vertical resolution is raised. Note that 1080-line interlace does not have higher vertical resolution than 720 lines proscan.

Lance made a very constructive proposal. He asked whether there was something that could be done to relieve the anxieties of those holding opinions like mine without at the same time placing an undue burden on the TV industry. Although my overwhelming and, I think, fully justified opinion is that interlace simply has no role to play in a new TV system, I offered the following compromise:

1. Film to be transmitted 24 fps proscan only.
2. All transmissions in all formats to be of full vertical resolution. (This means that there will be a great deal of interline flicker on interlaced receivers unless a vertical low-pass filter is used somewhere in the system.)
3. Interlaced receivers must have a vertical low-pass filter. (This means that proscan receivers can display with full vertical resolution.)
4. Receivers are to be labeled as to display format.

These principles cannot be entirely voluntary, since manufacturers who do not comply would have a cost advantage over those who do comply.

When I presented this proposal, the interlace proponents simply disregarded it, and instead engaged in crude boosterism, such as "Let's get on with it and make a demo for the 1996 Olympics." In view of this, I have decided to withdraw this proposed compromise and instead to lobby the FCC to eliminate interlace entirely from the HDTV standard. A precedent for this is the FCC decision to use FM sound in the first NTSC standard in 1941, over the very strong objections of RCA.

# Image Capture and Display Requirements

*Barry Bronson, Hewlett-Packard Company and Craig Van Degrift, NIST*

This breakout group (~20 members) focused on (1) identifying image capture and display requirements for various ADV/NII applications, and (2) the implications of decoupling capture and display devices from each other.

## 1.0 IMAGE CAPTURE DEVICES (still and motion, consumer and professional)

- Film
- Electronic photography
- Video
- Scanners (FAX, image, telecine)
- Sensors (MRI, Ultrasound)
- Synthetic (computer generated, ...)

Image capture devices were generally considered to be less of a gating technology for most applications than displays. The financial impact of conversions at the capture device are likely to be less significant than those at the receiving end.

## 2.0 IMPACT OF DECOUPLING SOURCE AND DISPLAY FORMATS IN THE GLOBAL INFORMATION INFRASTRUCTURE (GII)

- Need for calibrated colorimetry
- Logical relationship between formats
- Conversion cost - artifacts
- Calibration info / transfer characteristics

There is a clear need to convey information about the capture conditions (e.g., color gamut and system calibration data), and to use logically related formats. Logically related formats minimize both conversion costs and artifact generation. Multiple levels of conversion and compression through the capture, processing, editing, storage, transmission, and reconstruction stages increase the risks of image quality loss.

## 3.0 CONVERSION, DIVERGENCE, DIVERSITY

A discussion of display/appliance conversion, diversion, and diversity led us to highlight CURRENT attributes which DIFFER between product categories. Table 1 (on the next page) illustrates these differences. Additionally, characteristics of two of the Grand Alliance proposals show a close kinship to traditional television.

TABLE 1. Convergence, Divergence, Diversity

| Current Typical Attributes | Entertain-ment TV | Info/Comm Computer | Future PDA | 1280x720P GA | 1920x1080I GA |
|---|---|---|---|---|---|
| # Viewers | 1 to many | 1 | 1 | 1 to many | 1 to many |
| Screen Size | 1" to 6' | 15" | 6" | 25" to 7' | 36" to 10' |
| Room location | FR, LR, BR | Study | Mobile | FR, LR | FR, LR |
| Primary Usage | TV, games | Work, info, games,comm educ | All | Entertain-ment | Entertain-ment |
| Resolution H x V x Color | 320 x 240 x lots | 640 x 480 x 256 | 320 x 240 x 16 | 1280 x 720 x lots | 1920 x 1080 x lots |
| Refresh rate | 60 Hz | 72 Hz | 72 Hz | 60 Hz | 60 Hz |
| Distribution method | Broadcast | Point to Point | Both | B'cast/Pkg | B'cast/Pkg |
| Scanning of CRT | over | under | | over | over |

**(FR - family room, LR - living room, BR - bedroom)**

A key differentiator to display characteristics correlates with broadcast versus point-to-point communications modalities (and hybrid combinations such as multi-point and asymmetrical). For example, less rigorous attention to display extensibility and backward compatibility standards can be acceptable in a point-to-point system since the transmitting end knows the explicit capabilities of the receiving end.

## 4.0 DISPLAY REQUIREMENTS FOR GII

The "Display Requirements for GII (Global Information Infrastructure)" grid (Table 2, facing page) shows typical applications within broad categories that have varying display attributes and requirements. In the interest of avoiding prolonged subjective discussions, most of the boxes were left blank; with a few, less controversial ones, filled in. The "c" in the fidelity signifies "color" fidelity.

A brief discussion of the applications follows:

- Video games typically use all the display capabilities they can finesse, and are nearing the point where they will soon be display-limited.
- Video phones and teleconferencing are typically bandwidth (not display) limited, but video phones are display cost sensitive.
- Remote classrooms refer to the broad class of uses for remote learning/instruction in traditional educational environments as well as the home and office.

TABLE 2. Display Requirements for GII (Global I.I.)

| | Spatial Resolution | Contrast | Refresh Rate | Brightness | Aspect Ratio | Interlace tolerance | Fidelity | Size of scren | BC, pt-to-pt |
|---|---|---|---|---|---|---|---|---|---|
| Video Game | | | | | | | | | |
| Video Phone | | | | | | | | | |
| Remote Classroom | | | | | | | | | |
| Buy-A-Car | | | | | | | + C | | |
| E-mail | | | | | | | | | |
| Fax | | | | | | | | | |
| Olympics | | | | + | | – | | | |
| Movie | | | | + | + | | | | |
| MRI Scan | + | + | | | | | + | | |
| Home Floorplan | | | | | | – | | | |
| Fine Art | + | | | | | | + C | | |

- Buying a car represents an interactive shopping process that could involve product research, education, selection, comparison shopping, and purchasing. It also could imply navigation tools, and linked services (estimated insurance costs, finance plans...) that use multiple display media. Color accuracy is essential for purchase of many consumer items.
- E-mail is text today, but could easily migrate to richer media and incorporate voice mail, FAX (image mail) and video mail. FAX on a display needs fine lines and text.
- The Olympics represents the need for high image quality broadcast to a global market. Rapid motion rendition, minimized interlace artifacts from lined playing fields, and multi-standard interoperability are key issues.
- Movies are created with high spatial resolution in numerous aspect ratios. The fixed aspect ratio of electronic displays force the tradeoff between letterboxing and adulteration of the image.
- MRI scans used in medical diagnosis push the limits of image quality and fidelity. Some medical imaging can require considerable temporal resolution.
- The home floor plan can be characterized as a line drawing with very low tolerance to interlace artifacts, but low temporal resolution. It is best transmitted and displayed using vector graphics techniques.
- Fine art (pictures, sculpture, still and moving) would push overall image quality.

In terms of the requirements columns, temporal resolution was considered less of a concern than display refresh rate. Today, refresh on a TV CRT is tightly coupled to transmission frame rate, but need not be for other types of displays (e.g. LCD) and digital communication schemes.

## 5.0 CONCLUSIONS

Small market applications such as telemedicine and education, which are important to the long-term goals of the country, have special display and capture requirements. Base level display performance of NTSC has remained constant, while that of computers steadily increases. Extensible digital video standards should allow both to increase together .

Point-to-point connectivity, which affects applications and displays, will be gated by the communications infrastructure (e.g., deployment of fiber). With point-to-point video, the video format may be negotiated between the transmissing source to the receiving display system.

Although displays designed primarily for group and personal viewing have distinct requirements, it is important that these differences not prevent interoperability of their applications.

There is an enormous installed base of telephones, FAXes, and NTSC TVs. Initially, these may be the only links to the NII for a large class of consumers. Although the installed base of home and business computers is increasing and the costs are coming down (a CRT-based word processor with printer is already ~$300), old NTSC/PAL/SECAM TVs must be accommodated.

History has shown (in the computer and video game industries) that as display capabilities improve, applications and markets follow.

The decoupling of sources and displays of video forces new constraints on the conveyance of color. Each color capture/display/printer must be able to acceptably map colors between physical devices.

There was a strong desire on the part of all involved to move ahead quickly with the process of blending digital video into the NII while still not sacrificing its long-term capabilities.

# Advanced Digital Delivery Services

*Craig Tanner, Cable Labs and Donald Mead, Hughes Aircraft Company*

## NII SERVICE CHARACTERISTICS

This breakout group began its discussions by considering some of the attributes of existing communications networks. These are shown in the first table, from top to bottom as follows: Broadcast services are point-to-multipoint, are one-way in nature, and are wideband systems. Cable systems, by contrast, have a high bandwidth downstream channel, but can be bi-directional, either via a relatively low per-subscriber return bandwidth on the cable system, or via telephone return. The conventional public switched telephone network is fully two-way, but only at low bandwidth. What is needed are point-to-point networks that have high bandwidth, as shown on the fourth line of the slide. In addition, multiparty communication is important. Low bandwidth multiparty communication is common with today's telephone network's voice conferencing services. The ultimate NII should have wideband multiparty capability.

TABLE 1. Network Requirements

| Service | One Way | Two-Way | Low BW | High BW |
|---|---|---|---|---|
| Point-to-Multipoint | X | | | X |
| Point-to-Multipoint | | X | X<br>Reverse | X<br>Forward |
| Point-to-Point | | X | X | |
| Point-to-Point | | X | | X |
| Multiparty | | X | X | |
| Multiparty | | X | | X |

## THE INTERNET MODEL - GOOD FEATURES

A review of the Internet's desirable features was conducted in order to identify characteristics that ought to be preserved in future network infrastructure that will carry advanced digital video (see second slide). The Internet is becoming ubiquitous, is relatively inexpensive, and was developed in a collegial manner with the cooperation of many parties that saw the mutual benefit of such cooperation. There are a number of mechanisms such as Gopher, WAIS, and the World Wide Web, that are proving to be remarkably effective search mechanisms. Also, there are virtually no technical, policy, or economic barriers to information providers, as evidenced by the thousands of server sites on the Internet. The absence of gatekeeper organizations was seen as a positive attribute that has been of importance to the growth in, and breadth of, information sources available on the Internet.

- Ubiquitous
- Inexpensive
- Collegial in Nature
- Flexible search functionality
- Low barriers to information providers
- No gatekeepers

## THE INTERNET MODEL – NOT-SO-GOOD FEATURES

By contrast, the breakout discussion group identified a number of undesirable features of the Internet that should be resolved in any NII networks that will carry advanced digital video. Bandwidth limitations must be overcome; the network must control the flow of traffic to avoid service interruption due to congestion, particularly for isochronous services such as video; privacy must be assured whenever necessary to the application; security must protect the network from fraud and abuse; and the network operator(s) must be accountable to users if the network is to be depended upon. Also, the current Internet's lack of directory services must be remedied. Finally, consideration must be given to the availability of guaranteed delivery of messages, video or otherwise; and to the possible need for a defined minimum functionality to all users, in order to assure that all will be able to send and receive certain kinds of message content.

- Bandwidth limits
- No user/traffic control
- Privacy concerns
- Security
- Accountability
- Lack of directories
- No guaranteed delivery
- No minimum functionalitys

## AREAS FOR JOINT GOVERNMENT/INDUSTRY COOPERATION

The breakout group recommended a number of areas where the U.S. government and private industry might cooperate to further the development of an ADV-capable NII.

- Study Models for Growth
- Set goal for the NII and ADV
    - staged entry of functionality
    - a minimum service level?
- Government should establish ADV server sites with government information – these will serve as a catalyst to development of the ADV-capable network infrastructure.
- Development of protocols for internetworking
    - Cable (fiber/coax)
    - Satellite
    - Broadcasting
    - Telco (UTP and fiber)
    - Packaged media

## 1996 OLYMPIC GAMES DEMONSTRATION PROJECT

Finally, at the initiation of the Grand Alliance, which offered to commit resources for an HDTV-NII demonstration project involving the 1996 Olympics in Atlanta, Georgia, the discussion group devised a concept for such a project. It involved HDTV transmission of Olympic events, to be supported by Internet-delivered supporting information services with digital multimedia content.

- To demonstrate ADV/NII interoperability.
- GA-HDTV Coverage, Transmission, and Display
- Network-based ADV and Information Services transmission (SDTV and HDTV)
- 3 audiences
  - K-12 Education
  - Health care services
  - Consumers
- ARPA Technology Research Project Funding is a possibility
  - Interoperability testbed project

## ORGANIZATIONS AGREEING TO DISCUSS THE POSSIBILITY OF PARTICIPATION IN THE 1996 OLYMPIC GAMES/NII PROJECT

The final slide shows the companies and organizations that indicated a willingness to further explore participation in this potential project.

[Editor's note - Since this conference, NBC has made it clear that they have secured exclusive rights to cover the 1996 Olympics, and do not expect to become involved in any HDTV coverage of the event. This would appear to severely limit the prospects for the project discussed by the breakout group.]

- Grand Alliance
- Cable Labs
- Bellcore
- Electronics Industries Association
- The Association for Maximum Service Television
- Hughes Aircraft Company
- Mayo Foundation
- David Sarnoff Research Center
- Sony Corporation of America
- MIT
- IBM
- Los Alamos National Laboratory
- NEC of America
- Hitachi of America

## Standards Panel: Old Game, New Rules??

*Will Stackhouse, Consultant*

The following paragraphs outline the "background material" that the panelists considered as they prepared their presentations, the format of the panel and the three questions each panelist was asked to address, and a summary of each presentation. Copies of the panelists slides are included in the Appendix.

### BACKGROUND

Twenty or more years ago, technology lasted 10 or more years each, often even longer. Individual vacuum tubes, as an example, were easily available for 10 or more years. Standards, then, were often design specific; the standards process was fairly responsive.

Today technology-spans last 6-18 months, and these times continue to grow shorter. Additionally, there are more technology areas in motion simultaneously. To illustrate this, consider video streams moving through wired or wireless networks. Hardware, software, analog versus digital, compression techniques, encryption, "packaging" for transmission (tdma, fdma, parallel paths, spread spectrum, etc.)-- all of these areas, and more, see new announcements almost daily.

Systems of the present and future need to be characterized as "scalable, extensible, interoperable, portable, etc.", not to mention affordable, reliable, and user friendly! How can a designer consider all of these elements simultaneously? How can a national (or more likely an international) standards process create a standard if that process is consensus-based and normally takes 3 or more years, when things are literally changing daily, weekly and monthly?

Will future standards be interface, architectural or hierarchical in nature? How can future standards encourage and be enabled by rapidly evolving technologies?

How can the systems and products built, the standards process, and the rate of technology and application evolution all be economically viable simultaneously?

Will standards of the future more likely be architectural, hierarchical or interface types? Might an analogy to these new standards be the side rails of an infinitely long ladder, and the rungs of the ladder will be installed as rapidly as they occur -- the rungs being new technologies, compression algorithms, display technologies, microprocessors, operating systems, etc.

### PANEL FORMAT AND QUESTIONS

Each panelist was asked to reflect on the above, plus his/her total career experience. Then they were asked to prepare three slides.

1. What is the definition of the problem, as seen through their eyes?
2. What are the impediments to a solution or solutions in general?
3. What recommendations can be offered for a solution, or as steps towards a solution?

The panel was scheduled to last one hour, broken into three segments of 20 minutes each. The panelists were introduced and each was given no more than two minutes to present the first slide. With 8 minutes used, 12 minutes were then available for "question and answer" interactions with the audience and the panel. This process was repeated for the panelist's second and third slide.

**Panel Members**

Will Stackhouse, Moderator - 31 years US Air Force, 2 years national labs, IEEE-USA Board of Directors, MCI Advanced Technology and Strategy.

Rex Buddenberg - 20 years US Coast Guard, systems architect of Coast Guard and US Navy communications and navigation, faculty at Naval Postgraduate School.

Karen Higginbottom - prior careers with telecommunications and standards groups at the local, state, regional, national and international levels; today head of all of Apple Computer's relations with more than 30 international standards organizations.

Julius Szakolczay - multiple careers designing analog and digital consumer electronic systems and displays, designer of the most advanced Mitsubishi Multi-Synch monitor, Vice President over the manufacturing of all large screen and projection television sets for Mitsubishi USA.

Thomas Stanley - multiple careers in consumer electronics; Chief Scientist or Chief Engineer for the FCC since 1986.

## SUMMARY OF SPEAKER PRESENTATIONS

*(summarized by the Program Committee)*

**What is the problem?**

REX: A single metaphor, the "cosmology is wrong," identifies the problem. There are different views as to what is at the center of the NII-universe as well as different views for the overall system. Hardware engineers tend to put the CPU at the center, while everything else, including the network, is peripheral. This may be okay in designing chips, but will not scale for building the NII or the GII (Global Information Infrastructure). Software engineers tend to put the operating system in the center with network drivers at the outer layers which also won't scale. Johannes Kepler put the sun at the center of the universe, not because it was right, but because it made it easier to explain orbital mechanics. The NII community needs to figure out what should be at the very center of its architectural model. There needs to be agreement and consensus among the various bitway providers.

KAREN: Attempts to make one standard to try to do "everything" for "everyone" is the problem. The accommodations made during the standards consensus process get things mashed to a "consistent sludge." Working on standards is expensive with few meaningful returns, thus finding the resources to participate in standards is a problem at many corporations. Executives are looking for explicit time frames for when they can expect to build products to standards and are unsympathetic to the lengthy standards development process. Going with a proprietary system can produce return-on-investment in 18 months. Finally, the activity is fragmented; Apple is involved in 17 standards organizations and consortia. Choosing the right place to apply limited resources to optimize efforts is difficult. The international process, which involves thousands of people and crosses language boundaries, takes too long.

JULIUS: There are so many de facto standards that video consumer appliance manufacturers will likely be unable to build equipment for national distribution in the future. On the other hand, the consumer expects products that can be moved nationwide from place to place, and expects that they will all work the same at all locations. Consumers do not tolerate confusion. They expect their products to have compatibility or interoperability, which are different terms for the same concept. In the video area, compatibility or interoperability means there is the expectation that the appliance will provide comparable video whether the input is from the air waves or from a cable system.

As the industry moves from the analog to the digital video domain, there is lack of a comprehensive policy on digital video standards. There is need for a comprehensive policy that indicates where the industry wants to be, so that everyone can all start going in the same direction.

TOM: Fuzziness is a good metaphor to describe the problem. Apartheid of systems, services, and markets may also be used. Finally, entropy, a word that describes the increasing disorder in the universe and a lot of the current standards setting process, also applies. Increasing disorder will continue across the industries unless something happens to bring various concepts together. Industry needs to prominently recognize the customers and to design products and services that people want. The basic problem is the apartheid of the various systems and services available. Without a vision of what the customer wants and needs nothing really happens and the entropy of the universe takes over.

**What are the impediments?**

REX: Television, Internet, wireless, and telco folks each see the universe differently. Bringing them together to speak one language is a step in the right direction. Also, while there are adequate rewards for innovation in the marketplace there are inadequate rewards for interoperability. This is changing, but there is still a long way to go. Spectrum allocation policy stresses compatibility, yet ignores interoperability. Spectrum should be allocated for wide area network communications that can handle a large number of different applications.

KAREN: It is hard to distinguish between problems and impediments. However, the consensus process takes too long and should follow the 80/20 rule. "If you have it 80 percent right, go with it so you can get product out of the door." Otherwise, the process can be held back by a single representative who focuses exclusively on one issue. Further, there exists no clear process to bring standards from one phase to another. Milestone and PERT tools should be used in the standards setting process so everyone will know the risks associated with missing a milestone.

When there are multiple standards available, each with many options, it is difficult to know what should be implemented. When multiple options are implemented, due to limited user specifications, there is no guarantee of interoperability. Standards setting representatives should focus on standards that provide interoperability for products. An engineer that is intrigued with technology innovation may be the wrong person to send to a standards meeting. Finally, the personalities of the representatives and organizations that are involved can either assist or deter the process.

JULIUS: The impediments are similar to the problems. Multiple standards (which sounds like an oxymoron) are a problem. The perfect number for standard testing should be one. Industry is not in the standards creating business for their own sake, and any individual intrigued by technology should not be contributing to the standards setting process.

There is big money in de facto standards. Companies that succeed in setting the next generation of de facto standards will make a lot of money. De facto standards also inevitably mean multiple standards—which will fragment industry, create a loss in the economies of scale, and will result in higher consumer costs which limit the market size. This continues until market forces converge on a few or a single standard, which hopefully, will be used for life.

Everyone wants to make a box thinking that they have a better mousetrap; this results in another de facto standard. The consumer does not want multiple boxes that provide the same function. The FCC appears to want no part of the video standards battle at this time. While it is up to industry to set the standards, a clear government policy would be helpful so everyone moves in the same direction. Indications are that the FCC will get involved at the appropriate time.

TOM: The principal impediment to progress is in the area of convergence. The industries involved now in the parallel networks that will become the national information infrastructure, have roots in a pre-competitive world. Due to the lack of competitiveness there is a mind set that suggests we are comfortable. This comfort may be either in terms of resources, market stability, or existing standards.

However, a policy of convergence to a national network of networks has been evolving over the last few years. People are beginning to recognize that they can't get video from their telephone system; they can't talk through their cable system, and they can't use their TV as a computer. These are new concepts and great ideas. Thus, we are asking enormous corporations and networks, that grew up in a non-competitive environment, to address this convergence issue. This will challenge them in terms of market needs and stability. Michael Porter, of Harvard University, suggests that industries should be continuously challenged; they should be continuously forced to review where they are going based on market needs, in order to provide quantum improvements in products and services. Breaking the mold is very hard because it means getting away from those comfort levels that we all enjoy.

**What are the options and recommendations?**

REX: Information systems can be decomposed into four components; the sensors that detect the environment, the decision support system that collects data from the sensors, the data information system that processes data and leads to implementing decisions, and the networking system. Accordingly, we need to get the network into the center of the universe. The Internet folks do not have the right answers yet, but are headed in the right direction. If the network is perceived to be in the center and the sensors, decision support and data information systems are like planets revolving around it, then a lot of disparate parts will start to make more sense.

KAREN: There are two basic kinds of businesses. One is facility-intensive and lasts for tens of years. These businesses require formal de jure standards that take a long time to develop as they need to be meticulous and concise. The current standards setting process works well here. The second type of business, e.g., the computer and electronic industries, require standards that are frequently in need of revision or extension on a 12 to 18 months cycle. Killer applications are those things that will cut across, and can be brought to, the market very quickly. For quick-moving NII products, standardize what is necessary and plan for more standards later. As with the space program, you cannot expect to make all of the adjustments necessary to hit an exact spot on the moon before you launch; mid-course corrections are necessary.

Participants should make a better monetary commitment to the standards process. This requires timeliness, delivery milestones and postmortems when necessary; (a postmortem on OSI could yield some lessons that need not be repeated on the NII).

Marketing participation in the standards process is necessary. Marketing needs to tell the standards organizations what the customers want, what is going to sell and how much money they are going to make, in order to warrant investing resources in the standards development process.

There is need for a high level NII architecture. Initial steps need to be taken to recognize the next step beyond the three layer NII model. Definitions are needed for the interfaces and the components in the architecture.

The responsibility and steps being taken by ANSI in their Information Infrastructure Standards Panel is a step in the right direction. The NII is big enough for all, if foundations based on ATM, SONET, the Internet or some other approach can be put in place quickly. The standards cycle needs to be a lot faster.

JULIUS: A comprehensive policy is needed that requires industry to agree on standards for the critical interfaces. Industries should standardize on only those interfaces that are necessary for interconnecting networks and to insure Interoperability in particular applications. Industry is better qualified than regulatory agencies to make judgments concerning identifying markets and providing for consumer wants. The NII architecture should be kept open and the FCC should regulate when it is in the public interest.

TOM: Agrees with the position taken by Julius. Both industry and government need to be involved. Industry is the appropriate entity to look at the market and customer needs, while government is concerned with decisions on spectrum and standards. These need to be carried our promptly and with a strong degree of fairness.

There is no monolithic management approach in either spectrum or standards. Government has tried everything from tight regulation to maximum flexibility. It is hard to tell which is the right approach as the results do not show up for years.

The solution lies in "leadership" and "commitment." Both government and industry have to be conscious of their roles. Risks have to be taken, especially during periods of comfort. This is when there are periods of stable growth, and industry feels fairly comfortable about their products. There comes a time at the end of the comfort period where discomfort sets in because competition is always pushing the edge of the envelope.

# *Appendix to the Report on the Workshop on Advanced Digital Video in the National Information Infrastructure*

***May 10-11, 1994***
***Georgetown University Conference Center***
***Washington, DC***

Presentation Materials,
Transcripts of Selected Talks,
Additional Submissions by Participants, and
Roster of Participants

# Visions & Services of the National Information Infrastructure

*Robert E. Kahn, Corporation for National Research Initiatives*

My objective here is to talk about the way digital video systems fit into the National Information Infrastructure (NII). Hopefully, this will provide some context for the rest of the discussions to follow in this workshop. Digital video is such an important and broad area that to touch all the bases, and to do justice to it in a short talk is probably impossible. This is actually not a topic that I'm new to. I've sat in on the discussions of the joint expert panel on interoperability. In fact, it might have been in this same room that we considered some of the advanced video alternatives being proposed, along with a careful look at the Grand Alliance Strategy. It seems very clear to me that building a national information infrastructure that doesn't take into account the role of advanced digital will be not only a mistake but probably a disservice to everyone.

Information technology is going to be the engine of economic growth well into the 21st century. To the extent that the information superhighway metaphor applies, the national information infrastructure will reduce barriers to getting more effective information productivity and provide the ability to access needed information very rapidly. Information technology has had a rather amazing growth over the past ten decades. I would estimate the total investment in the field of information technology by the end of the 1970s to be about $60 billion; by the middle '80s it was about $250 billion, and now it's probably over a half a trillion dollars and growing.

Somewhere in the mid or late 1980's, information technology as a whole, including computing, telecommunications, and the like, overtook the field of housing and autos as a major driver for economic growth in the country. Those were two of the biggest drivers in the early part of this century.

We've given inadequate consideration to the role of video as part of the integrated infrastructure in this country. For too long we viewed it as something separate, something that you could look at, but somehow wasn't integrated with many of the other capabilities. I'm delighted to see the Technology Policy Working Group addressing this area. This conference has a potential to actually deal with this issue head on and perhaps make some mid-course corrections that could be significant strategic changes for this country.

We've actually made enormous progress in the field of advanced video in the last several years. Through the combined efforts of some governmental bodies and some private sector groups, leading most recently to the Grand Alliance proposal, we've gone from notions that would have created a more advanced analog system, to one that will be all digital. One of the most important attributes of this change has been the recognition that we need to break apart the task of generating video from the task of actually putting it on the screen.

Another thing that's relevant to mention is the effect of packet switching on the telecommunications industry. When we did our first experiments with packetized voice on the ARPAnet in the early '70s, most people thought it was a curiosity that you could actually take a continuous signal, like speech, digitize it, chop it up into little packets, send them in different directions, and put them back together at the destination and maintain real-communication between the two ends. Even with a few artifacts like inserting coughs over missing packets, the reconstructed speech signal still came out sounding extremely good even in the face of a lossy network environment. The carriers have more recently ratified a similar approach by the apparent adoption of ATM as the switching technology of choice.

Today, we are at a very similar stage in thinking about video. It has many of the same attributes as voice only at higher data rates. We think of television as a continuous stream, but there's no reason why we should. With adequate bandwidth you can take video streams, chop them up into pieces, move them over ATM or some other network technology, put them back together again at the destination and play them whenever you like.

I believe that we're going to see the convergence of the video sector with many of the other sectors. We've already seen a growing convergence between computing and telecommunications more generally. In fact, there are already so many computers in our nation's communications systems, and so many communications systems in the computers, that it's really hard to tell where one stops and the other takes off anymore. I think, we're going to see the fields of entertainment and video get integrated with computers and telecommunication networks because these are driving factors. Those of you who read the May 8, New York Times probably saw the article that was entitled, Do You Know What's On Your PC Tonight? It was a discussion of how the computer and TV industries are really not that much different at this point in time. This is indicative of where things are going.

Let me begin by identifying some of the pieces that are complementary to what we are dealing with and then look at how they might actually all come together. Let's start with the media on the first slide. From telephone dial-up connections at low speeds we later went to higher speed via leased point-to-point circuits. In the early '70s, we thought 50 kilobits per second was very high speed and now some people are beginning to wonder if 2.4 gigabits will be fast enough.

Packet switching is probably the most notable development in wide-area networks with ATM as a specific instance. Cable systems have come into their own in recent decades. Satellite technology and satellite systems are still another communications alternative and the whole field of terrestrial wireless is one that very few of us really understand the full implications of yet. We have over-the-air broadcasting whether it be radio or television. We use cellular radio for a variety of its mobile attributes. Many people feel that radio may actually have a place in the last mile between the carrier's central office and the home, as the most effective way of getting from a place near the home, into the home, without the need for rewiring every home.

The next slide talks about some artifacts that might get connected. We all know about telephone, fax, modems, and various controllers like you might have on your home security system. These are typically things which might use dialup connections, but they could go through leased lines as well. Computing systems of all kinds are connected; these include not only the ones that are used by individuals, but ones that are servers somewhere else on the network acting on behalf of a community of users. Embedded computers are increasingly showing up and I expect will increasingly be used in display systems as well.

Video displays include not only plain monitors but those that have receivers of different kinds. Local area nets primarily involve routers and gateways but they could incorporate other capabilities as well. Radios are the key element in radio-based nets. The variety of peripheral devices range from storage systems and printers to a full range of sensors which are used for different purposes.

We have a telecommunications world which is still very different from cable and broadcast and yet they are starting to merge in various ways. Perhaps this is due to the whole field of interactive entertainment which is just starting to burgeon. Entertainment has got to be coupled with education or education just won't be as meaningful to our kids. Finally, there is the whole field of applications and services that the infrastructure is intended to support.

The next slide talks about trends. Personal computers and workstations are becoming very powerful machines at very low cost. They are able to support multimedia, so we are now routinely seeing very high quality images and even movies on some low cost machines. This trend is only going to accelerate as time goes on. At the same time, the whole field of television is moving from a combined and dedicated broadcast/ reception package, where the transmitter sends what's actually to be painted on the screen, to separated production and presentation mechanisms. We are moving irrevocably to digital transmission. We're moving from lower to higher resolution and we are going to see multiple uses made, not only of the content, but of the facilities themselves.

Packet technology is emerging with a key role in broadcasting, although it is not yet tightly coupled to the NII. High resolution video over ATM clearly is technically feasible. Whether it actually happens or not depends on the business opportunities and on getting sufficient end-user bandwidth at affordable cost. Of course, there is the role of wireless which continues to develop.

A major cut cross all of these trends is the need for portability. No matter how we interact with the infrastructure, whether it's in our office or in our home, we'd like to be able to be mobile and not leave our system interactions behind. We want to take this capability with us in whatever form that might entail; for example, we may accept a lower resolution display caused by lower speed connections until we can replug in somewhere else.

I think it's fair to say that while some people have fairly clear ideas about what the NII is, more generally there is confusion about it. Congressman Markey likes to say, "There's good news and bad news about the NII. The good news is that the Congress is 100% behind it; the bad news is that they have absolutely no idea what it is." The nature of the confusion is just one of the reasons why it's been successful, i.e., it's currently a little bit of everything for everybody. The minute you start to refine choices, from block diagrams to specific technologies, that's when things start to fragment and polarize. We need an integrated view of how different capabilities will be integrated into the NII. I refer to this as a framework.

The media often suggests that the superhighway is 500 channels to the home. Other people say it's here already, or it's been here for a long time. Still other people say that if it's even 128 channels, they don't want it. The Vice President talks about the contents of the Library of Congress being made available to every individual in their home; while that's a laudable goal, it's not obvious how one gets that capability in other than public domain material without the permission of the owners of the material.

There are a set of people who require very high bandwidth for their work and others for whom connectivity at any speed is sufficient. Providing kilobits per second to every home is not the same problem as providing high end gigabits per second to the gurus. Both are important.

We all know that today's computing technology on the desktop is comparable to supercomputers of about 10 years ago. That trend is going to continue. Whatever is available at the state-of-the-art to the most advanced researchers working on the most elegant of the Grand Challenges, will be feasible in a portable desktop computer perhaps ten or some number of years in the future. The same trend is probably going to be true about networking if the demand for higher bandwidth applications grow. So, are we talking about low speed access to lots of people, or very high bandwidth access to a few, and if we're really talking about both, how do we keep them in balance as the competing demand for both research and application funds are being spent?

We all know that most new technology gets developed for profitable, affordable applications. Are we talking about an NII that's going to focus on a few profitable business applications, with a hope that the technology gets nurtured there, and then propagates to something akin to a universal service? Or, are we talking about starting out with something that is universally accessible on day one?

Is this a domestic matter only? The word national shows up in the NII, but we should be worrying about the international aspects if only to know how our national systems will interoperate globally. I know of no field that's had more international input than HDTV. There are those that say we ought to focus on our national needs and requirements first and then worry about the linkage to the rest of the world. Or, should we first worry about a multinational set of capabilities as we formulate what to do nationally?

There is also an issue about terminology. When I talk about the national information infrastructure, I really mean the "infrastructure." The user sees the socket in the wall as part of the infrastructure of the electrical system. It has certain key properties, such as being shareable, easy to use, ubiquitous and standardized. However, many people think about the things they use as being part of the infrastructure too. For example, are the overhead lights part of the electrical infrastructure? You might say they are, because they are an end application. On the other hand, if the lights are on a plug and you can physically plug them into the electrical system, as opposed to flipping the switch, you might say they are an application and therefore we should not consider them as part of the infrastructure. When people talk about the highway infrastructure, they almost always talk about the roads, the cars, the people, the gas stations, the restrooms, and the eating facilities. So, what is the infrastructure? Is it really the infrastructure, or is it the infrastructure plus all the applications that depend on it?

We need to understand where things are going long term as well as understand where they are going short term. There are those who say if you are not leveraging the investments that are out there today, you should first figure out what to do with the existing things that nobody is using very well before making longer term investments? Another set of arguments can be made for not worrying about the short term implications, but to focus on putting the right plan in place for the long term.

We don't know yet who will be the dominant users of the NII. My hope is that it will be everybody. We still don't know if most end-users will prefer to be active or passive. If television continues to be passive, that will be a mistake in that it restricts everyone. If it becomes more interactive, we can deal with it in more interesting ways. And we certainly don't know, what new capabilities and opportunities will be enabled. So, as you can see, there is a substantial reason for confusion. I think our goal ought to be to help reduce it, lower the entropy, and move on towards some clearer understanding of the NII framework.

The Cross-Industry Working Team (XIWT) has been dealing with the issue of the NII architecture and has explored a number of different ways to think about it. ARPA put together their view of the NII and included applications in it. The XIWT view on the next chart, also includes applications in the overall framework. The Cross-Industry Working Team first started in with a four-layer model of the NII. Forgetting the interfaces between the layers, their current model consists of the Applications, Infrastructure Services and the Physical Infrastructure layers although this may yet evolve further. In the earlier XIWT model, The Infrastructure Services Layer was divided into a domain specific layer and a generic services layer. Ultimately, there was a consensus to reduce from 4 to 3 layers. Hence, the final XIWT model is closer to the original view that ARPA had suggested, except that instead of calling the bottom level Bitways, XIWT actually wanted to simply identify it as the physical part of the infrastructure. This layer includes the computers, wires, switches, peripheral devices, etc.

The applications sit in the top layer. Anybody who has ever gotten a PC without any software knows that you can write an application on a piece of raw hardware, but then you have to reinvent everything all over again for every application. Once you figure out that you do not have to redo your naming conventions, your filing conventions, memory management and scheduling, you can get two programs to run on the same machine by reusing these capabilities. They can even run "simultaneously" if the system allows that without stepping on each other's programmatic toes.

The whole need for something in the middle to adjudicate between the applications and the hardware was pretty evident early in the computing industry. This has led to the development of the operating systems and even whole companies that make a living by providing this kind of middleware.

In the case of the NII, there is the same kind of need. What goes in the middle is not an operating system, but rather a set of distributed infrastructure services. There is an interface layer between the physical and the infrastructure services where certain lower level distributed software activities take place. There is also an interface between infrastructure services and the applications layer, and one between the applications layer and the ultimate user. The reason for these interfaces is not so much because it is a defined interface, but rather it is a boundary layer, in which things can move back and forth. For example, in the services layer there are things like routing and naming technology. These functions could be built on a chip and as physical hardware, could become part of the physical infrastructure. Hence, there is a boundary where functions can move in either direction. Likewise, if some part of the infrastructure is domain specific, that part could move into the applications layer, and therefore no longer be part of the infrastructure services layer.

Generic language conventions might be in the infrastructure services layer if they're fairly broad but, if they are unique to one specific application, they may move to the applications layer depending on how they are handled. Things like X-Windows might be in the applications interface on which applications were built, but a presentation interface may very well be a user interface.

This model of the infrastructure components permits broad convergence because it does not say very much about what is anywhere. It leaves room for anybody to claim any part of the picture and as we map the video components you will see the same thing as well.

XIWT is a coalition of several dozen US organizations that are primary producers of information technology and services. It is a broad group cross-cutting across industries like computers, telecommunications, finance, publishing, cable, networking, various equipment manufacturers and semiconductors. Most of the larger information technology oriented companies in this field are involved or they're involved through representatives.

XIWT is a forum for technology discussions. This group is concerned about the technological aspects of the infrastructure. They are trying to form consensus views where possible or to articulate their different views where necessary. XIWT is also developing pilot projects in selected areas.

I see the XIWT effort as much a social process as anything else. Getting people in these different but related fields to know each other, develop common terminology, language, and understand where they're coming from is important to effectively working together. XIWT is a social mixing bowl for the technology folks because not everybody sees the NII the same way. Some of the early documents may look more structured one way or another. They will evolve over time as more people react and change their views.

Currently, there are a series of white papers in preparation. There is an NII Architecture Framework document being prepared. There are white papers also being prepared on Applications Services, Digital Cash, Health Care, and on Portability. US organizations may apply for membership.

The next slide addresses the question, what NII trajectory are we really on? The people who provide the different media are each able to go their own way. However, there are standards-making efforts that naturally arise within each of these industries as they see short term needs and requirements developing. People will write applications as they see the market developing. The same is true about services. We could put a label on the results of all these parallel and independent activities and call it the NII. This is essentially what the economy is all about. It is "what it is." It is determined by what you do, what businesses do, what the marketplace is doing, etc. However, it is not a very likely scenario for developing something that has real power of convergence among the different activities. The economy in this country probably wouldn't grow if it didn't have some boundary conditions, some framework in which it operates. And that is what is needed for the NII except with a real power of convergence among the services and applications.

The middle star in the next slide represents an architectural framework with a power of convergence. Using the Internet as an example, it has a framework embodied in the TCP/IP protocol suite. The standard Internet protocol used by the networks and computers attached to them can be interpreted, but it says nothing about what kind of networks should be built to use it, who can operate them, or even about the detailed structure of any portion of the system. The Internet is like a marketplace for the networking technologists and scientific researchers to provide their wares, where all the pieces fit together almost magically by virtue of the TCP/IP protocol suite. This was also the magic of the old Bell System. It came about by virtue of a single party supplying all of the facilities, i.e., through Western Electric. In the Bell system, there was no need for national debate on how to get commonality. By virtue of everybody using common equipment, it simply occurred.

The Internet uses a very different approach in which equipment is provided by lots of different companies. The Internet is not stagnant because there is a process for managing its evolution. In this process, individual ideas can flourish. The use of a protocol like TCP/IP is no more constraining than would be the use of English in terms of what you say to someone. Arguably, there are some constraints automatically caused by any framework and by any language, but they are META-level constraints. They are not the usual tangible, structural, business kinds of constraints.

There are people who expect the NII architecture to be like a blueprint of a building where you can show it to someone and they will say, 'we can build it.' It's not going to be like that in my view. I think it's going to evolve more like the Internet. Probably, it will be even more like the economy because it is much more complex than a best effort packet delivery from one place to another. So, if we have the right framework to incorporate the needed elements, we have a good chance of creating an NII with a real power of convergence that will be of real benefit to society.

Will we get there? I suspect we'll get much of the way there, but I think independent of how much convergence we get, as the next chart suggests, there will always be some independent efforts taking place that are not necessarily part of the national convergence. This may only occur in extreme cases where somebody introduces a new technology that we do not understand how to fit in and so it develops on its own for awhile. I suspect that it may also involve some people with mainstream activities and interests that want to try both paths. They may want to be part of the NII, and also try their own thing outside of the NII. In fact, it may be that some groups will choose to be NII compliant and also follow their own independent approach as well.

Integrating the pieces, as indicated in the next chart, is what the real goal of an NII should be. It should be possible for application areas that are developed independently but as a part of the NII, to interact with other application domains subject to administrative controls. This is similar to the way things happen in the economy today; one producer makes something available that somebody else can use. You can contract for it, and you can buy it, and you can factor it into your daily working efforts.

In this chart is an example of a health care application. Notice it penetrates a little into the infrastructure services level. There are three pieces of physical infrastructure shown. These are the network, wireless and other kinds of equipment, e.g., computing or storage equipment.

Suppose the healthcare application is such that you need to pay for some kind of medical service. You need to make sure your insurance carrier will support the procedure or that there is appropriate approval for payment. Finally, the patient needs to be educated by interaction with knowledgeable people or by being taught, perhaps by video. How is it possible to develop those interactions in such a way that you don't have to put a team of wizards from four different groups together to build a special purpose system each and every time? This is possible if the applications that have been developed in one case can support applications in other cases and they can draw on various services within the infrastructure to do so. Examples include routing services, how to name things, and how to plug them together dynamically. Integration services allow the right parties to be put together once they know what their names and addresses are, provided they can communicate in a common language. Various resource allocation mechanisms can be used if appropriate. One of these may be conferencing if they need to bring in doctors or laboratories or to display materials to several parties.

A framework that will enable transactions to take place independent of the details and to call upon other functions as needed is also an important scenario for activity in the services layer. This is one critical goal for the NII - to make it possible for all the pieces to work together and, in the process, to stress the idea that maybe the system capabilities ought to be portable as well.

The next chart takes a look at the video challenge. How should we go about trying to achieve the hybrid integration which is necessary for getting video into the NII? There are several issues here. Clearly, the set-top box is one issue. As you'll see in the next couple of slides, the set-top box and the personal computer are starting to look very similar, at least in my view.

How do we achieve the commonality of the interfaces, protocols, and the kind of digital objects that are going to move around in the NII or the alternative delivery mechanisms that are available? These can move over the air, on various networks or through physical devices that you physically plug in somewhere, like a CD ROM. Can one make use of the capability for broadcast and wireless for multiple transmission purposes? As the NII evolves, we are going to find many uses for every one of the media. Dedicating any one medium to a single purpose may in fact be counterproductive, because one capability may need to be shared with some other capability as we see in relationships between different media and content sources.

Various kinds of new generation displays will undoubtedly be developed. There may involve self-emanation technology or microscopic movements that produce refractive patterns or whatever. We will want these new generation displays to meet NII requirements, whatever they may be.

Let's consider the structure of video display systems. On the left side of this chart you see the display -- some kind of a monitor, let us assume it is high resolution at this point. In the middle there is the control electronics and the things that handle transport, compression, conversion from one format to another and possibly security if there are access controls required. The user can interface with a whole variety of methods including a joy stick, a VCR, a digital source of some sort or other, with maybe a pointer. There are external network interfaces. These are cable, wireless (such as satellite or cellular), terrestrial networks and so forth. That's a model of what a video display system looks like.

The personal computer workstation as we currently know it is shown on the next chart. It is strikingly similar to the video display system. There is a display on the left. It may show video; it may not. It could show images or graphics as there is no reason not to have graphics on a video system as well. The electronics is in the middle. Typically we think of it as the place where the software runs. There is an operating system to make it easier to run software and do some data processing. We do not call it control exactly, but you could. It includes some transport, like the TCP/IP protocol, so you can talk to other machines and you have to have some way for getting interactions to and from the user. It might be via the operating system from tape drives, a mouse, a keyboard, a CD ROM, a VCR, a camera, or from a projector for large screen display. Again, there are external network interfaces, probably the same ones as in the previous scenario.

Where is all this going? It's probably going to end up looking more like this next chart eventually. You are going to have some kind of high performance LAN or local distribution system in your building or in your home. It is going to be low enough in cost and high enough in bandwidth, that having dedicated systems with dedicated external interfaces does not make any sense. So, you will have one place where external network interfaces show up. Multiple displays will all be plugged into the same LAN. Computation may be in one or two boxes or embedded somewhere so you may not even see them as external boxes. There will be storage facilities so you can keep digital objects (including video) around. There will be input and output devices of different kinds. Cameras and sensors for entertainment, control, or security purposes will also be included. There may be pointers that interact directly with the display. Things are going to change!

What I'd like to do in trying to wrap up this talk is to discuss some of the issues and a few recommendations for your consideration.

First, I would like to address the issue of where video playout may occur. I think we should take a broad view of this. In terms of the devices, it could be in your workstations or it could be in what you consider your TV. It could be on large or small screens. You ought to think broadly about where it might show up. In terms of location, it could be in the classroom, the home for personal use, at public places, in laboratories, offices, and the factory floor. The potential is large to make it show up anywhere.

How does the video get there? Modes include wireless, fiber and by various hybrid paths. We ought to be open to any mechanism for moving it. It can be on a fixed path, through networks, or you can carry it physically and plug it in yourself. I think there is still going to be a very strong demand for the sale of physical media that one can own. You own it in some tangible form. Some materials will be prerecorded or they can be generated on line.

In terms of video representation, one must be prepared for lots of different forms of representation. I do not think they are going away anytime soon, any more than I suspect paper is going to go away anytime soon. I think film isn't going to go away either, but it may continue to evolve. We are probably going to have some high quality analog around for a while too.

In the area of digital standards, there is the whole panoply of possible options ranging from MPEG and JPEG to SMPTE. There is the issue of how we use video with the NII. It seems to me, we have got to be open for all the reasonable possibilities. These range from a user passively viewing a screeen to full two-way interactivity. There will be issues about stored video and staged video, where it is being moved from place to place according to some strategy. Video will be integrated with other computer generated data and presented as output. We can address navigating stored video archives and producing computer assisted video. We can worry about more than you can see.

If you have control over the output, you may adjust granularity and resolution to suit your needs. You may even be able to get multiplexed user strings where each string carries different video channels, related or unrelated, so that you can deal with them as a bundle.

My goal is to watch a golf tournament as a bundle where I actually get to pick from something like 128 different channels, one for each golfer, so I can pick and choose when and whom to watch. Notice I didn't mention the video phone, but I'm sure that it is going to show up. Finally, in terms of playback and transport, issues arise like maintaining real-time requirements for continuity on a video screen. How much storage is needed to do a decent job? How do you merge multiple frames in interesting ways? How do you do digital zooming and panning from the user's point of view? Is it going to support fast forward or reverse? What kind of quality can you expect? What kind of support can you acquire from the network? What kind of latency can you tolerate when timeliness is relevant? These are some of the issues that we need to deal with.

The issues list goes on in the next chart. The issue of matching multiple media, multiple data formats and multiple destination equipment is really part of the set-top box and the

PC issue. However, it's really a larger issue because it also deals with the integration of text with video and graphics with video.

The whole issue of repositories need to be addressed. How do we develop them and make them available? What goes into them? Are they annotated or not?

The whole area of broadcast where lots of people can receive a common signal as a datastream, needs to be assessed in comparison with retrieval on demand. It comes up particularly in video today, but also in advertising where you do not want to intrude upon people, but you may want to put video ads in a place where people can get to it later. Retrieval on demand is less intrusive but may not be as effective as other more direct advertising strategies.

How do we develop collaborative arrangements among different sites and different organizations that involve video as the key media? I am referring not only to how we put it together physically, but how we really integrate it into our daily work habits. The design of efficient local distribution systems to get both high and low bandwidth capabilities to the home will be important here. People really want options here because we are going to deal with different and competing requirements, not only for the video, but for data as well.

A big issue which could be the subject of a separate discussion is accommodating intellectual property (IP) protection. Among the various content media, I believe that broadcasting, satellite and the cable people have come closer to getting IP right in terms of how the NII environment will have to deal with this issue in the future. In the print world one thinks about moving physical copies of things. You talk about that less frequently in the video world; you talk about things like, receiving a performance of MASH on your TV set. When you make a copy, you have made a copy of a performance. You did not make a copy of an original work. The whole idea of performance versus copies over networks is one that I think is going to come to the fore. In many ways, the video folks seem to have gotten it right from the beginning, but the NII offers new possibilities so they will be worth studying further.

Finally, there's the issue of vendor convergence. How do we get all of the parties together to ensure that the NII converges and, to identify the kind of framework that makes sense to adopt so that video is compatible with everything else?

If we're going to deal with interoperability, we're going to need to do addressing so it means the same thing in the video as in the computer world. If we are going to provide content to particular devices it may help if these devices have ID's. In the portable environment, particularly, we will need to be able to describe not only the kind of device we're dealing with, but the environment in which it is operating, in order to accommodate downloading. We're going to need to be able to describe the kind of service performance that is desired, not only in our local system, but in the networks that are connecting us. There really is no capability for a session layer right now that can support the integration of multiple sources. However, I think that is an important thing to develop. I think the ability to support multiple transport media, including the NII standards, needs to be factored into the video world. We need to ensure that as we proceed, new displays can handle text, graphics, images and video in all of the standard configurations. We will need to define what we think are reasonable standards and configurations.

There has been a lot of discussion about square pixels and non-square pixels, but I think we need to understand this issue in an NII context. If you look at some of the video proposals, they include layered architectures, but layering and modularity are very different things. The Empire State Building is a layered architecture but not terribly modular. It is hard to swap out the 34th floor and put in a different 34th floor. Sometimes one can have a nice layered architecture, but if the interfaces are such that they are not well-defined and published so people can design and build to them, you really do not have the ability to pull out and replace modules. We need to be modular!

We need to find a way to incorporate software upgrades, whether they are required in the displays, in the controllers, in the PC's, or in the workstations. In this regard, the computer industry is way ahead. We must allow for software upgrades that support generally accepted interfaces, protocols, and digital objects. We also need to find a way to use public broadcast channels with standard NII interfaces. There are a lot of different options on how to do this that need to be considered.

In conclusion, it seems clear that video is going to play a central role in the future evolution of the NII. Exactly what shape and form this undertaking will take to realize this goal is really what this conference is all about. It is a very important topic and I wish you well on your deliberations.

# Visions & Services of the National Information Infrastructure

Robert E. Kahn

Corporation for National Research Initiatives
Reston, Virginia

May 10, 1994

## Media

- Dial-up Connections
- Leased Point-to-Point Circuits
- Wide-Area Networks
- Cable
- Satellite
- Terrestrial Wireless

## Devices & Systems

- Telephones, fax, modems, controllers
- Computing Systems
- Video Displays
- Local Area Networks
- Radios
- Peripherals
- Sensors

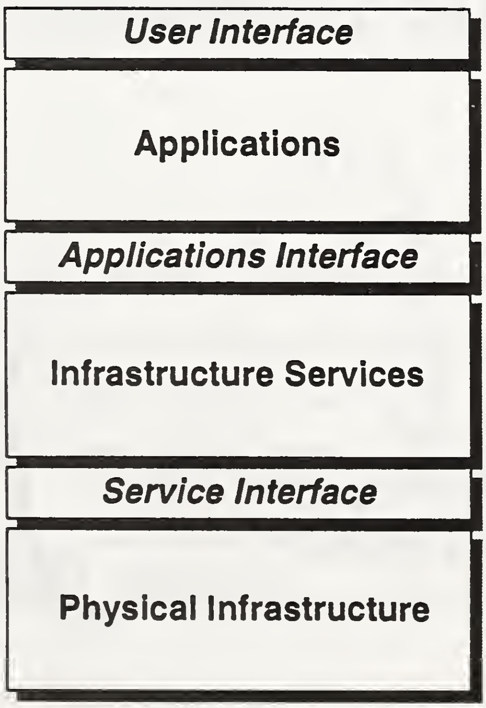
## Trends

- PCs & WSs Developing into Powerful Multi-Media Systems at Relatively Low-Cost
- Television moving from a combined/dedicated broadcast/reception Mechanism to a Separated Production and Presention Mechanisms
  - *Analog to Digital, Low to High Resolution, Multiple Uses*
- Packet Technology Emerging in Key Role within Telecommunications Industry - ATM
- High Resolution Video over ATM technically feasible - depends on sufficient end-user bandwidth at affordable cost
- Major Role for Wireless
  - *Satellites for Broadcast, access to/from remote areas*
  - *Terrestrial Wireless for the "last leg"*

# What is the NII?

- Many Different Perspectives
  - *500 Channels of Cable TV or the Library of Congress in every home*
  - *Kilobits to All Americans or Gigabits to the Gurus*
  - *Profitable Business Applications or Universal Service*
  - *A Purely Domestic Matter or an International Enterprise*
  - *The Infrastructure Only or also all the Applications which make use of the Infrastructure*
  - *A Long Term Investment for the Nation or a Short Term Effort to Make Better Use of Existing Capabilities*
- Who will be the Dominant Users of the NII?
- Will most end-users be Active or Passive Participants?
- What New Capabilities and Opportunities will be Enabled by the NII?

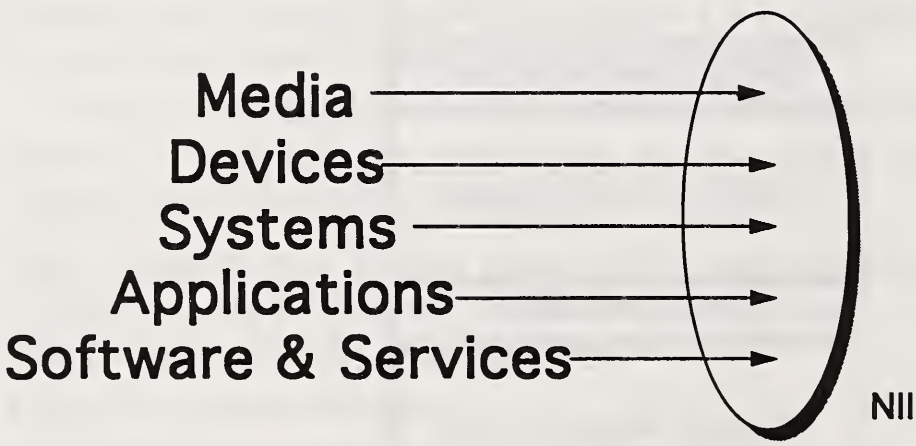
# NII Components

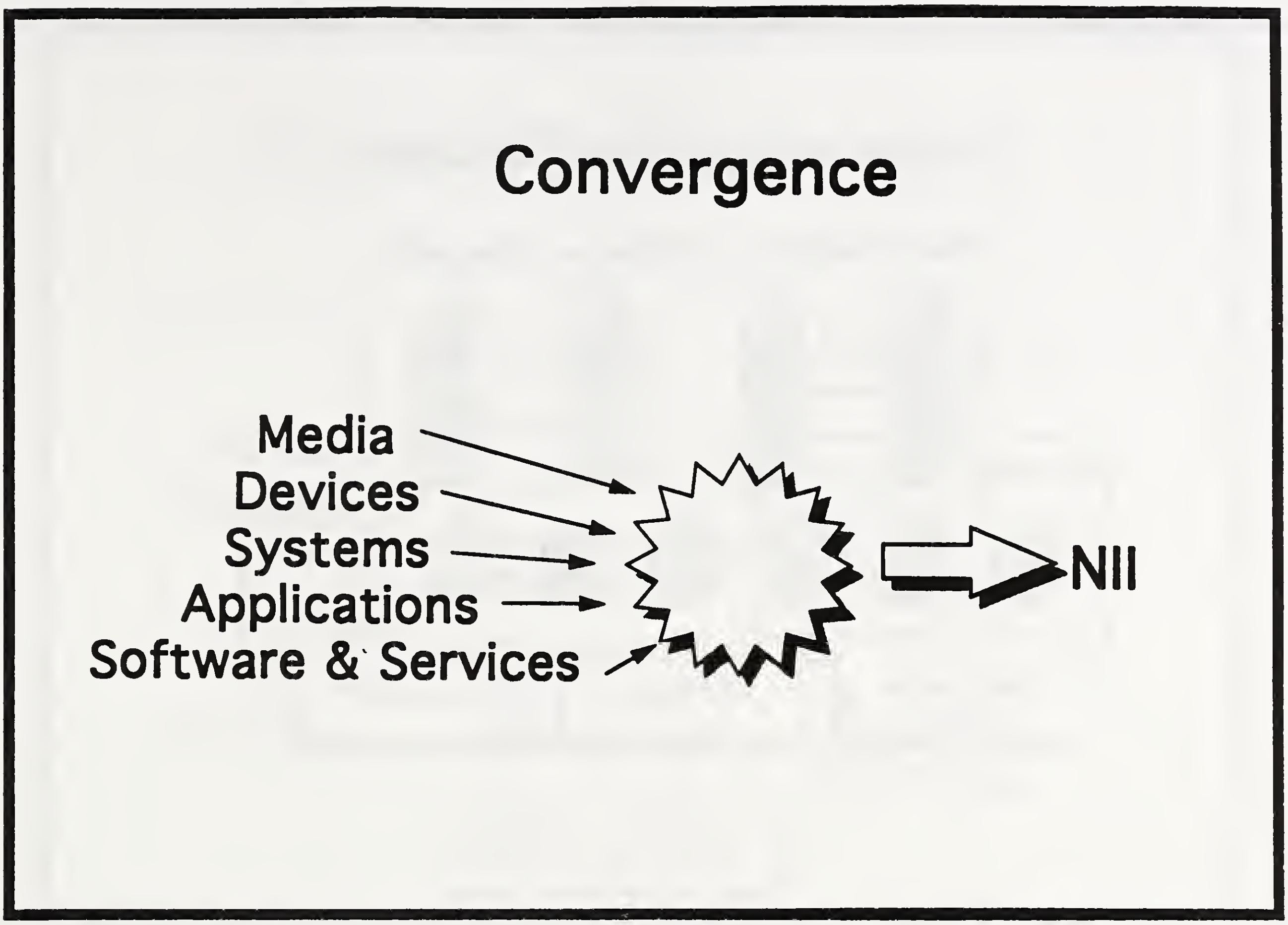


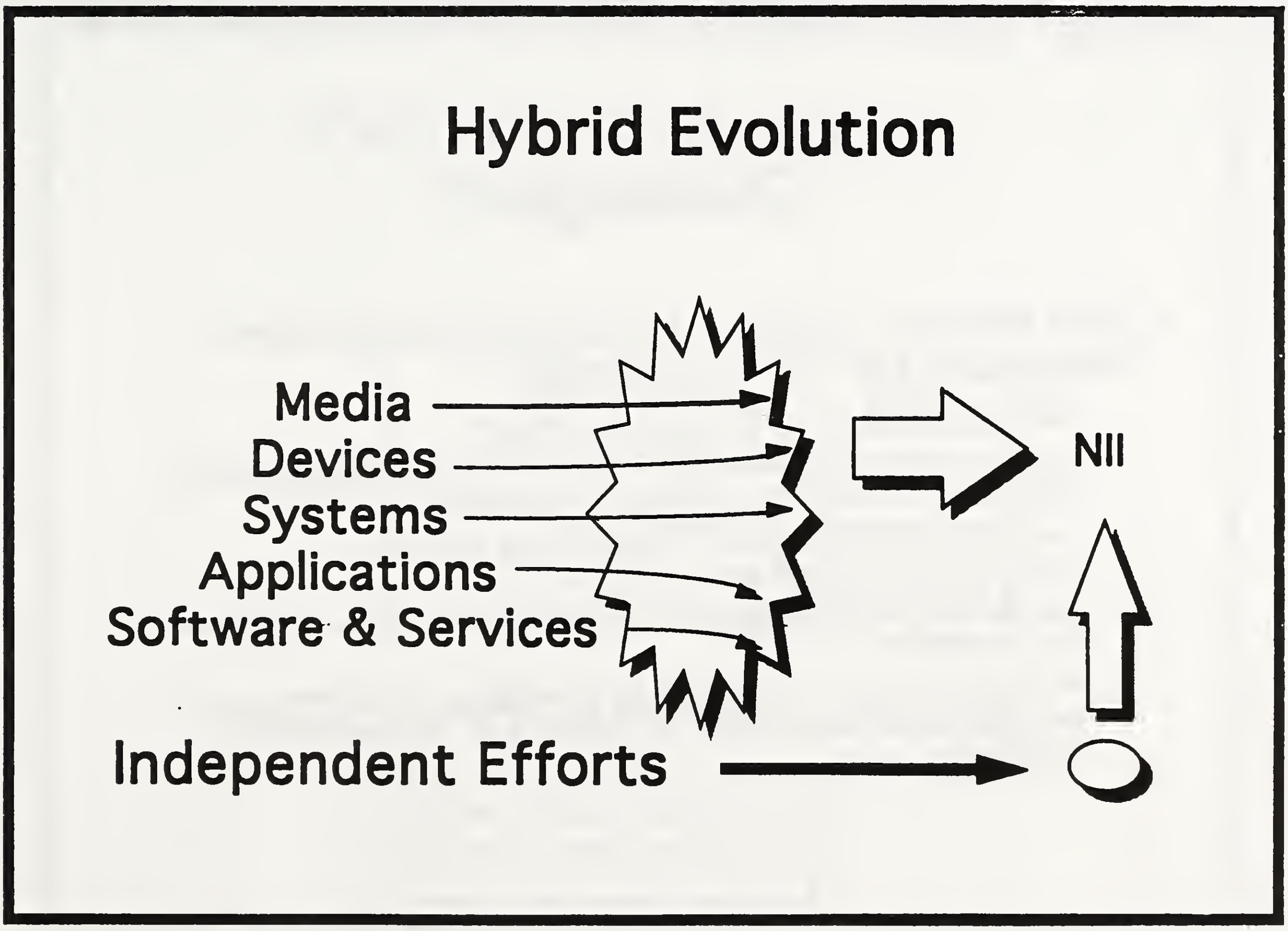
## Cross-Industry Working Team

- Coalition of several dozen US organizations that are primary producers of Information Technology & Information Services
  - *Computers, Telecommunications, Financial, Publishing, Cable, Networking, Equipment Mfgs, Semiconductors*
- Forum for Technological Discussion, Formulation of Consensus Views on the NII, Development of Pilot Projects
  - *Social Process a prerequisite to technological progress*
  - *Not everyone sees the NII in the same light*
- Currently, a series of White Papers are in Preparation on Applications Services, an Architectural Framework and Portability
- Membership Fee, Open to US Organizations

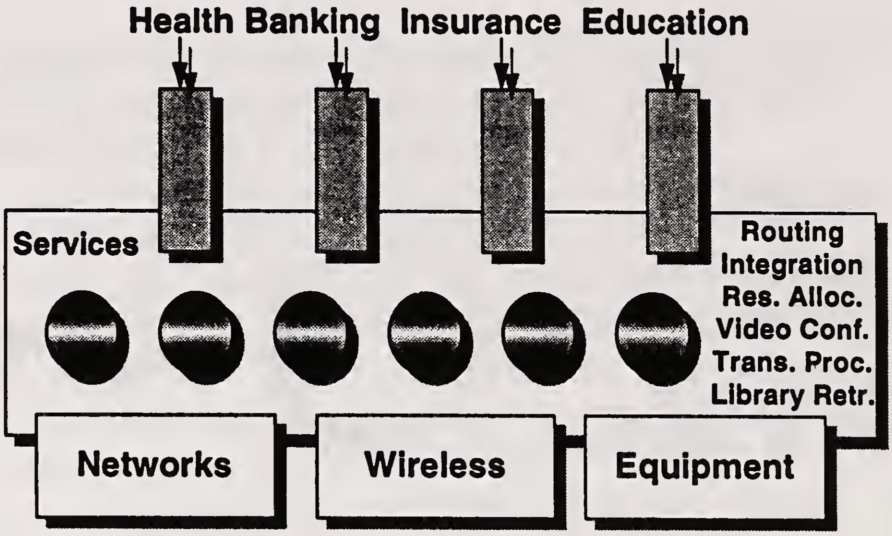
## Isolated Developments




Convergence
Media
Devices
Systems
Applications
Software & Services
NII

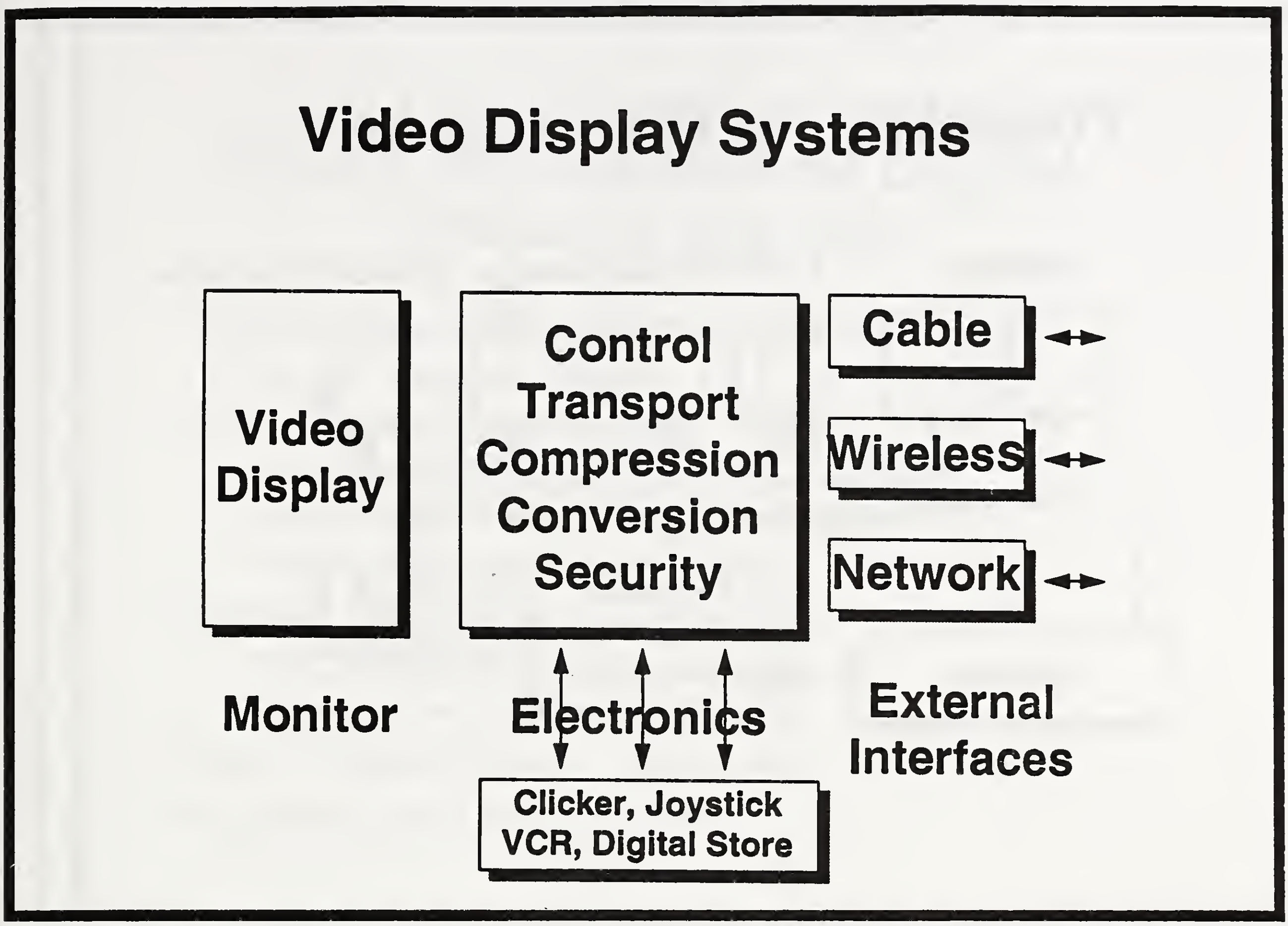

Hybrid Evolution
Media
Devices
Systems
Applications
Software & Services
NII
Independent Efforts

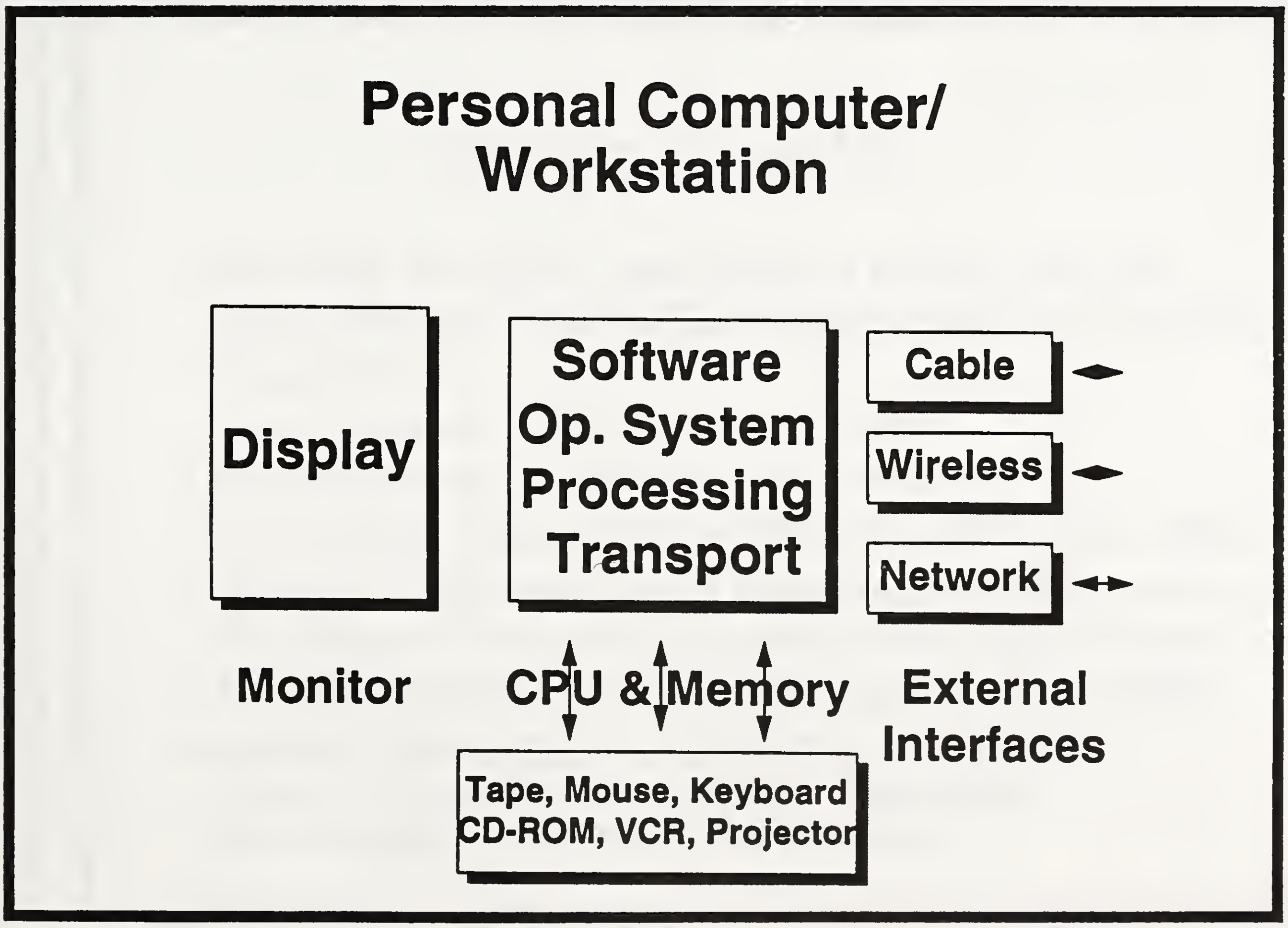
# Integrating the Pieces



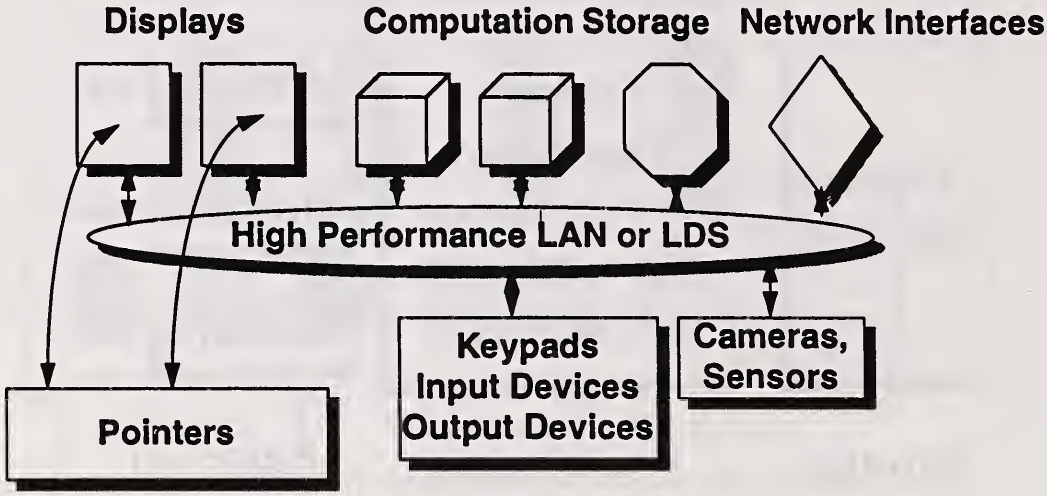

# Challenge

- How Best to Achieve the Hybrid Integration Necessary for Video in the NII
  - "Set-top Box" and the Home Computer
  - Commonality of Interfaces, Protocols and Digital Objects for Alternate Delivery Mechanisms
  - Availability of Broadcast Channels for Multiple Transmission Purposes
  - Conforming New Generation Displays to NII Requirements
  - Participation in the Process to Develop and Maintain an Architectural Framework for the NII and its Associated Standards


Video Display Systems
Video Display
Control
Transport
Compression
Conversion
Security
Cable
Wireless
Network
Monitor
Electronics
External Interfaces
Clicker, Joystick
VCR, Digital Store


Personal Computer/ Workstation
Display
Software
Op. System
Processing
Transport
Cable
Wireless
Network
Monitor
CPU & Memory
External Interfaces
Tape, Mouse, Keyboard
CD-ROM, VCR, Projector

# Projection for the Local Area



## Issues for Advanced Digital Video in the NII

- Where may Video Playout Occur?
  - Device? Location? When?
- How Does the Video Get There?
  - Wireless? Fiber? Hybrid Paths?
  - Fixed Path or Networked? Physical Media?
  - Prerecorded? Generated On-line?
- How is the Video Represented?
  - Film, Digital Studio Quality, Compressed?
  - Analog as well as Digital Standards?
- How is the Video to be Used?
- Playback and Transport?

## Issues (cont'd)

- Matching Multiple Transmission Media, Multiple Data Formats and Multiple Destination Equipments
- Repositories
  - How to Develop? How to Make Available?
- Broadcasting vs. Retrieval on Demand?
- Developing Collaborative Environments with Video
- Design of Efficient Local Distribution Systems for the range of low to high resolution requirements
- Accommodating Intellectual Property Protection
- Vendor Convergence, Evolution of the NII Architectural Framework and Standards Development in the NII Marketplace

## Recommendations

- Universal Addressing
- Universal Device IDs
- Device & Environment Descriptions
- Service Performance Descriptions
- Session Layer Definition Including Integration of Multiple Sources
- Provide Support for Multiple Transport Media including any NII standards
- Insure All New Displays handle text, graphics, images and video for standard configurations

## Recommendations (cont'd)

- Modular Structuring of the Overall System Architecture
- Incorporate Means for Software Upgrades that Support Generally Accepted Interfaces, Protocols and Digital Objects
- Public Broadcast Channels to be usable with standard NII interfaces

# PRODUCTION AND DISTRIBUTION OF ENTERTAINMENT IN THE NII

**by Ken P. Davies, Vice-President Engineering, SMPTE**

**(Society of Motion Picture and Television Engineers)**

## INTRODUCTION

The production and distribution of entertainment is a very important economic activity in the USA. The motion picture industry has annual revenues of $12 billion in the US, employs 400,000 people directly and is a major ($8 billion) contributor to exports. The television industries have gross revenues of $25 billion annually and deliver services to almost 100 million homes over 1500 stations. Other elements of the cultural industries, including music, recording, the theatre and the arts are similarly important. Radio and TV broadcasting have, for many decades, formed the "information network" for most Americans, in good times, in emergencies and in times of disasters. The cultural industries will doubtless form an essential part of the NII in the future.

## DIGITAL VIDEO AND IMAGING

Motion pictures and television have made use of digital techniques in production for many years, initially in applications that were otherwise impossible in analog technology, such as standards conversion, storage and special effects. Increasingly, this technology has moved into applications where the unique properties of digital technologies offered cost, quality or performance advantages and today virtually all professional level production is based on digital techniques, frequently making use of advanced computing techniques. Motion pictures, such as Jurassic Park, would be impossible without the processing provided by a large number of processing work-stations, while the TV news would disappear from the screen without digital effects, transmission and storage.

Increasingly, the standards employed for these activities are convergent with those of computers and telecommunications, as these industries move to common technology for their diverse applications. Current standards for motion picture and television are used widely in the computer field for graphics and displays. In production and distribution these industries are already in the "digital age", in fact leading the way in practical applications. The entertainment industries make heavy use of new technologies, to enhance the value of the products, to make them more available, of higher quality or more acceptable to the users. They are, however, very conscious of the need to protect the value of the consumers' investments in equipment and access to services. Thus compatibility and interconnectivity are of high priority in the setting of standards, avoiding premature obsolescence and allowing software and hardware from the earliest days to work satisfactorily today in all American homes. In the development of the NII, this concept may be a significant contribution to its acceptability by consumers.

## DIGITAL DISTRIBUTION

Over the next few years, the distribution of motion pictures and television will inceasingly become digital, irrespective of the delivery medium, terrestrial broadcast, cable, satellite or the telecommunications network, and also in package media such as video cassette, video CD or CD-ROM. Development of digital compression techniques has made digital delivery the technique of choice due to the inherent flexibility, economy, quality and compatibility with the burgeoning communications networks. These developments will enable better distribution of current services to consumers and will allow the development on new innovative services, with levels of significant interactivity, for entertainment, education, information and transactional services. Such broadcast services are highly complimentary to many of the interactive services likely to form the content of much of the NII and their inclusion within the NII structures and enabling regulation is strongly recommended. This would have the effect of making this very large pool of services and the nationwide, broadband (20 to 40 Mb/s) delivery capability available to bootstrap and advance the implementation of the full range of NII services by many years at the consumer level.

## INTELLECTUAL PROPERTY RIGHTS

Introduction of the NII and of digital delivery to the home will open up many questions concerning the protection of property rights associated with cultural items, including motion picture and television programmes, works of art, books, music and performance. Such items are likely to be available in the NII and in related "appliances", in high-quality, digital forms and will be widely accessible. It is thus essential that means be provided, in both the NII and in legislation, to ensure that these rights are respected, by the inclusion of access control, mechanisms for payment and audit and security of storage, transmission and display at all levels. Additionally, traceable codings will be needed to enforce such laws in the event of piracy or other unauthorised uses of content. Similar security concerns may exist in respect of privacy for other potential NII services, such as health-care. The value of many cultural properties is very high and failure to respond, from the beginning, to these concerns may have significant negative consequences on the development of the services essential to the implementation of the NII.

A further concern of the cultural industries is that the NII should be open to all suppliers of content and services equally and on an equitable basis. In this way consumers will be better served and the potential for the creation of "gate-keepers" exacting an undue influence on content would be eliminated.

## CONCLUSION

Although technology may make the NII possible and telecommunications and computing may form the backbone of its implementation, it is content and useful applications that will attract the usage necessary for its success. The cultural industries, particularly motion pictures and television, can thus be seen as an essential part of the NII, providing the content and services that will provide many of the high quality services, both point-to-multi-point (broadcast), on-demand (interactive) and informational. The inclusion of the cultural industries in all phases of the development and implementation of the NII, including policy, legislation and regulation, is thus essential.

In addition, the digital delivery infrastructure currently being planned and deployed by the TV broadcasting industry (over- the-air, cable satellite) can readily accommodate the wider needs of the NII for the delivery of a wide range of services and is already, in large measure, interoperable with the other telecommunications network elements of the NII. Its inclusion within the NII has the potential to advance by many years the availability of NII services to consumers throughout America, to render the NII universally and equitably available and to reduce significantly the cost of implementation and operation, making it more affordable for all applications and services, especially at the consumer level.

WORKSHOP ON ADVANCED DIGITAL VIDEO
IN THE
NATIONAL INFORMTION INFRASTRUCTURE

PRODUCTION AND DISTRIBUTION OF ENTERTAINMENT

Kenneth P. Davies

SMPTE

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OUTLINE OF PRESENTATION

- PRODUCTION ISSUES, MOTION PICTURES, TELEVISION, MUSIC/SOUND
- DISTRIBUTION ISSUES, TECHNICAL AND BUSINESS
- STRATEGIC ISSUES
- PROPOSALS FOR THE FUTURE

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MOTION PICTURE PRODUCTION

- A $12 BILLION BUSINESS IN THE US
- EMPLOYS 300,000 PEOPLE IN PRODUCTION/DISTRIBUTION OF A WIDE VARIETY OF SKILLS
- 450 NEW RELEASES OF FEATURE FILMS PRODUCED IN 1993
- MAJOR RESOURCES IN ARCHIVES OF PREVIOUS YEARS
- FILM PROVIDES A LARGE PERCENTAGE OF HOME ENTERTAINMENT
- HOME REVENUES 60 PERCENT OF TOTAL

4-

MOTION PICTURE PRODUCTION (contd)

- FILM PRODUCTION USES VERY ADVANCED DIGITAL IMAGE PROCESSING FOR EFFECTS AND EDITING
- FILM IS VERSATILE, INTEROPERABLE, EXTENSIBLE AND COST EFFECTIVE
- FILM DATA IS READILY TRANSPORTABLE AND EFFICIENT TO COMPRESS
- FILM STANDARDS ARE MATURE, 24 fps, 16, 35, 70 mm
- FILM PRODUCTION IS NOT RIGIDLY STANDARDISED, ASPECT RATIOS, FRAME SIZES, SOUND ARE FLEXIBLE. COMMONALITY IS THE TRANSPORT BASE
- FILM MATERIAL IS AN ESSENTIAL PART OF THE FUTURE OF THE NII

5-

TELEVISION PRODUCTION

- ABOUT 1500 TV STATIONS DO A TOTAL BUSINESS OF $25 BILLION PER YEAR
- PREDOMINANT COMMUNICATIONS MEDIA IN AMERICA - MORE TV SETS IN THE HOME THAN TELEPHONES!
- NEARLY 100 MILLION HOMES HAVE TV, 70 MILLION MORE THAN ONE SET, AVERAGE ABOUT 2.4 SETS PER HOME
- VIEWERS AVERAGE 20 TO 25 HOURS PER WEEK OF TV WATCHING
- TELEVISION BROADCASTING HAS BEEN THE NII FOR MORE THAN 40 YEARS AND IS AN ESSENTIAL PART OF ANY FUTURE NII

6-

TELEVISION PRODUCTION (contd)

- DIGITAL TV HAS BEEN WIDELY EMPLOYED IN TV PRODUCTION SINCE 1976 AND COMPONENT STANDARDS HAVE EXISTED SINCE 1982
- TODAY'S TV PRODUCTION INDUSTRY MAKES EXTENSIVE USE OF ADVANCED DIGITAL PRODUCTION, POST-PRODUCTION AND DISTRIBUTION OF BOTH PICTURES AND SOUND
- DIGITAL RECORDING IS USED FOR ESSENTIALLY ALL ELECTRONIC TV PRODUCTION
- MOTION PICTURE FILM USED EXTENSIVELY IN HIGH-END TV PRODUCTION FOR MULTI-DESTINATION RELEASE
- TV PRODUCTION IS ALREADY VERY WELL DOWN THE ROAD TO ADVANCED DIGITAL VIDEO (AND AUDIO)

## TELEVISION PRODUCTION (contd)

INCREASINGLY, COMPUTERS ARE BECOMING PART OF THE PRODUCTION PROCESS, EDITING, STORAGE, MANIPULATION, FILE SERVERS ETC. DESK-TOP TV IS NEARLY ACCOMPLISHED

STANDARDS FOR DIGITAL TV ARE IN PLACE AND WIDELY USED. e.g. SMPTE 125M, 290M, ITU-R REC. 601, 656, 709.

STANDARDS DEVELOPED FOR ATV ARE "NII FRIENDLY", FORMING A "DESCRIPTOR LANGUAGE" FOR STILL AND MOVING IMAGES. SQUARE PIXELS, COMMON COLORIMETRY AND PIXEL CODING, FLEXIBLE IN RESOLUTION AND FRAME RATES.

## PRODUCTION OF RADIO AND MUSIC RECORDINGS

SOUND IS A VERY IMPORTANT PART OF ENTERTAINMENT

DIGITAL SOUND SERVICES ALREADY EXIST IN THE INTERNET

STUDIES AND DISCUSSIONS ALREADY IN PROGRESS ON SOUND SERVICES IN THE NII AMONG EXPERTS IN AUDIO

WORKSHOP ON ADVANCED DIGITAL VIDEO INCLUDE A SLIGHT OVERSIGHT

## DISTRIBUTION ISSUES (IN ENTERTAINMENT)

DISTRIBUTION OF ENTERTAINMENT IS HIGHLY ASYMMETRICAL

- FLOW TO USER FAR HIGHER THAN IN REVERSE DIRECTION
- POINT TO MULTI-POINT OPTIMISATION OF COSTS
- PUBLIC INTEREST IN UNIVERSAL AVAILABILITY
- SMALL DEMAND FOR HIGH LEVEL OF INTERACTIVITY

10-

DISTRIBUTION ISSUES (contd)

TECHNICAL STANDARDS

- DIGITAL FORMATS
- COMPRESSION STANDARDS
- TRANSPORT AND STORAGE
- INTEROPERABILITY WITH OTHER SERVICES IN THE NII
- FORM AND RANGE OF CONSUMER EQUIPMENT (THE INFORMATION APPLIANCE)

11-

DISTRIBUTION ISSUES (contd)

| CURRENT VIDEO FORMATS | SMPTE-125M | REC-601 | SMPTE-240/290M | ATV-1994 |
|---|---|---|---|---|
| COLORIMETRY | NTSC | NTSC/PAL | ENHANCED | ENHANCED |
| PXL. CODING | 10 BIT G.C. | 8/10 BIT G.C. | 10 BIT LIN/G.C. | AS 240M |
| PXL/A. LINE | 720/960 | 720 | 1920 | 1920/1280/864 |
| LINES/A. FRAME | 483 | 483/575 | 1035 | 1080/720/480 |
| PICT.ASP. RATIO | 4:3/16:9 | 4:[illegible] | 16:9 | 16:9 |
| PXL. ASP. RATIO | 0.89 | 0.89/1.06 | 0.96 | 1.00 |
| FRAME RATE | 59.94 | 59.94/50 | 59.94/60 | 24/30/59.94/60 |
| FORMAT | 2:1 | 2:1 | 2:1 | 1:1 AND 2:1 |

12-

DISTRIBUTION ISSUES (contd)

COMPRESSION

MPEG-2 MP/HL, MPEG-2 MP/ML, DIGICYPHER II

DOLBY AC-3, MUSICAM

13-

DISTRIBUTION ISSUES (contd)

BUSINESS MATTERS

- IPR AND COPYRIGHT
- CONTROL, ACCOUNTING AND PAYMENTS
- SECURITY FROM UNAUTHORISED USES, PIRACY, COPYING, ABSTRACTING

14-

DISTRIBUTION ISSUES (contd)

BUSINESS MATTERS

- DESIRE FOR OPEN, INTEROPERABLE AND EASILY NAVIGABLE SYSTEMS
- OPEN ACCESS TO BOTH USERS/CONSUMERS AND CONTENT AND SERVICE PROVIDERS
- ESTABLISH A FULLY COMPETITIVE ENVIRONMENT AMONG PROVIDERS
- ACCESS TO BE FREE OF PROPRIETARY LIMITATIONS, WHICH MAY CREATE TECHNOLOGICAL "GATE-KEEPERS"

15-

DISTRIBUTION ISSUES (contd)

BUSINESS MATTERS

- SECURITY OF CONTENT ESSENTIAL, IN STORAGE AND TRANSMISSION AND USE
- FOR COPYRIGHT MATERIAL, THERE IS A NEED TO BUILD IN SYSTEMS TO ACC T FOR THE USES SUCH MATERIAL AT ALL LEVELS OF THE SYSTEM, WITHOUT COMPROMISING USER RIGHTS TO PRIVACY
- INFORMAT ON APPLIANC S MUST BE ARRANGED TO PROTECT APPROPRIATELY THE RIGHTS OF IPR OWNERS

16.

STRATEGIC ISSUES

ROLE OF ENTERTAINMENT IN THE NII ENVIRONMENT

- AS CONTENT PROVIDERS
- AS SERVICE PROVIDERS
- AS A PART OF THE NETWORK

17.

CONTENT PROVIDER ROLE

- CONSUMERS BUY CONTENT, NOT TECHNOLOGY
- ENTERTAINMENT, BOTH INTERACTIVE AND NON-INTERACTIVE, IS PRODUCED EFFECTIVELY AND EFFICIENTLY BY THE MOTION PICTURE AND TV INDUSTRIES TODAY IN ADVANCED DIGITAL FORMATS
- NII WILL NEED THE ECONOMIC MASS OF ENTERTAINMENT TO SUPPORT THE EMERGENCE OF NEW SERVICES OF NARROWER APPEAL
- NII SHOULD INCLUDE ENTERTAINMENT

18.

SERVICE PROVIDER ROLE

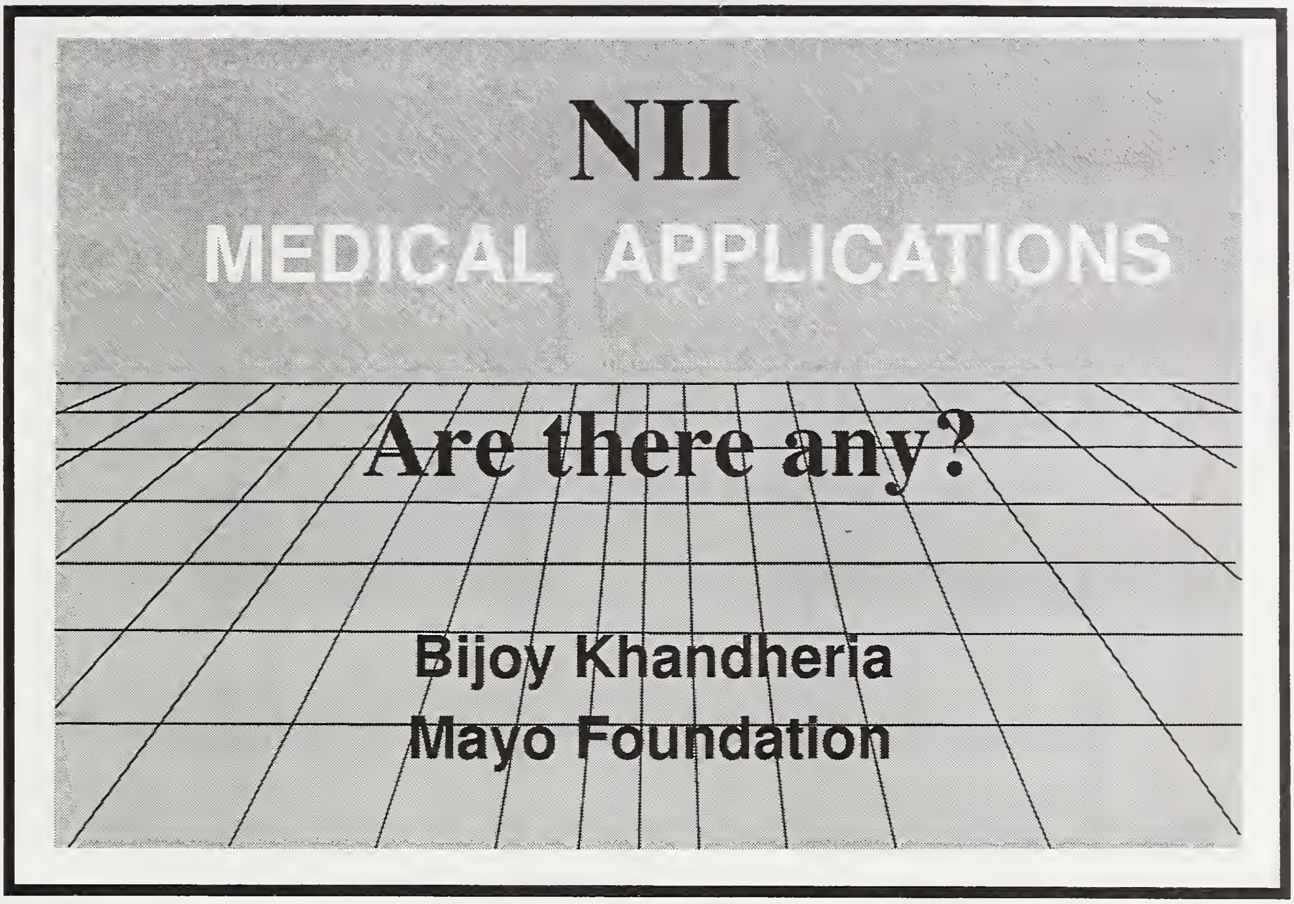
- BROADCASTERS HAVE PROVIDED THE NII FOR 40 YEARS TO CONSUMERS
- BROADCASTERS ARE TUNED TO THE NEEDS OF USERS AT NATIONAL, REGIONAL AND LOCAL LEVELS FOR ENTERTAINMENT AND INFORMATION
- GLOBAL RESOURCES ARE ALREADY IN PLACE TO SUPPORT INFORMATION AND ENTERTAINMENT SERVICES
- BROADCASTERS HAVE AN INTEREST AND CAPABILITY FOR PROVIDING SOME OF THE SERVICES WITHIN THE NII
- NII WILL BENEFIT FROM ENTERTAINMENT AND INFORMATION SERVICES FROM BROADCASTERS

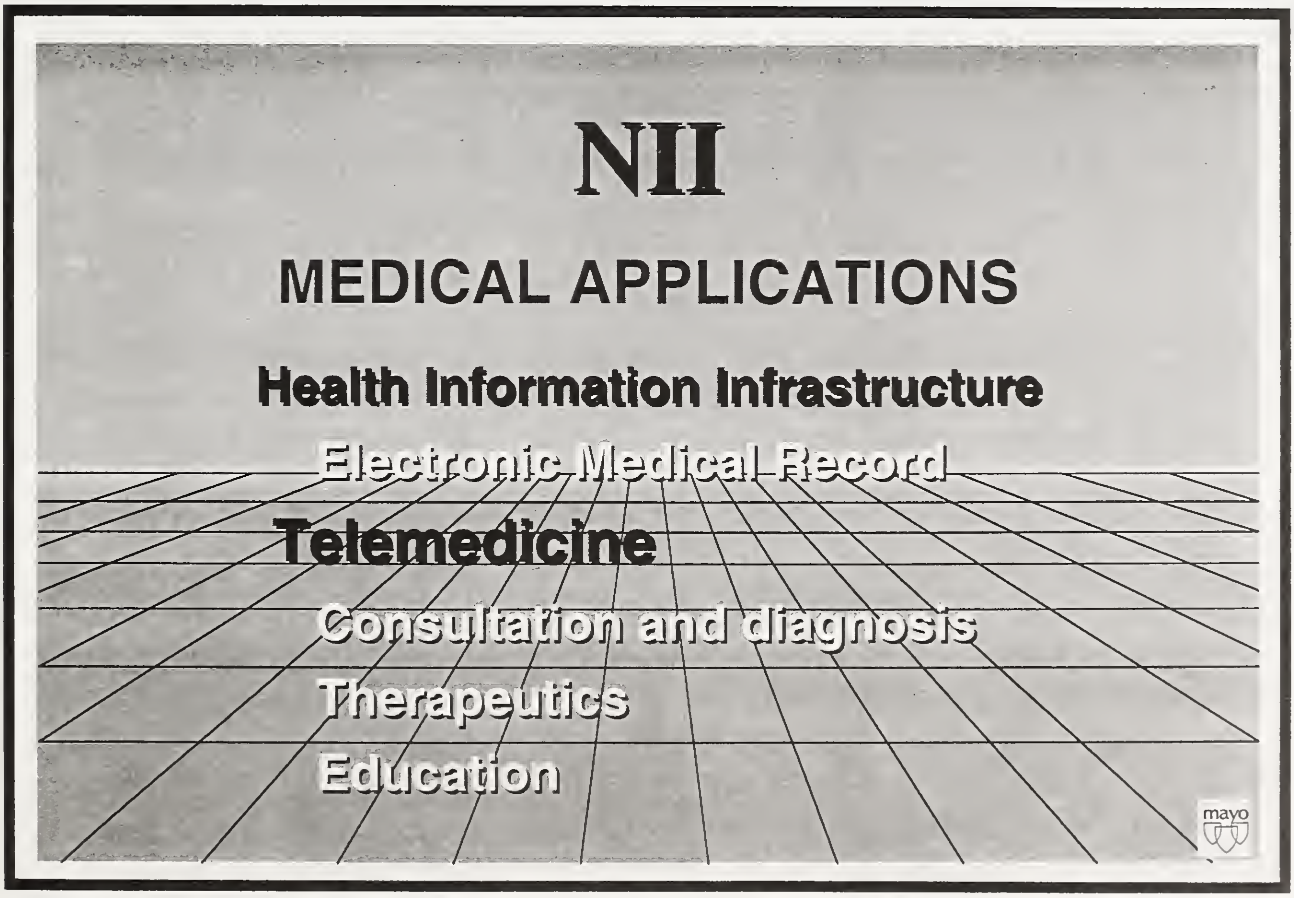
NETWORK PROVIDER ROLE

- INTRODUCTION OF DIGITAL BROADCASTING (ATV) (TERRESTRIAL AND SATELLITE) MAKES POSSIBLE WIDE-BAND SERVICE DELIVERY TO THE NON-WIRED RECEIVERS
- CABLE SYSTEMS WILL SHORTLY HAVE A LARGE CAPABILITY FOR DIGITAL DELIVERY
- THE LIMITED INTERACTIVITY REQUIRED FOR MANY POTENTIAL NII APPLICATIONS ALREADY EXISTS IN CABLE AND IS DEVELOPING FOR BROADCASTING SERVICES
- DIGITAL BROADCAST AND CABLE ARE KEY TECHNOLOGIES FOR THE IMPLEMENTATION OF THE NII AND ARE NEARING THE ROLL-OUT PHASE. INTEROPERABILITY WITH THEM AND OTHER ELEMENTS OF THE NII IS ESSENTIAL
- UNIVERSAL ACCESS TO THE NII FOR CONSUMERS CAN BEST BE ACHIEVED EFFICIENTLY THROUGH THE INCLUSION OF DIGITAL BROADCAST AND CABLE IN THE NII ENVIRONMENT

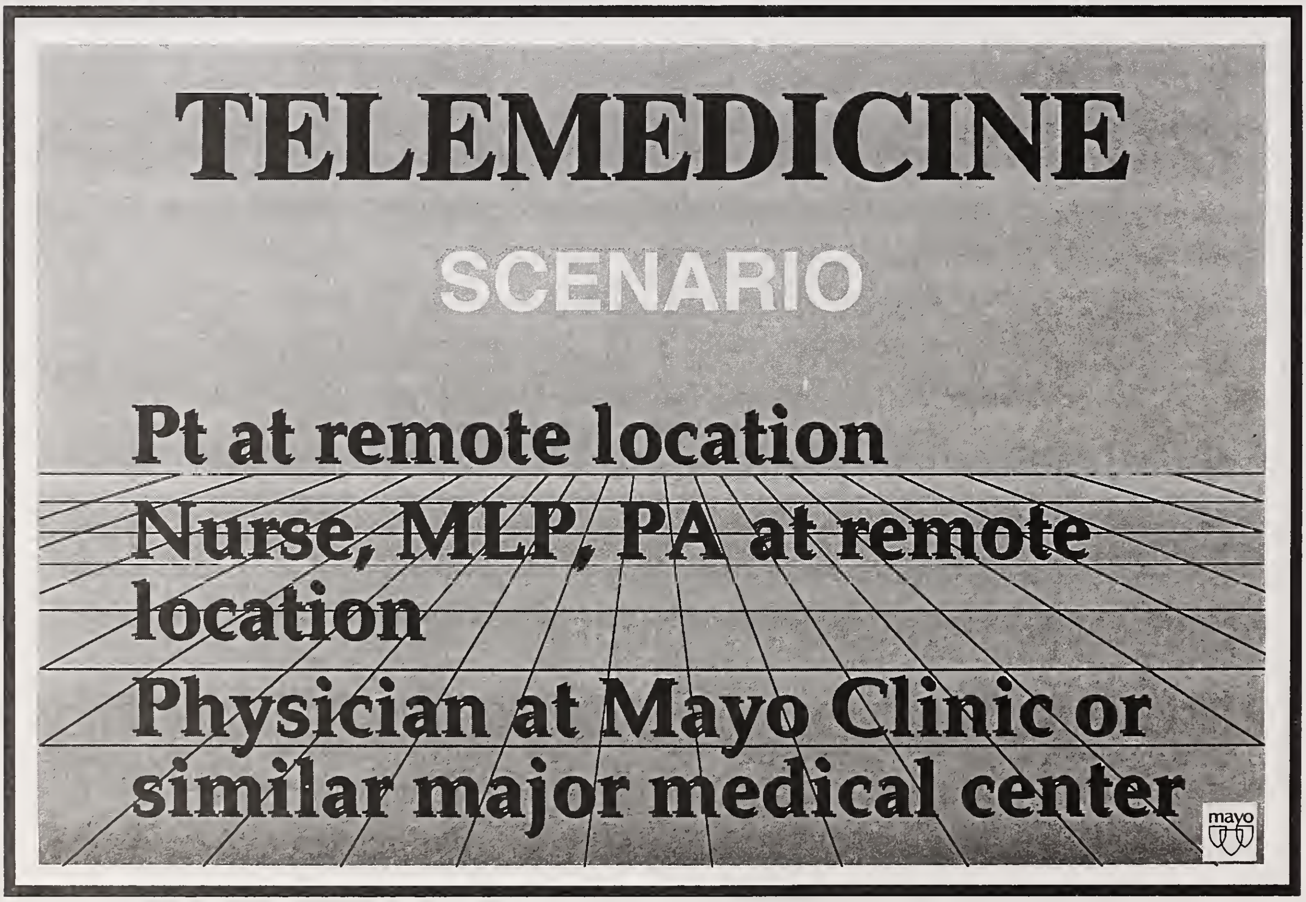
FUTURE WORK

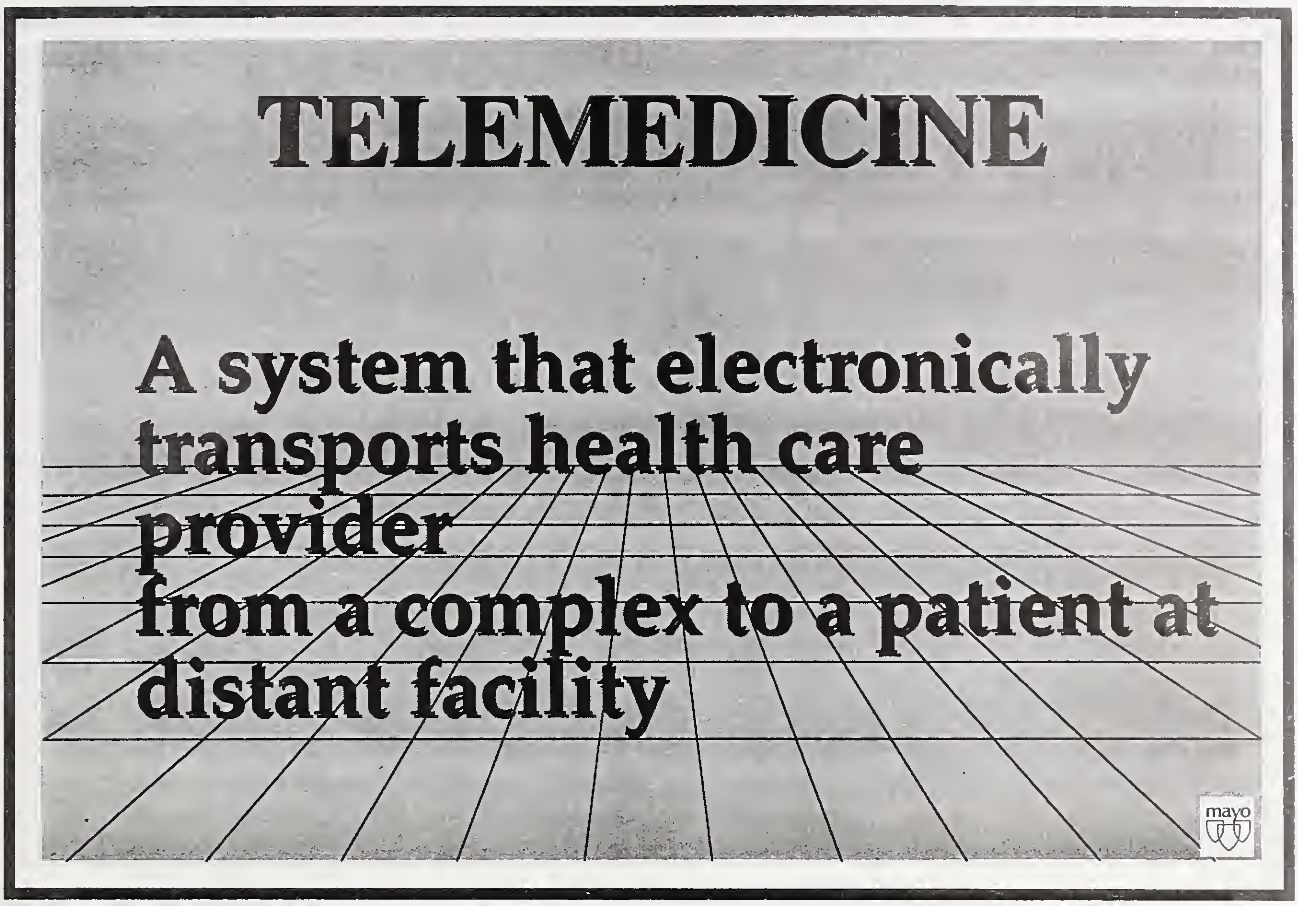
| | |
|---|---|
| TECHNOLOGY | • STANDARDS FOR INTERFACES |
| | • INTEROPERABILITY OF DIVERSE NETWORKS |
| | • COMMONALITY IN CONSUMER EQUIPMENT (APPLIANCES) |
| POLICY | • RECOGNITION OF BROADCASTING AS KEY NII ELEMENT<br>• INCLUDE BROADCASTING IN NII ENABLING ACTIONS |
| LEGAL | • PROTECT RIGHTS OF OWNERS OF IPR IN AN OPEN ELECTRONIC ENVIRONMENT |

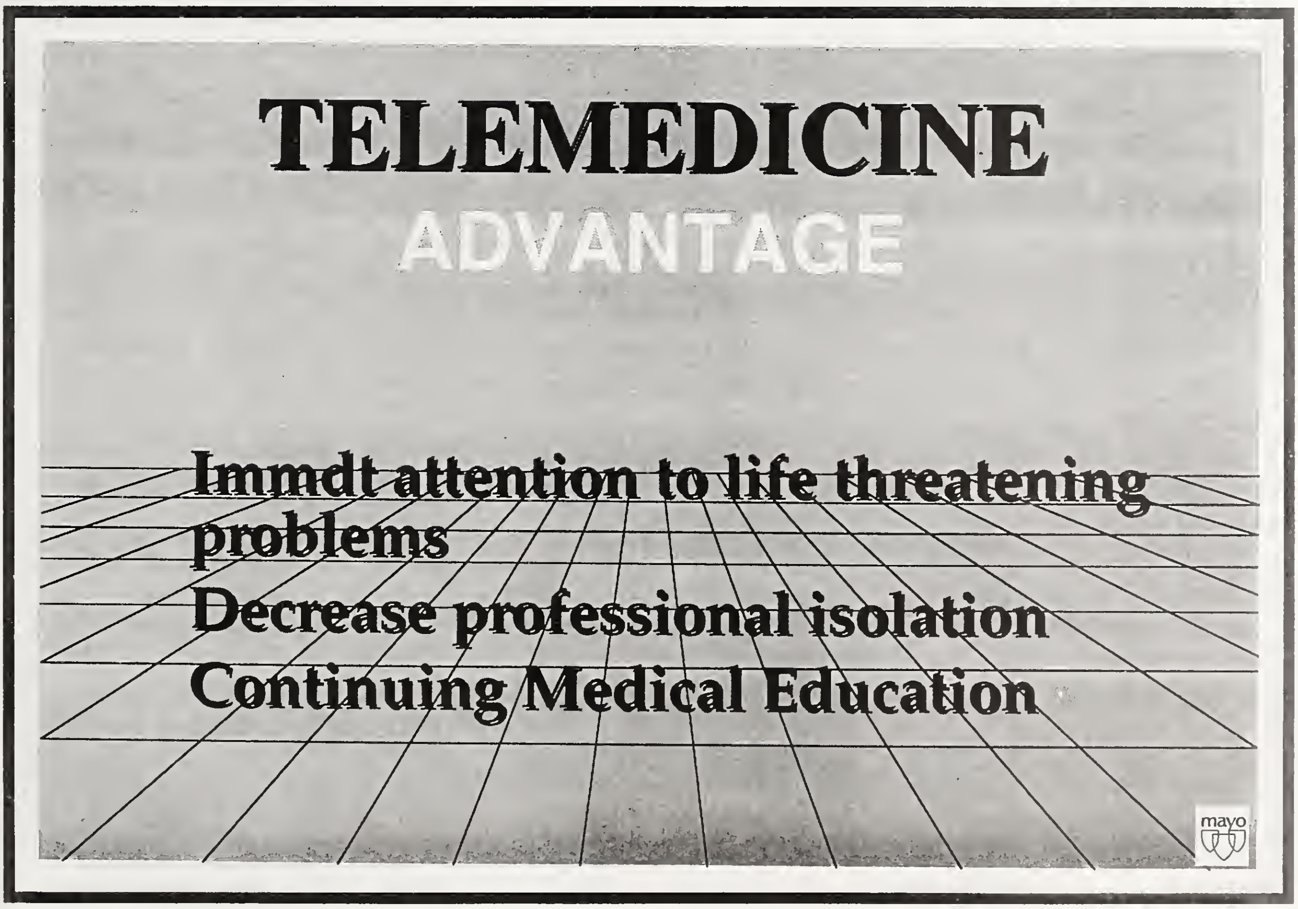

NII
MEDICAL APPLICATIONS
Are there any?
Bijoy Khandheria
Mayo Foundation

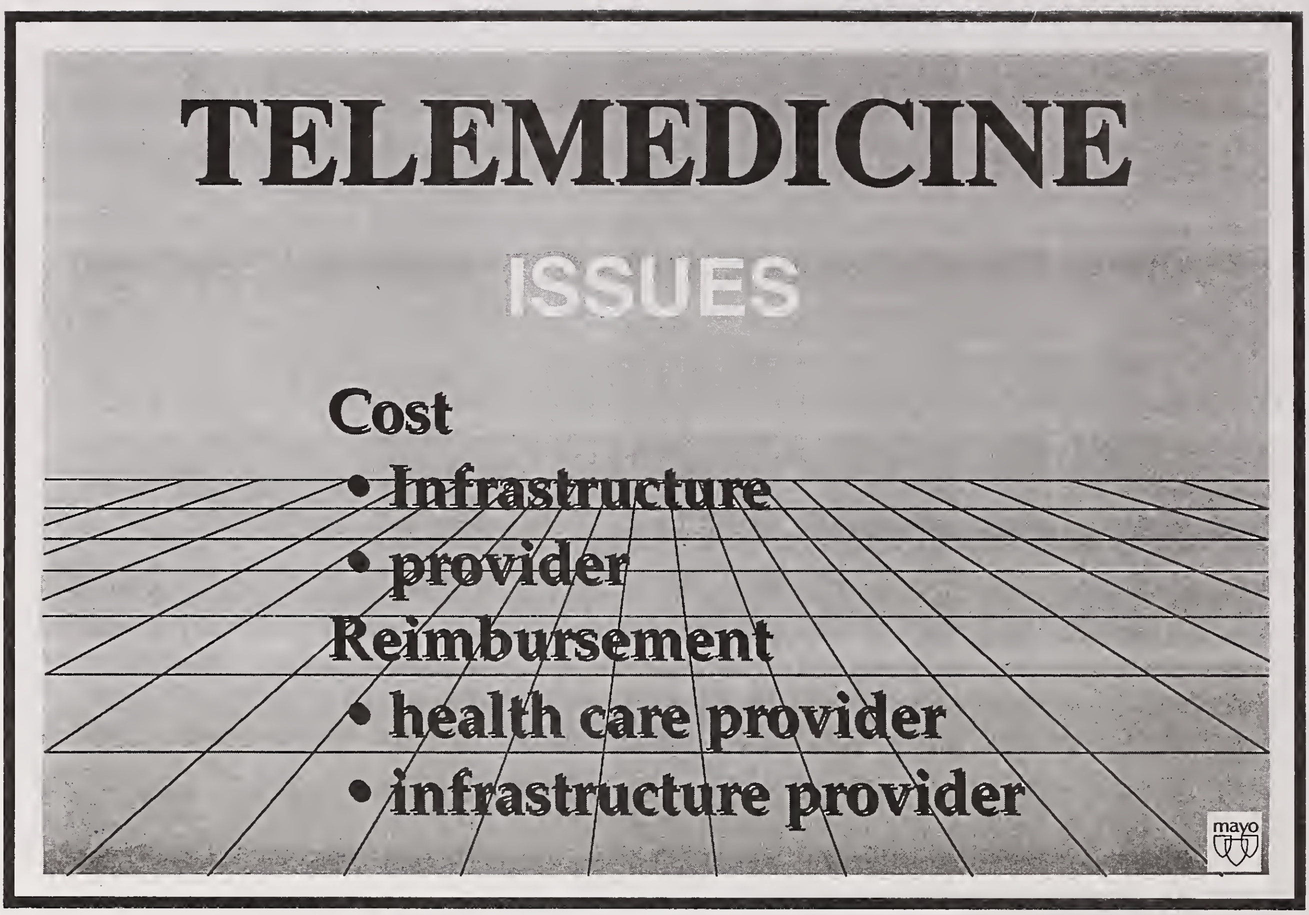

NII
MEDICAL APPLICATIONS
Health Information Infrastructure
Electronic Medical Record
Telemedicine
Consultation and diagnosis
Therapeutics
Education
mayo


NII
critical role of telemedicine
remote sites manned by health care providers such as nurses, primary care physicians, mid level practitioners
• increase access
• physician resource available
• major advantage to pt and community


TELEMEDICINE
SCENARIO
Pt at remote location
Nurse, MLP, PA at remote location
Physician at Mayo Clinic or similar major medical center


TELEMEDICINE
A system that electronically transports health care provider
from a complex to a patient at distant facility
mayo


TELEMEDICINE
ADVANTAGE
Immdt attention to life threatening problems
Decrease professional isolation
Continuing Medical Education
mayo


TELEMEDICINE
ISSUES
Cost
• Infrastructure
• provider
Reimbursement
• health care provider
• infrastructure provider
mayo


TELEMEDICINE
ISSUES
Feasibility
Acceptance
• patient, family members
• Health care providers
Technical issues
mayo

# EMR

## POTENTIAL BENEFITS

Time Saving
- House staff
- Attendings

Increase throughput
- Lack of Data

mayo

## ELECTRONIC MEDICAL RECORDS

## STRUCTURE

Integrated
- data from all sources located and available in a single unit

mayo

# HEALTH CARE

## INFORMATION TECHNOLOGY REQUIREMENTS

- Real or virtual digital data network
- Scalable communications infrastructure
- Portable, bidirectional, "personal communications/display system"
- Large, cost effective, multi-terrabyte data repository

mayo

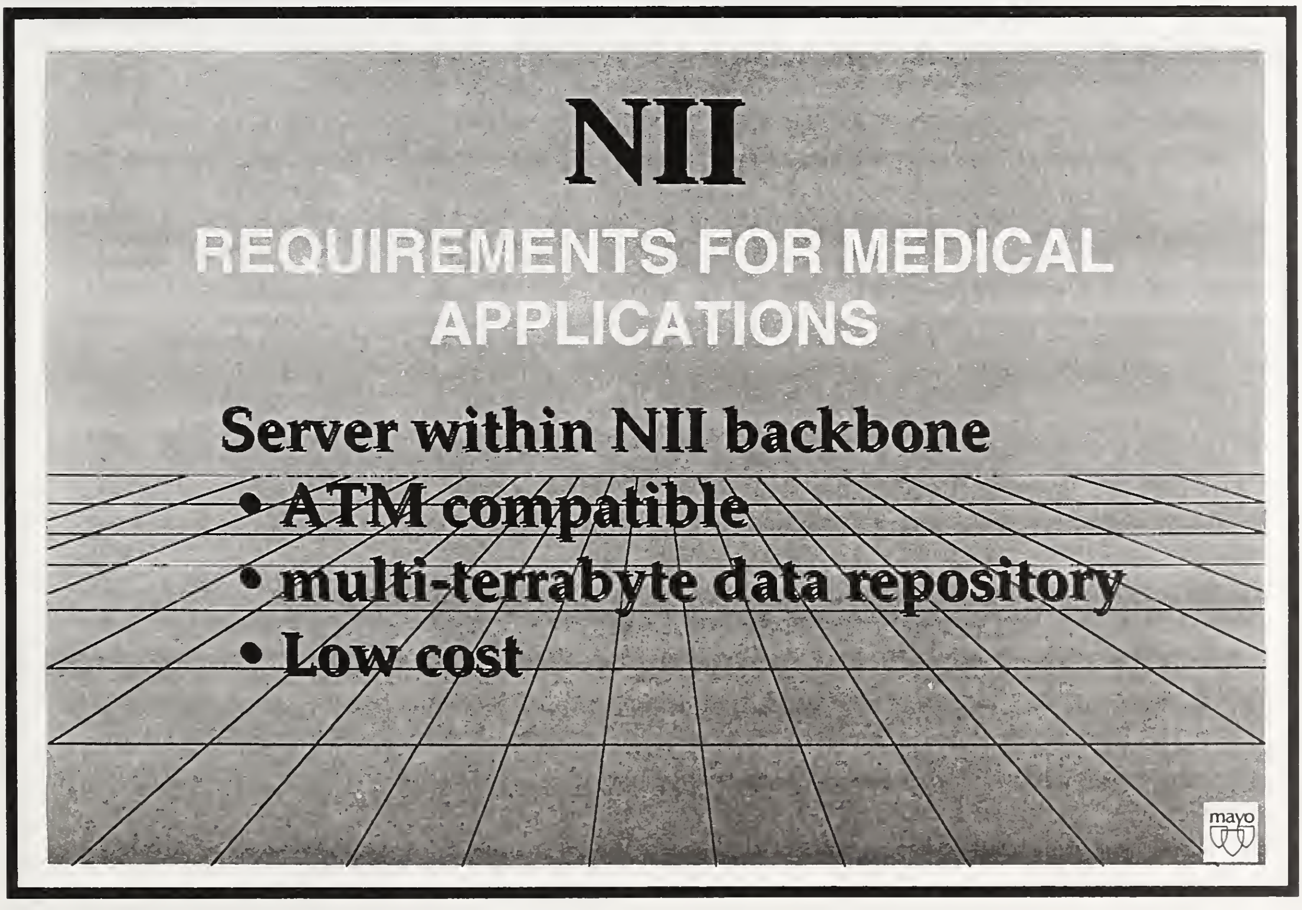
# HEALTH CARE

## INFORMATION TECHNOLOGY REQUIREMENTS

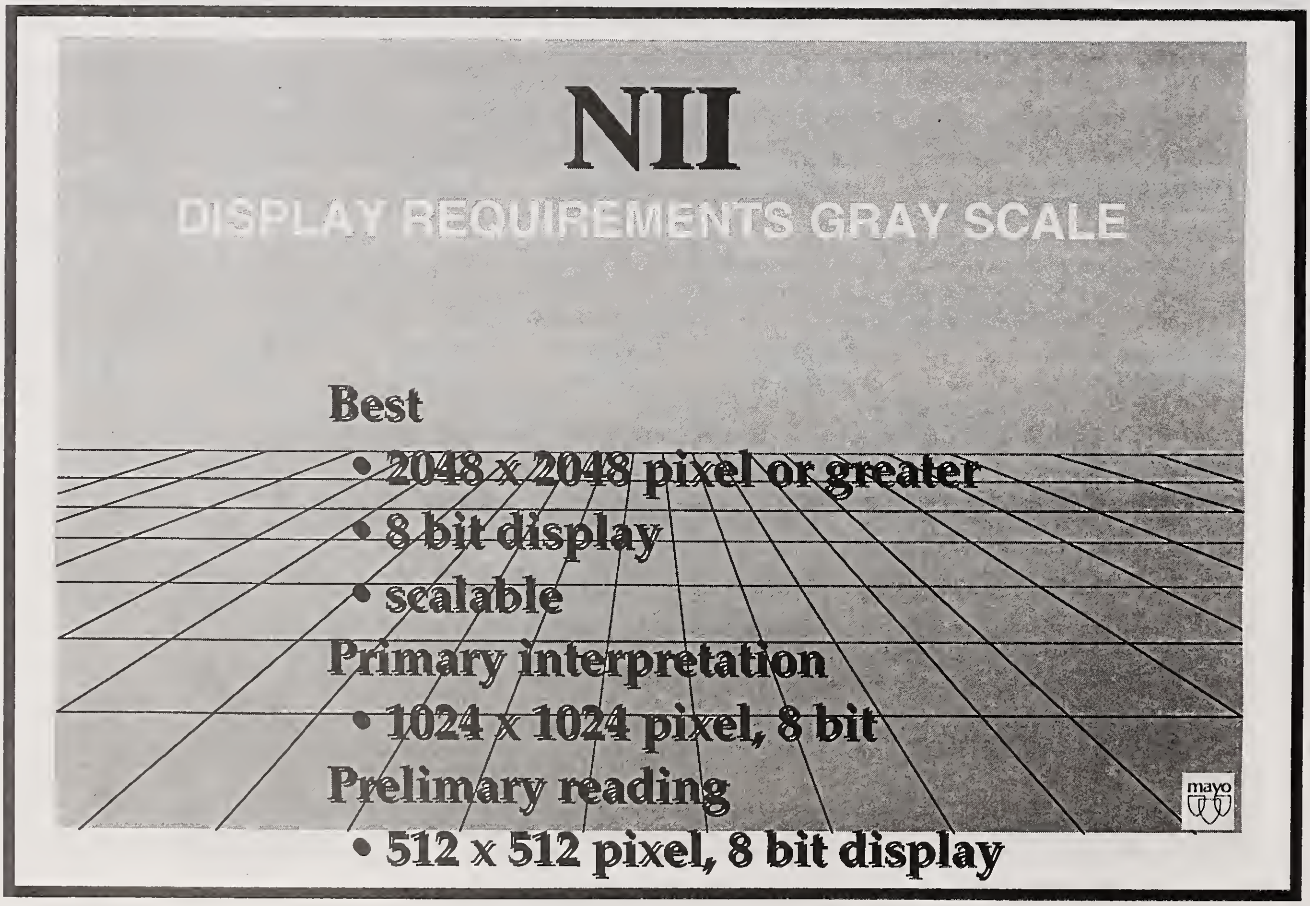
- Information preserving data compression algorithms optimized for medical imagery
- Gigabit/sec LAN
- Real time, on-premise key - based encryption/decryption
- Watchdog algorithms

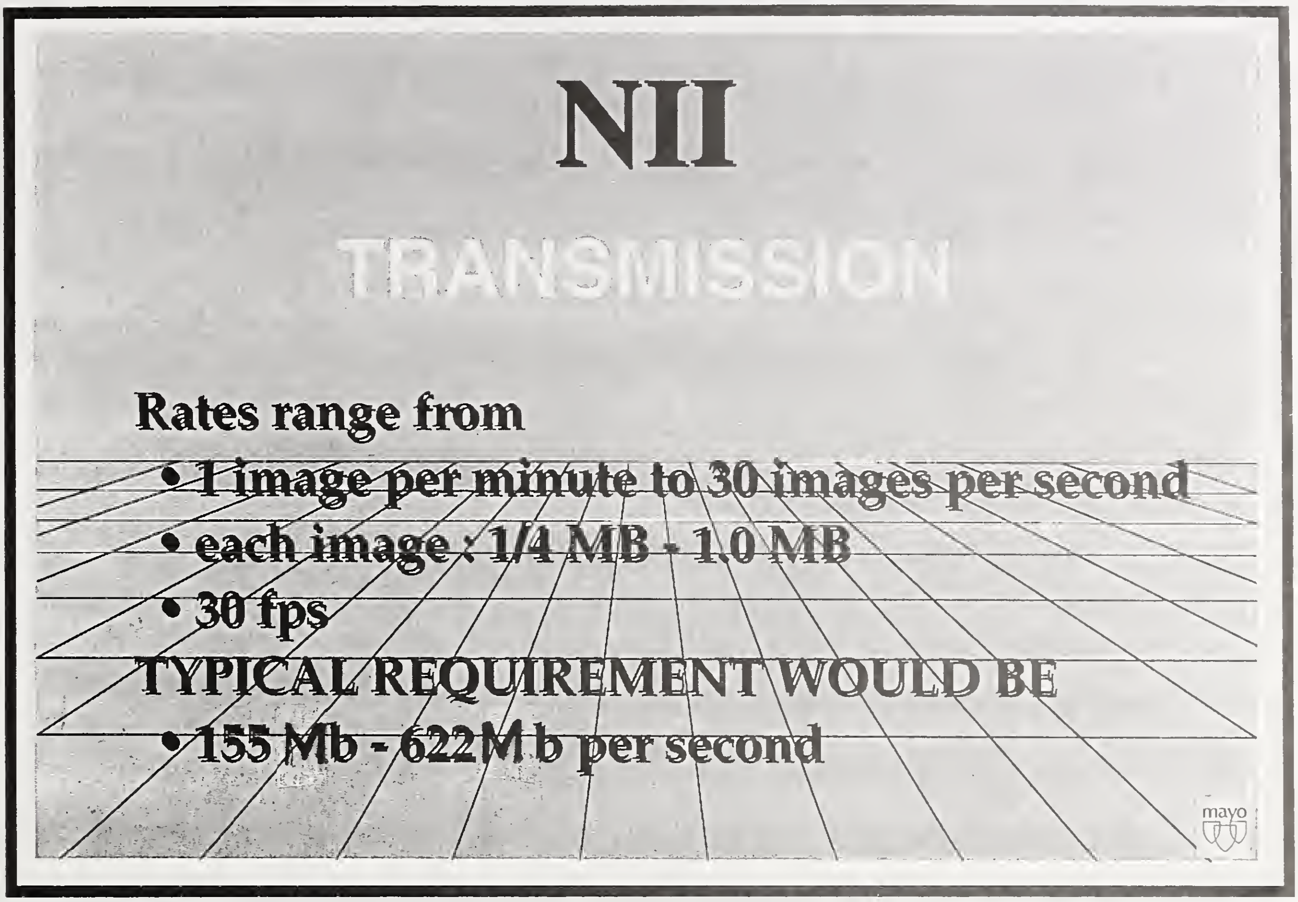
mayo


HEALTH CARE
INFORMATION TECHNOLOGY REQUIREMENTS
Standard Language
Interoperable
Open System
Secure system
mayo


NII
REQUIREMENTS FOR MEDICAL APPLICATIONS
Server within NII backbone
• ATM compatible
• multi-terrabyte data repository
• Low cost
mayo


NII
REQUIREMENT
matrix and spot size producing a resolution of
2.5 line pairs per mm
10 - 12 bits/pixel
S:N ratio 256:1
density range: 0-3.5 OD
• NOT APPLICABLE TO MAMMOGRAPHY
mayo

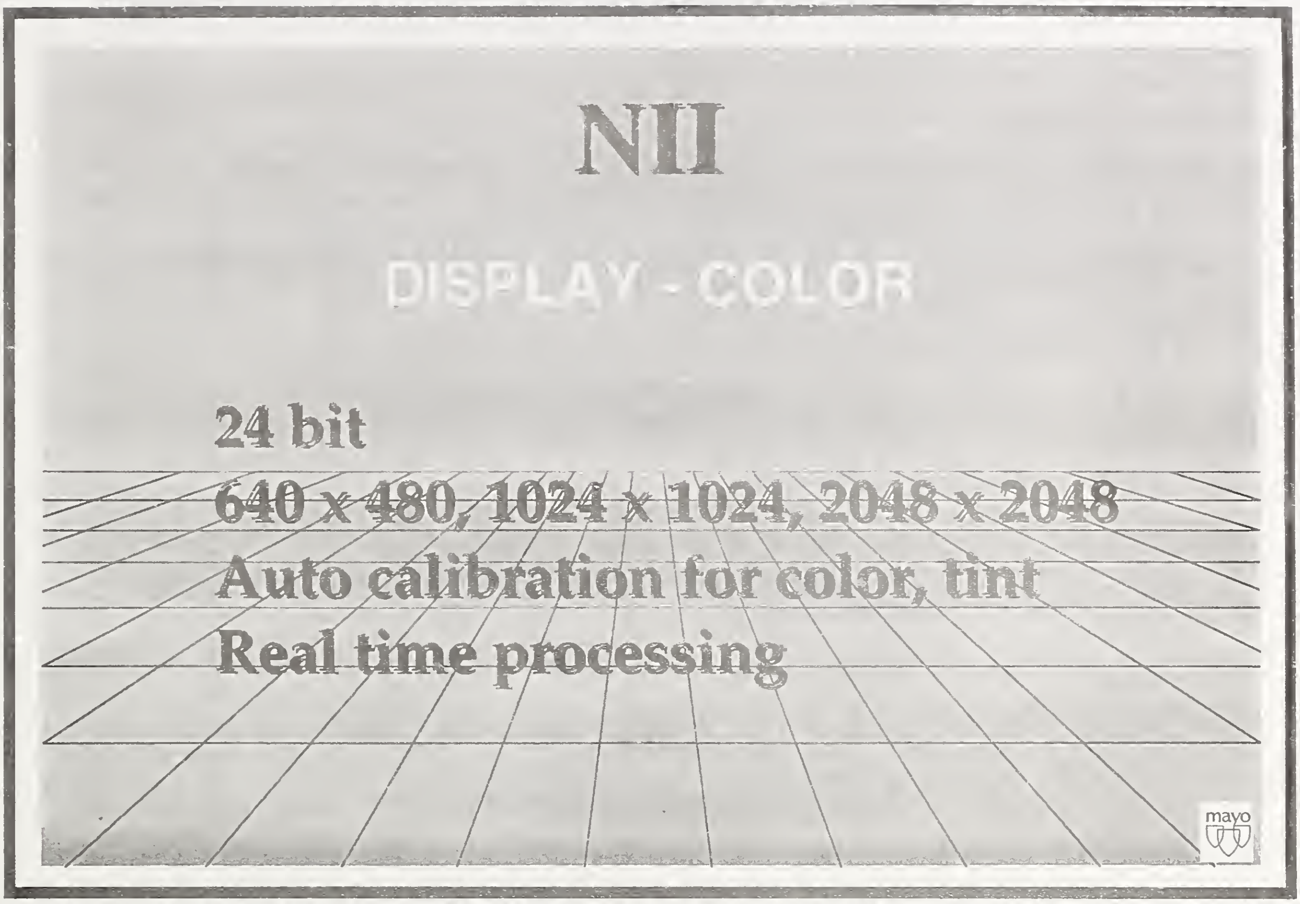

NII
DISPLAY REQUIREMENTS GRAY SCALE
Best
• 2048 x 2048 pixel or greater
• 8 bit display
• scalable
Primary interpretation
• 1024 x 1024 pixel, 8 bit
Prelimary reading
• 512 x 512 pixel, 8 bit display
mayo


NII
TRANSMISSION
Rates range from
• 1 image per minute to 30 images per second
• each image : 1/4 MB - 1.0 MB
• 30 fps
TYPICAL REQUIREMENT WOULD BE
• 155 Mb - 622M b per second
mayo

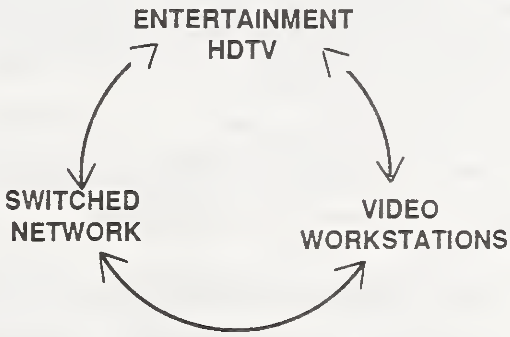

NII
REQUIREMENTS
poorest is analog video quality
ATV - is it better ???
• remains to be seen
mayo


NII
MINIMAL REQUIREMENTS
Audio, Video, Data
• simultaneously
Data amount range in terrabytes
Audio has to be stereo quality, in synch with video
Video - at least analog TV quality
mayo


NII
COMPRESSION
Lossless
• 1:1, 4:1
Lossy
• 10:1, 15:1 have been reported to be clinically useful
• remains to be tested
mayo

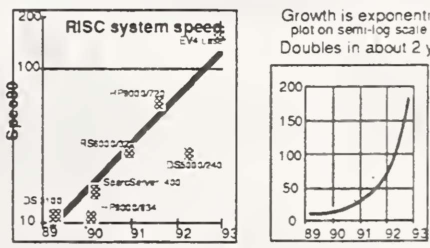

NII
DISPLAY - COLOR
24 bit
640 x 480, 1024 x 1024, 2048 x 2048
Auto calibration for color, tint
Real time processing
mayo

# Putting Advanced Digital Video on the Technology Curve




David Tennenhouse
*Telemedia, Networks, & Systems Group*
*Laboratory for Computer Science, MIT*
*(dlt@lcs.mit.edu,617-253-4719)*

# The Problem in a Nutshell




Computing, communications & video use the same technologies
- Processors, Memory, Fiber Optics, Displays

These technologies are moving fast
- Computing customers benefit quickly (price & **performance**)
- **Communications & video customers do** not

How do we get information infrastructure onto the curve?
-- **how do we keep it there?**

## Information Infrastructure -- Today

- **Examples –**
  - **— Radio, Television, Cable, Satellite, Telephone, Newspaper.**
- Each information supplier has its own distribution system.
  - – Similar to gas / water / electricity.
- Appliances are tailored to the medium.
- Markets are segmented by tightly coupled architectures.
- This structure doesn't make sense in a digital era.

**Are all bits created equal? digital magic!**

- To suppliers and users? — some bits are more valuable than others.
- To distributors? — **bits is bits!**

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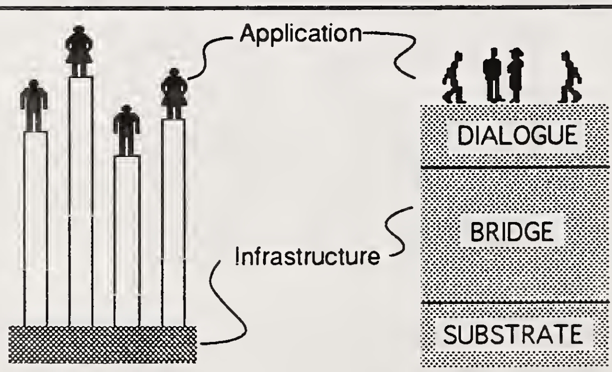
## What's Wrong with the Left Hand Picture?




TRADITIONAL "THIN" NETWORK INFRASTRUCTURE
Applications call for large development efforts and do not share much with each other

PROPOSED INFRASTRUCTURE
Applications involve less development effort and share services with each other at several levels

- **Driven by suppliers rather than consumers.**
- **Resembles mainframe-era computing.**

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## The End of the Mainframe Infrastructure Era

- **Information that is represented digitally is decoupled in space & time from the real world**
  => Digital information is easily re-packaged and stored.
  => We can easily convert from one representation to another.
- **The Technology Curve**
  => Cost of conversion is cheap & getting cheaper
    - **especially software-based conversion.**
- **NII Implications**
  => Information rides any and all available substrates
    - **decoupling of supply and distribution.**
    - competition at all levels & across all markets.
    - Lower barriers to entry (by innovative / small players).

## Architectural Guidelines

- **Inter-Operable**
  – ***Flexible / Loose coupling* amongst components.**
  – Focus on key interworking points.
  – Open Interfaces & Open Interconnect
- **Scalable & Extensible**
  – Infrastructure must ride the technology curve.
  – Plan for **continuous deployment & renewal.**
  – Heterogeneity / Migration is the steady state!
- **Simple**
  Do *the right thing* architecture-wise then optimize its engineering.

***Don't buy anything you can't afford to replace!***

## Implications for Advanced Digital Video

- Inter-Operable

  **Decouple programming, distribution and appliances.**
  **Decouple individual program media. (audio, video, etc.)**

- Scalable & Extensible

  Parameterized Standards – establish a clear evolutionary path.
  Agree specific parameter values to facilitate efficient markets.

- Simple

  Ride existing standards (MPEG, ATM, SNMP, etc.)
  Leverage power of digital converters (esp. software).

**Information that is represented digitally is decoupled in space & time from the real world**

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## Implications – Video as a Program Medium

- Inter-Operable

  **Decouple programming and distribution.**
  Digital video can ride any distribution channel.

  **Decouple media-dependent & media-independent functions.**
  Video must be independent of other program media (e.g. audio).
  Adopt media-independent composition standards.

  **Decouple media-dependent actions and representations.**
  Capture - Processing - Storage - Compression - Rendering

- Scalable & Extensible

  Continuum of **program** spatial and temporal resolutions.
  **Adapt to available resources & mode of interaction.**

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## *Implications – Headers & Descriptors*

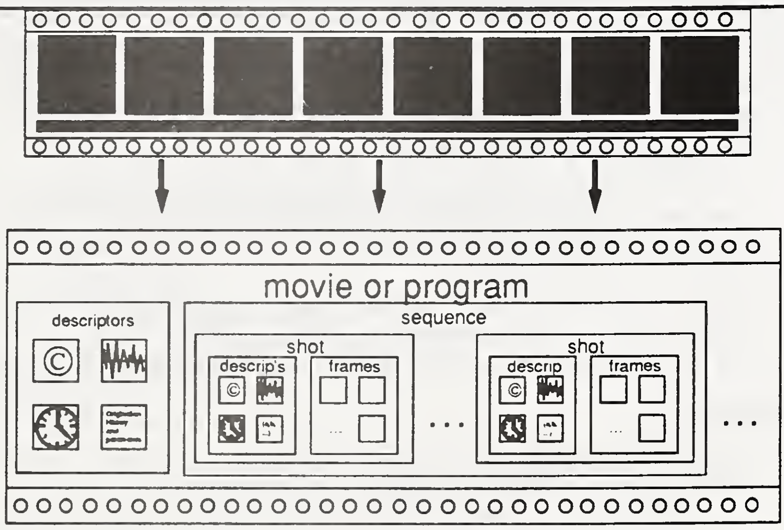


Diagram Credit – David Carver

DLT

## Implications – Television as a Distribution Medium

- Inter-Operable
  - Decouple programming and distribution.
  - **Digital broadcast channels will be application-neutral.**
    - (may become cellular / narrow-cast in the future).
- Scalable & Extensible
  - A range of channel modulation and FEC techniques may be in use.
  - Parameterized *staircase* of channel codes.
- Simple
  - Do *the right thing* then optimize its implementation.
    - (compressed / corrected ATM channel vs MPEG-2 transport kludge.)

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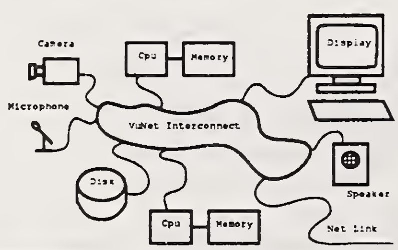
## Implications for Video Appliances

- Inter-Operable
  **Decouple programming and distribution.**
  – pave the way for an information-rich HII.
  – modular cameras, displays & storage devices.
  – adapters facilitate attachment to distribution channels.
- Scalable & Extensible
  Parameterized *staircase* of camera/display standards.
  Agree parameter sets to facilitate manufacturing.
  Foster multi-standard compatibility, e.g., multi-sync computer displays.
- Simple
  Dedicated / integrated appliances are possible.
  Software-based implementations are the end-game.

## *The ViewStation Research Program*



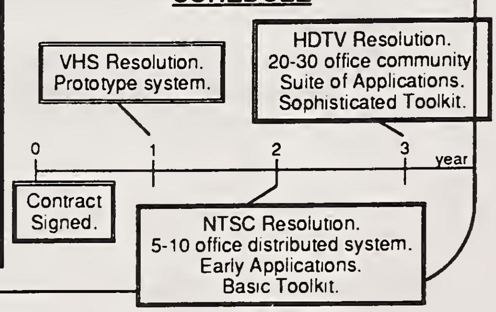

**NEW IDEAS**

- Establish video as a ubiquitous and extensible medium.
- Software-intensive approach to voice and video.
- Desk Area Networks (DAN).
- ATM-based DAN / LAN / WAN.

**IMPACT**

- Applications – Computer participation.
- Programming – Media-oriented. Model, conventions, tools, library.
- Operating Systems – Voice & video to the application, **not just the desktop.**
- Workstations – DAN standardizes attachment of cameras, displays, etc.

**SCHEDULE**



### *Video to the Application*

**Two waves of applications...**

- **Computer-mediated** (copying)
  Video conferences, video mail, video files.
- **Computer-participative** (processing)
  Image processing, recognition, databases, etc.
  Examples:
  white board, sentry, news clipper,
  joke browser, sports editor, etc.

**Implications...**

- temporal & spatial decoupling of components.
- leverage power of software-based converters.
- ride the technology curve!

## The NII - An Administrative Perspective

*Michael Nelson, White House Office of Science and Technology Policy*

What I thought I would do is to first give an overview of the administration's National Information Infrastructure (NII) initiative. Then I'll discuss the government's role, and I will end in a quick summary of the Adminstration's initiatives to make the information highway a reality. A survey found that only 32% of all Americans know what the information highway is. I know this group knows it, but it's always good to start by defining terms. I like to quote Ed Markey who is Chairman of the House Finance Telecommunications Subcommittee, a key player in telecommunications policy. He always likes to say that the good news is that 535 members of Congress are all wholeheartedly in support of the National Information Infrastructure. The bad news is they cannot agree on what it is. So let me give you a quick definition.

This is a working definition. The NII, according to Mike Nelson, is: "a system to deliver to all Americans the information they need when they want it and where they want it -- at an affordable price." This one sentence definition doesn't mention what technology will be used; it doesn't mention who will build it; it doesn't mention what kind of services will be provided. It simply focuses on the goal of getting information to people who want it.

In the end, when the NII is up and running, which we hope will be sooner, rather than later, everyone will be able to use a simple information appliance to exchange two-way video as easily as we exchange two-way voice today over the telephone. This is a simple goal, one I think that will be achievable, especially with all of you working on it, in just a few years.

Another goal is to have a fully competitive marketplace in which any company can provide any service to any customer. As all of you know today there are pages and pages of telecommunications regulations which often get in the way of the full implementation and deployment of the technology we're talking about. In the future, customers will have a lot more choice, many more services at much lower prices.

So what is this NII? There are basically four components. The information highway is worthless without the information and the services to make it useful. The first component of the NII is networks. There will not be a single monolithic network, but thousands of separate networks, all tied together in an interoperable, interconnected system. These include cable TV networks, phone networks, wireless telephones, satellite systems, etc. Basically, these are all the pieces that are there today, operating much faster and interconnected. The second component is the information appliances that hook into the NII to make it useful. The third item is really the information, the databases, that people will want to access. And the last are the people who make the infrastructure work. The administration is focusing on all four of these, because you cannot have an infrastructure without all four.

One of the models that we like to use with the NII is the Internet. The Vice President is a long supporter of using the Internet as a technological and a policy testbed where we can test out our thoughts about what the NII can be. This is a nice comparison that allows us to contrast the Internet today with what the NII will be tomorrow. Today, the Internet is a network of networks, over 30,000 networks all interoperable, all connected together. Today, it involves mostly text and computers. The NII of the future will be structured in much the same way. Thousands of different companies, thousands of different networks, all interconnected together, but instead of just text, it will be full multi-media, voice, text, music, video. And it won't just be computers. It will be whatever information appliance you want to hook into it, such as computers, TVs, phones, faxes, radio.

So how do we get from where we are today to where we're going? There are lots of things we need, but there are four that are most important. The first one is interoperability. Now I think you're going to talk about that this afternoon. If we are going to hook in computers, telephones, faxes, and TVs to the same system, we're going to have to develop standards to make them interoperate. That has been the secret of the Internet, a single standard that allows everybody to build their applications on top of it. Which is not easy for two reasons. First, it's not easy politically to get industries that are as disparate as the cable industry and the computer networking industry to come together on a common set of standards. That is not easy technologically, as all of you know, particularly when you start trying to tie in satellite systems with phone systems. Different technologies were developed for different niches, which now have to be made compatible.

The second thing we need is bandwidth to provide the video in the future as easily as we move voice today. We're going to need a factor of a hundred or a thousand increase in the bandwidth, particularly for that last mile into the home or office. Doing that will require massive private sector investment because the private sector, not the public sector is going to build this information highway. We probably should use the information railroad instead of the information highway for our NII metaphor. The Feds pay for the highways but the private sector pays for the railroads. As with the railroads, a lot of people make a lot of money. Hopefully, we'll do it without quite as many monopolies.

And we also need applications to make it all run. You need killer applications as well as niche applications that will make information available to the Americans that want to use the NII. Why is it that we care about this?

Why is it that President Clinton and Vice President Al Gore went campaigning around the country talking about information highways? A simple reason - we think it's going to dramatically improve the quality of life of all Americans. I think you have already talked about many of the applications: education, digital libraries, manufacturing, entertainment, video on demand, healthcare, home shopping, government services. The list is quite a long one. These are the ones that are always mentioned at meetings like this. We really think that this technology is fundamental to solving many of the big problems we face in these different areas, particularly in the area of education and the area of health care. In the area of health care the most conservative estimate is that we could save $36 billion a year if we properly deployed the technology that will make up the NII. It may be that in other areas there will be similar cost savings to make American companies more efficient and improve the quality of life for all of us.

It's interesting, I meet frequently with foreign visitors. This afternoon it's with the Japanese, again. They still don't believe that we don't have a master plan for the NII. We give them a 30 page handout instead. It's interesting, they often say that they wish they had an Al Gore to champion it. The fact that we have made this a top priority of our administration, and the fact that we did it early on, has meant that the momentum is here, industry and government and Congress are all moving together to make this happen. We actually announced our policy in this area just about one month after we got in office, so this is one of the first initiatives out of the box when we came in to the White House.

In a very important technology paper that the Vice President and the President released on February 22, 1993 in Silicon Valley, at Silicon Graphics, we laid out 5 different roles for the government. First is in the area of R&D, which many of you have been involved in for a long time. Second, is in the area of demonstration projects. Let's take this technology and use Federal funding to show how it can work. In the third role, the government can serve as a customer to use this technology to provide better government services. The fourth and fifth items are combined. We need to put in place telecommunications policies and information policies that will promote the deployment and use of this technology. We don't want to continue to have regulatory barriers that stand in the way of this digital nirvana that we're trying to build.

Let me quickly summarize what we're doing in each of these areas. First, in the area of R&D, the Federal government is now spending about $1 billion on a High-Performance Computing and Communications Program. This is the program that is working with industry to develop technology for the infrastructure that will be built in the 21st century. This is long-term research; much of it is generic research and in many cases the profits won't come in for 5 or 10 years. So without a profit motive, we need the Federal government to work with industry to develop new supercomputers and networking technology to keep the US in the lead technologically.

One of the reasons we're able to move so quickly and the US has the lead in NII technology, is because of massive Federal investments over the last 30 or 40 years - particularly at DoD and ARPA. This helps keep American industry and American universities at the leading edge.

In another area, demonstration projects, there's a program that we've set up at the National Telecommunications and Information Administration of the Department of Commerce. They have a long name for it, but I like to call it the Information Highway On-Ramp Program. This year its a $26 million program. We're requesting $100 million for this program for the coming year. It will help schools, libraries, hospitals, and other non-profit institutions get on-line to discover what the Internet is, by supporting the purchase of servers, computers, and modems. In many cases the matching grants will be small, $5,000 - $10,000 dollars. We hope to get every school in the country on-line in 3 or 4 years. We want to get the excitement of exposing every student to the thrill of sending E-mail to Australia. We want to give every school librarian the opportunity to log into digital libraries and servers all around the country, and around the world.

That's one of many demonstration projects. The Department of Education is spending about $50 million a year doing similar things. The Department of Energy and NASA are also funding some exciting networking projects.

The third area I mentioned is government services. As we all know, the Federal government is not particularly good at using information technology. When the President and Vice President got to the White House on January 20th, last year, they were astonished to discover that in the basement there was a switchboard. At the switchboard were sitting operators with headsets, picking up cords and plugging them into little holes in the board to connect the calls. Needless to say, that was not working very well, because we were getting 100,000 phone calls a day and 95% of those people were getting busy signals. We quickly went to fixed that. We're also trying to upgrade our computers. We were astonished to discover 4 and 5 year old computers when we got there.

The computers have now been upgraded at the White House. We're still working on some of the other agencies which are struggling with 10 and 15 year old computer systems. We are very committed to moving forward, using these technologies to make the government run better, run cheaper and to make the government more user friendly. There are a number of different activities under way. We have a top notch committee working on this, and we have a number of initiatives under way to make the US government at least as good at using computer technology as a medium-sized insurance company of the 1970s.

That leaves us with the last two items which are perhaps the most daunting and the most difficult, these are telecommunications policy and information policy. Both of these areas that have been in the paper a lot. As you know, the administration is working with Congress on the largest rewrite of the Telecommunications Act since 1934, when it was first enacted. There are a huge number of issues, but at the bottom line, there is a very simple need. We have got to get rid of these outdated regulations that are standing in the way of a fully competitive marketplace. Regulations are standing in the way of investments in new technologies.

Today, in many states, it is not only illegal but it is unconstitutional under state law, to compete with the phone company for providing local phone service. That, can no longer be the case. We have new technologies that can allow cable companies to provide phone service and there are all sorts of new wireless technologies. We want to have a competitive marketplace.

We envision a world where everybody is a "bit" company. They're not a cable company, they're not a phone company, they're not a cellular company. They are a "bit" company, delivering all kinds of digital services. In that world, it will make no sense to have regulations for the cable industry and for the phone industry. It'll make sense to have regulations for the "bit" industry.

Many of the regulations in place today were put there because we had monopoly providers. We had to regulate monopolies to protect the customer. In the future, we hope to replace regulation with competition. We are already seeing that in the many different states: in New York City for instance, you have a choice of 6 or 7 different telecommunications providers for your phone service and your data network service. State regulators have encouraged that kind of competition and have made it work. As a result, customers in Manhattan have cheaper rates, a bigger choice of services, and better quality service. We would like to see that happen throughout the country. We have already done it for long distance back in '84. Today, AT&T controls only about 2/3 of the market, rather than 100% of the market. But, they are still making more money than they ever did, and we all enjoy are cheaper prices, a higher demand, and better service, because of competition. We're looking to put in place policies that remove regulatory barriers, that anticipate technology, allow people to develop new services in all locations, and encourage the marketplace to provide them. In the area of information policy, there are a number of very difficult issues that I probably spend most of my time on. I think its fair to say that if we pass the legislation on the Hill this year, we will be well on the way to promoting the development of an information infrastructure that will serve all of us much better than the one we have now. On the other hand, there are some very thorny information policy issues that stand in the way of the full utilization of that network, particularly in the area of privacy and electronic copyright. I've been very involved in the Clipper Chip initiative. It is one attempt to deal with a very difficult issue to protect peoples' privacy in this electronic world. It is the same thing with copyright. If we're going to have this wonderful network of networks, with millions of different providers of information, we're going to have to have ways to protect the copyrights of the copyright holders.

I have laid out quite an agenda, and at times it seems kind of daunting. Luckily we have people at ARPA , NIST, and other key agencies to help us. To coordinate the effort, we've created an Information Infrastructure Task Force, the IITF. Most of you've probably heard of this. Ron Brown, the Secretary of the Commerce, chairs it. It reports to the White House through OSTP and the National Economic Counsel. This group has pulled together all the key players. Commerce plays a very important role both in technology and telecommunications. Justice is involved, so is Defense, OMB, and several research agencies. The key thing is that we have pulled together all the right people. In the past there has either been no telecommunications policy, or there have been four or five. We have attempted to hash out differences, formulate a single telecommunications policy, and then work with the Congress to implement it.

The Task Force is broken up into three different committees. The first one is for Telecommunications Policy. They are working on the legislation that's going through the Hill right now. They have added universal services and international issues working groups underneath and they have recently added another working group on network reliability and vulnerability so that we can look at the very important question of how to make sure the networks stay up and running.

The second committee is on Information Policy. Sally Katzen from the Office of Management and Budget chairs it. They are grappling with the issues of privacy, intellectual property rights and government information policy. How do we make government information more available?

The last committee in which many of the people in this room are very involved with, is the Applications and Technology committee, chaired by Arati Prakhabar, the head of NIST. They are looking at information technology for government services. That is what the GITS group does.

Another group, headed by Duane Adams from ARPA, is working on technology policy, and addressing standards. They are looking at Federal programs to develop ways to make sure this technology moves out to the private sector as quickly as possible. These are the technical gurus who are plugged into the process, making sure that the legislation working through the Hill makes sense not only for today, but for technologies that will be developed in 4 or 5 years. They have the difficult task of working with industry, to work on digital video standards to see if we can develop new ways to improve interoperability between networks. They will work on questions about the evolution of the Internet. There are a very wide range of issues being addressed-- all of them very technical and very difficult. I think that we have the right people involved and they are moving ahead very, very sharply.

Another working group that's been added is on healthcare, which is a big priority with this administration. They are working on applications in the area of telemedicine and information services for healthcare. There are many areas here that require a multi-agency approach. They are getting people at ARPA, HHS, and other areas working together to develop the new technologies needed for healthcare.

The IITF is just a government body of agency representatives. We are really the less important player here in many ways because the private sector is going to be the one that makes this all happen. We have created an Advisory Council, consisting of representatives from industry, public interest groups, state and local government, to provide input to the IITF on the big issues, to identify places where we may not be paying enough attention and places where our policies might not make sense. This group started out with 25 people, quickly became 27, is now 30, and we are about to make it 34, I think. That is an indication of how much interest there is and how many different people and interests have to be represented.

In addition to the formal Advisory Council, we are also working very closely with groups like the Cross-Industry Working Team headed by Bob Kahn, who spoke to you this morning. That group is working on many of the important issues that will make the interoperable network happen. They are also working on key application areas, like healthcare, and manufacturing, electronic commerce and helping identify for us the regulatory barriers that stand in the way of full implementation of the NII vision.

We're also working with groups like the Council on Competitiveness, the EIA, the AEA, the IEEE, and other industry groups that have a key role to play. The door is open. This is probably the reason why I'm working too hard and why there are no conference rooms ever available at the White House. We are constantly talking to people because we want to hear what is going on in industry and where we can be of help or where we can stop being a hindrance. There are lots of ways we can work together.

I would just like to finish by saying that I'm very grateful that a number of groups have worked together to organize this conference. I'm grateful to all of you for being here. I'm hoping to be able to stay here as long as my beeper permits me and hear a little bit of the afternoon session. You are really dealing with some of the critical technological issues that will make the NII happen. If we're going to have a fully competitive marketplace; if we're going to have a world in which you can use your TV or your computer or some other device to get information, we're going to need to have interoperable standards. We're going to have to have the technology that allows us to put digital video over the Internet or over a cable television network or over a wireless system. There are a lot of technological challenges here. It's easy to do one thing, to demonstrate a technology. It is harder to put it into the marketplace and it is even harder to make it compatible with systems that are already there. I know that is never easy.

One other thing I should mention is that the Committee on Applications and Technology is working on ways to use digital video in healthcare, manufacturing, environmental monitoring, libraries and the like. That group is also looking to work with the entertainment industry and the TV networks. As we move forward, we would like to link with those industries more effectively. We are very well linked with the research and the healthcare communities. We have not done as well as we could in talking to the entertainment community and are working with them to determine how we can move forward and roll this technology out more effectively. I think at this point, I'll be happy to take questions.

## QUESTIONS

*Q:* I would like to take this opportunity to ask a question that I've asked a lot of colleagues who weren't quite knowledgeable enough to give me the answer. I use the Internet to talk to my business colleagues, to talk to my kids in college and I loved your statement of going forward with the NII like the railroads and not the highway system. But who is paying? I feel like I am cheating Ma Bell every time I talk to my kids over the Internet, and I am wondering, who is paying?

*A:* That's really funny because the head of the National Economic Counsel, Bob Rubin, recently got a demonstration of Mosaic, which many of you are familiar with. It is a wonderful multi-media interface for accessing databases on the Internet and that was his first question. He is not a technologist. His first question was, "Who pays for this? How is it done?" The Internet is really funded by thousands of different people. Mostly by the different institutions that are using the system. A given university may pay 1/4 of a million dollars to hook its network, onto a regional network that links them to 10 other colleges, and then all of them chip in, so that regional network gets hooked up to a national network that will link them to the rest of the world. So, it's this kind of an anarchic process where it is never quite clear where the money's flowing.

You're not cheating Ma Bell. The carriers have recently announced that they're going to provide Internet services. Many companies now will be able to buy service from them to allow them to hook into this system. The answer is you are actually taking advantage of investments that were made by thousands of different entities. In most cases you're paying the freight for the connection into that system. It all works out. The amazing thing is that it's so cheap. I can sit at my home, and for $20 or $25 a month, I can access literally millions of different sites all around the world for 1 - 5 percent of the cost of making a phone call to them. That's what's driving this technology. That's why the Internet is growing still at 7 to 10% per month and why these new databases are growing even faster. The World-Wide Web which is a new technology for digital libraries, at last count was growing at a pace of 320,000 percent per year. Of course, that probably means they started with two last year, and now they have 3,000. Everyday there are new users and new applications.

*Q:* Bill Schreiber, MIT. My question is, don't these things worry you a little bit? I'm going to mention 3 or 4 things. Yesterday, in a publication called Digital Media there was an article which said that the government is seriously considering a national identity card. I communicated with the author, over the Internet, and he assured me that this is no joke. He has actually heard of the officials named in the publication. That's one thing, another is the Clipper Chip which you've already mentioned, and the final one is the possibility that the NII eventually will encompass the equivalent of today's video telephone and Internet service. Now, we once had a President in Washington who had an enemy's list. He used various agencies of the federal government to do as much damage to his enemies as possible. Fortunately, the system didn't allow him to do too much, because it was very inefficient, very sloppy. Now, they are talking about a system which is going to be far from sloppy, and my question is, don't you worry about this sort of thing?

*A:* I do worry a great deal about privacy along with electronic copying in this digital world. These are fundamental issues which could be showstoppers. If we do not address these issues properly, nobody's going to want to use the system. In the future, we are going to have an information society where everybody is on-line and half of the conversations you have will be done face-to-face, in video. You will be talking to your pastor, lawyer, doctor, your psychiatrist, and other people that you might today see in person, you will see in video in the future. Those conversations have to be just as private as they would be if you went to their office today. It has to be that private. If we cannot assure people of that kind of privacy, they are not going to use the system. Certainly, they are not going to use it for all the things that it might be used for.

*Q:* People may be forced to use the system because there's no other way and then find they have very little control over privacy.

*A:* These are the very issues we're looking at. We just recently put out a list of fair privacy practices. This is the first update of the privacy practices in about 15 years. Sally Katzen, who's the head of the Information Policy Committee and the head of the Office of Information and Regulatory Affairs, put out the document for public comment. It makes it very clear that our priority here is to protect privacy. We have to have privacy.

On the Clipper Chip issue, the dilemma is that we now have encryption technology that can protect privacy very well. We want to use encryption technology widely and we are making new and better versions of encryption available. The down side is that same technology can be used by terrorists, drug dealers, and corrupt officials to do some pretty nasty things. We have developed a system which is designed to give Americans better privacy while at the same time, preserving our present ability to do wiretaps. We are not in any way reducing any of the safeguards that are in place today. All of the present safeguards against unauthorized wiretaps will remain in place. We are working with industry to find very innovative solutions. The goal is a very simple one; maintain the present privacy safeguards and maintain our ability to do wiretapping when it is necessary. Congress has decided that wiretaps should be authorized when they are the most effective tool for fighting crime. We have eliminated organized crime from many of our major cities because of wiretaps and we wouldn't like to lose that tool. This is the toughest issue I work on and if anybody has a good idea on a way to handle this in the future, come and talk to me. We are not just talking about telephones, which is what Clipper is designed for, but we're talking about two-way video as well. On the Digital Media article, I don't know what the author has been reading or to whom he has been talking to. I have had several calls on that article, have read it and find no validity.

*Q:* Speaking as a potential NII consumer, my concern really goes back to who pays for the service. It does not matter to me as a consumer, whether its funded by the Feds or by private industry, I still end up paying for it. My concern is that we have got things in place that sound great. We have generic bit carrying companies and a whole plethora of service providers. That sounds good, except that it seems to me, the single most expensive part is the last mile infrastructure which is probably going to end up with both my telecom company and my cable company providing it. This may be competition, but it sure is paying twice for the most expensive part of the system.

*A:* I don't think that's quite the case. I would much rather pay twice to two different companies than to pay three times the market rate to one company who happens to have a monopoly. We would like to see a world in which there are two or three different ways into your home. There is wireless, satellite, fiber, and the telephone wires that are there today. Each of those different technologies provide you with different services and fill a need. I think that's the world we would like to see.

These services are all providing bits at different rates with different quality of service, different levels of reliability, and different prices. Many people will say that "I'm a technophobe, the telephone is all I ever want." That is okay for them and the copper wire that is there today will do just fine. For other people, that want something better, they will want fiber to the curb or fiber to the home. They will have everything that we talk about today. The technologies that are out there allow competition in local loop now. In the UK we are now seeing competition between the cable companies and the phone companies. I think it's going to be an interesting five years and it's going to be pretty nerve-wracking one for many of the former monopolies that are used to guaranteed profit margins. I think that multiple access to the home provides competition and is the most effective way to get the infrastructure built. It has been proven in many other industries.

*Q:* My name is Will Stackhouse. This is just a comment and not really a question. When it comes to the question about the Internet, I'm just going to throw this out for what it is worth. The Internet is not a single entity. According to the Internet, it is a collection of over 30,000 separate, disparate networks scattered around the world that are all interconnected. It is an interconnection of networks and not a single entity. Over half of those networks are outside of the jurisdictional boundaries of the United States. The United States is not funding the Internet. The second thing is that the lines that provide all the interconnectivity are leased back and private services are paying for the lines. The Internet no longer resides in the United States alone and the economics of that are very important. The other thing that is important is the fact that with it you can go anywhere. I like Mike's comment about information to anybody, anywhere, anytime, because with the Internet you can go anywhere to anybody. The fact that it is digital, the fact that it's scalable, extensible, artifact free and you can go across all the boundaries, is something that most people miss and its very important to the model of what Mike's talking about for the future.

*A:* You have a point there. We've recently started talking about the GII, which is the global information infrastructure, because the NII is an artificial construct. There are no boundaries here. Everything that goes on here can be connected to other networks around the world. We really would like to see and are eager to make that happen.

*Q:* Van Johnson, MIT. I liked your analogy to the railroads rather than the interstate highway system, except I should point out that the Western railroads were primarily built by land grants. In 1893 there was an order by the Federal government to make all the rails the same gauge. Hence, this is a standards issue. Before that time there were 20 different gauges and nobody could interchange freight cars with anyone. The standards issue is very important.

*A:* I think that's a very good point. I think maybe I will try using the railroad analogies. I'm getting tired of jokes about roadkill on the information highway. The government has a very important role in convening people to work on standards. We are not going to force standards on anybody. We are not going to set the standards; we will certainly help industry get together and work together to make it happen.

OSTP

# NATIONAL INFORMATION INFRASTRUCTURE (NII)

MIKE NELSON

## OUTLINE

OSTP

- What is the Information Infrastructure?
- What is the government's role?
- Administration initiatives

## National Information Infrastructure (NII)

OSTP

Definition:"A system to deliver to all Americans the information they need when they want it and where they want it--at an affordable price."

Goal: Transmit images and video as easily as a telephone transmits voice today.

## Components Of The NII

OSTP

- Thousands of interconnected, interoperable communications networks
- Computer systems, televisions, telephones, fax machines, and other "information appliances"
- Information services and databases ("digital libraries")
- Trained people to build, maintain, and run these systems

## Today's Information Infrastructure

OSTP

- Phone system
- Cellular
- Cable TV
- Broadcast TV
- Radio--AM, FM, CB, shortwave
- Computer networks (e.g. Internet)
- Video stores, bookstores, software stores

## What's Needed?

OSTP

- Interoperability
- Much more bandwidth
- Massive private sector investment
- Applications

## Characteristics Of The NII

OSTP

- Built, owned, run by the private sector
- Hundreds, thousands of companies providing services
- All interconnected and interoperable
- Lots of competition and choice for the customer

## Use Of The NII

OSTP

- Education
- Digital libraries
- Manufacturing (e.g. electronic blueprints)
- Video on demand
- Health care
- Shopping at home
- Government services

## Government's Role

OSTP

- February 22, 1993 technology policy paper
  - R & D
  - Demonstration projects
  - Customer (for better government services)
  - Forward-looking telecommunications and information policies

## Research & Development

OSTP

- High-Performance Computing and Communications Program
  - About $800 million in FY 93 to $1 Billion in FY 94
  - New emphasis on applications of supercomputers, networks, and software (additional $96 million requested)

## Demonstration Projects

OSTP

- NTIA "information highway on-ramp program"
  - $28 million for FY 94 in matching grants
  - Could link a computer in every school in 3-4 years.

## Government Services

OSTP

- National performance review
- Information access
- Electronic tax filing
- Reform Procurement!!!

## Need New Policies

OSTP

- 1950s regulations blocking 1990s technology
- Technology moving forward, policy often lags behind
- Policies that promote competition, new investment, new technologies

## Information Infrastructure Task Force (IITF)

OSTP

- Coordinate policy regarding the information infrastructure
- Established by the White House Office of Science and Technology Policy and National Economic Council
- Chaired by Ron Brown, Secretary of Commerce
- Coordinate with FCCSET subcommittee on High-Performance Computing, Communications, and Information Technology

## Key Agencies On IITF

OSTP

- Department of Commerce (NTIA, NIST, NTIS, NOAA)
- Department of Justice (Antitrust Division)
- Department of State
- Department of Defense
- Office of Management and Budget
- Research Agencies

## Structure Of The IITF

OSTP

- Telecommunications Policy Committee (NTIA chair)
  - Universal service
  - International issues
- Information Policy Committee (OMB chair)
  - Privacy
  - Intellectual property rights
  - Government information policy
- Applications and Technology Committee (NIST chair)
  - Government Information Technology Services (GITS)
  - Technology Policy

## National Information Infrastructure Advisory Council

OSTP

- Industry
- Public interest groups
- State and local government

## Legislation

OSTP

- Appropriations bills
- High-Performance Computing Act of 1991 ("Gore Bill")
- Information Infrastructure Act of 1993 ("Boucher Bill") and S.4
- NTIA information infrastructure grant authorization

## Stakeholders

OSTP

- Telecommunications companies
  - telephone
  - cable
  - broadcast
  - wireless communications
- Computer companies
- Information industry
- Users
  - education
  - manufacturing sector
  - financial services
  - health care
  - libraries
- State and local government

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# Interoperability Aspects

# of the

# Grand Alliance HDTV System

Glenn A. Reitmeier
David Sarnoff Research Center

May 10, 1994

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## An FCC Standard

- The Grand Alliance system is the candidate HDTV *transmission* standard under consideration by the FCC through its ACATS

- The Grand Alliance system is NOT:
  - a production standard
  - a display standard
  - a consumer interface standard

- Digital systems decouple these standards

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# Interoperability

***PS-WP4 Definition of Interoperability: "The capability of providing useful and cost-effective interchange of electronic image, audio and associated data: among different signal formats, among different transmission media, among different applications, among different industries, among different performance levels."***

- **Interoperability is an issue of degree**
- **Must be evaluated in a complex multidimensional space that considers established standards and practices of various industries, and the technical feasibility and cost impact of providing interfaces at different operational boundaries between applications or industries**
- **In the design of the GA system, we are often faced with *conflicting* goals!**

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# Grand Alliance Goals

***...essential criteria for a successful HDTV transmission standard...***

↑ *Must achieve to create an HDTV industry* ↓

- **High quality HDTV pictures and sound**
- **Wide service area for terrestrial broadcast**
- **Avoid unacceptable interference to existing NTSC service during its lifespan**

↑ *Must achieve for long term success* ↓

- **Cost effective solution for consumers and users at the time of introduction *and* over the long term**
- **Interoperability with other media (e.g., cable, satellite, computers, telecom) and applications**
- **Potential for worldwide standard**

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# The Importance of HDTV in the NII

- Universal Access
  - HDTV fits available terrestrial, cable and satellite television broadcast channels and infrastructure
  - likely the highest data rate to the home for some time

- Affordable by all
  - terrestrial broadcast is free by virtue of FCC license
  - use of available channels lowers cost
  - low cost receivers will be produced (manufacturers will design with appropriate cost/performance tradeoffs)

- Supports many applications
  - high picture quality
  - high performance receivers are enabled
  - receivers, encoders and other products will span a wide range of performance and cost

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# Interoperability Introduction

- The Grand Alliance HDTV system was designed to provide a high degree of interoperability with other image-based media, ranging from computers to film

- Grand Alliance HDTV is a layered digital system
  - picture
  - compression
  - transport (packet format)
  - transmission

- Layered architecture is fundamental to interoperability

- Header/descriptors provide flexibility

- Each individual layer provides important capabilities and interoperability characteristics

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# HDTV System Layers

***...layered system with header/descriptors provides flexibility...***

**Picture Layer**

1920 x 1080
1280 x 720
60,30, 24 Hz

Multiple Picture Formats and Frame Rates

**Video Compression Layer**

Data Headers — Motion Vectors — Chroma and Luma DCT Coefficients

Variable Length Codes

MPEG-2 compression syntax

**Transport Layer**

Packet Headers → Flexible delivery of data

Video packet | Audio packet | Video packet | Aux data

MPEG-2 packets

**Transmission Layer**

6 MHz

8-VSB

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# Transmission Relationships

U.S. Cable
8-VSB
≈6 MHz
≈15 dB CNR
≈19 Mbps

*Direct-carry*

U.S. Cable (High Capacity)
16-VSB
≈6 MHz
>30 dB CNR
≈40 Mbps

U.S. Terrestrial
8-VSB
6 MHz
≈15 dB CNR
≈19 Mbps

Internat'l
Terrestrial, Cable & Satellite
?????

Satellite
QPSK
≈40 MHz
<6 dB CNR
≈25 Mbps

ATM Networks
SONET Interface
>1 GHz (Optical)
>30 dB CNR
≈1 Gbps

FDDI LAN
baseband
BER < 10^-9
125 Mbps

Ethernet

**Each delivery medium has unique capabilities and constraints**

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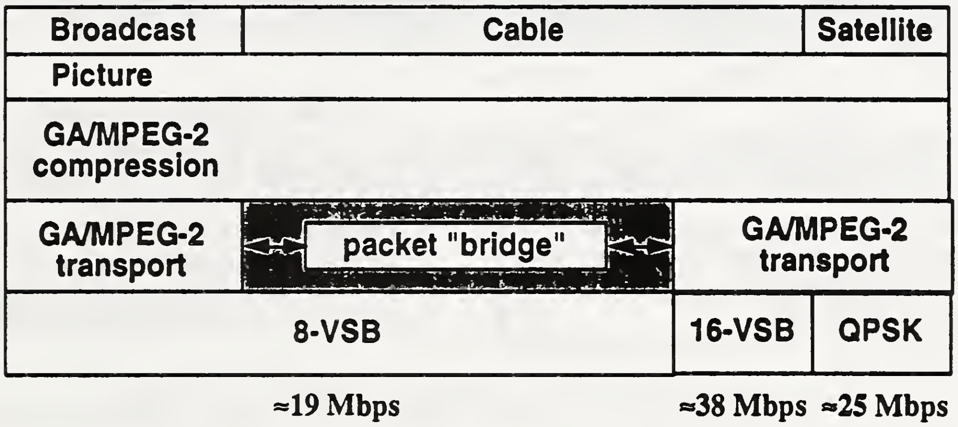
# Cable and Satellite Interoperability

- Terrestrial 8-VSB signal can be carried directly by cable
- Packets can be merged into the packet stream of a higher rate transmission system, such as 16-VSB on cable and QPSK on satellite

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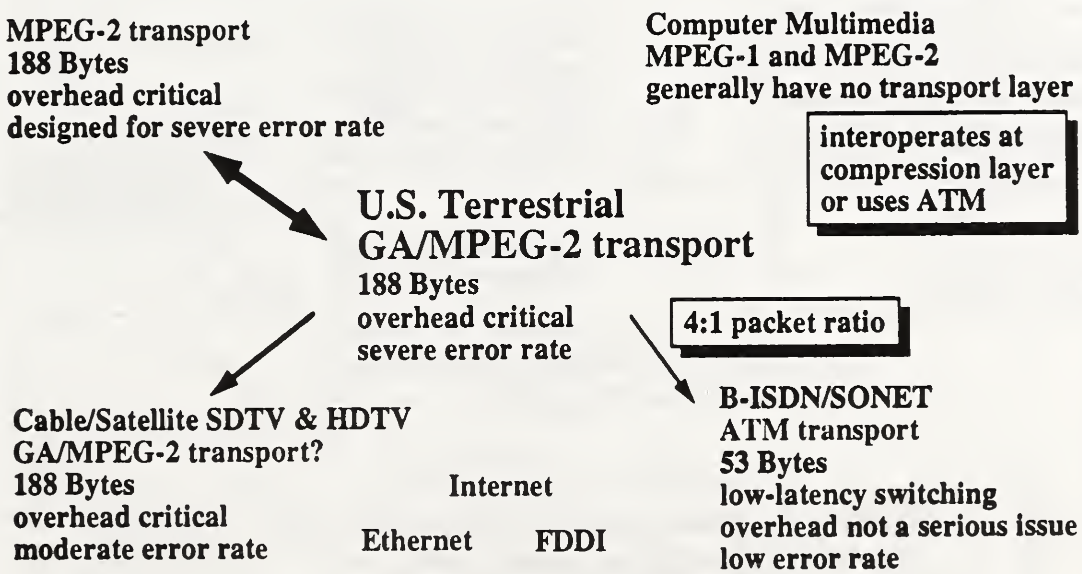
# Transport Relationships




*MPEG-2 transport is an emerging standard that provides interoperability with ATM*

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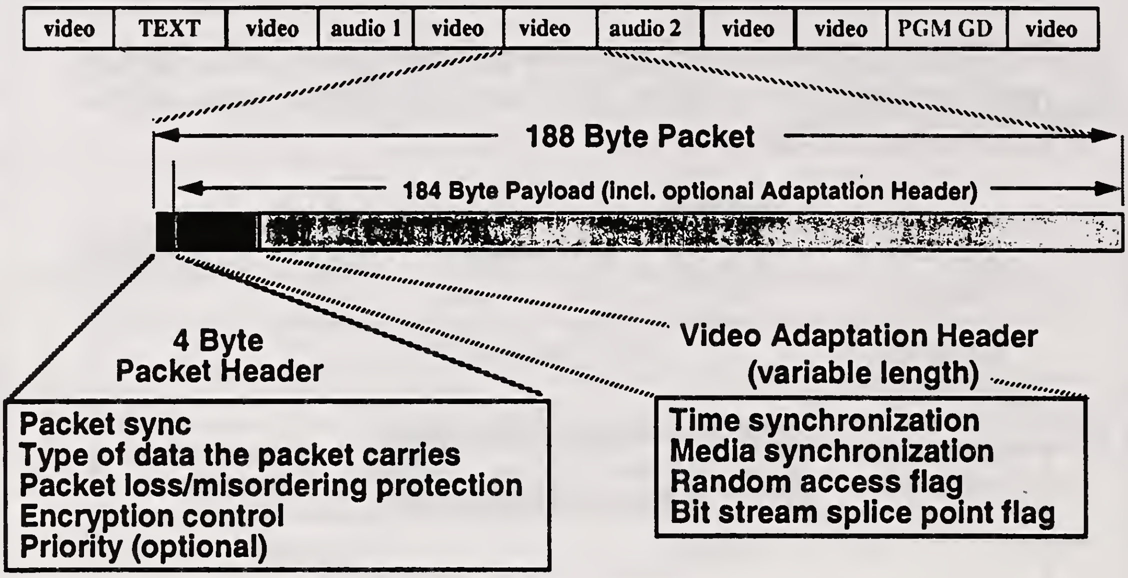
# GA/MPEG-2 Transport

***...packets with header/descriptors enable flexiblility and features...***

**Many services can be dynamically multiplexed and delivered to the viewer**

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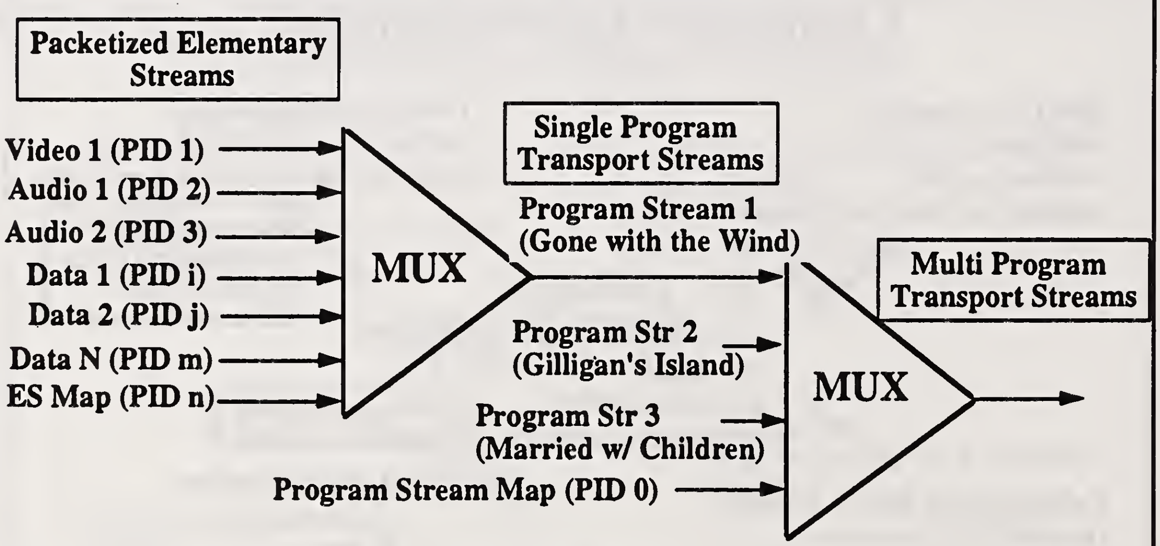
# System Level Multiplex




**PID0 (program_association_table) =>**
**PID (program_map_table) =>**
**PIDs of elementary bitstreams**

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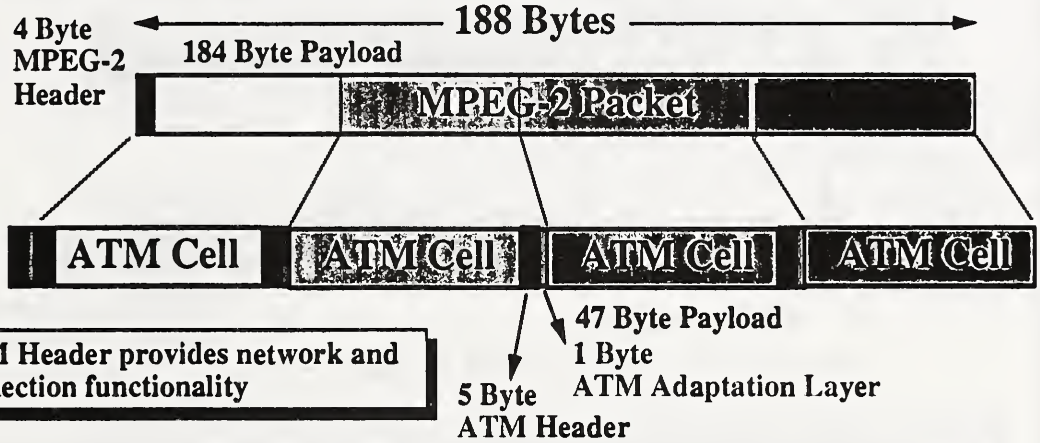
# ATM Interoperability

- One MPEG-2 packet fits into 4 ATM cells
- MPEG-2 and ATM headers provide different functionality
- This allows HDTV to be easily used on ATM networks

MPEG-2 Header provides multiplexing, synchronization and encryption functionality




ATM Header provides network and connection functionality

188 Byte GA/MPEG-2 packet = 4 x 47 Byte ATM Payload

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# Compression Relationships

Cable/Satellite SDTV & HDTV
MPEG-2
≈4 Mbps and greater
a few standard image sizes and frame rates
> VHS quality

Computer Multimedia
MPEG-1 and MPEG-2
1.5 Mbps and greater
wide variety of image sizes and display frame rates
wide range of quality

## U.S. HDTV Transmission GA/MPEG-2

≈19 Mbps
a few standard image sizes and frame rates

Teleconferencing
H.261
≈64 kbps
low frame rate
<< VHS quality
low latency

*MPEG-2 is an emerging multi-industry, international (ISO) video compression standard that provides efficient encoding for both progressive and interlaced sources*

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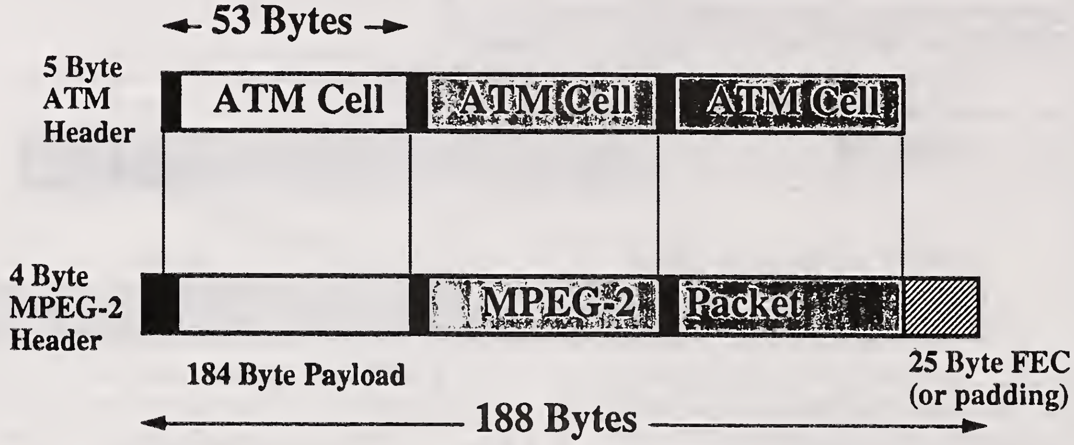
# MPEG-2 Carrying ATM

- Three ATM cells fit into one MPEG-2 packet
- MPEG-2 and ATM headers provide different functionality
- This allows ATM data to be transmitted over HDTV




3 x 53 Byte ATM Cell + 25 additional FEC/padding = 184 Byte GA/MPEG-2 payload

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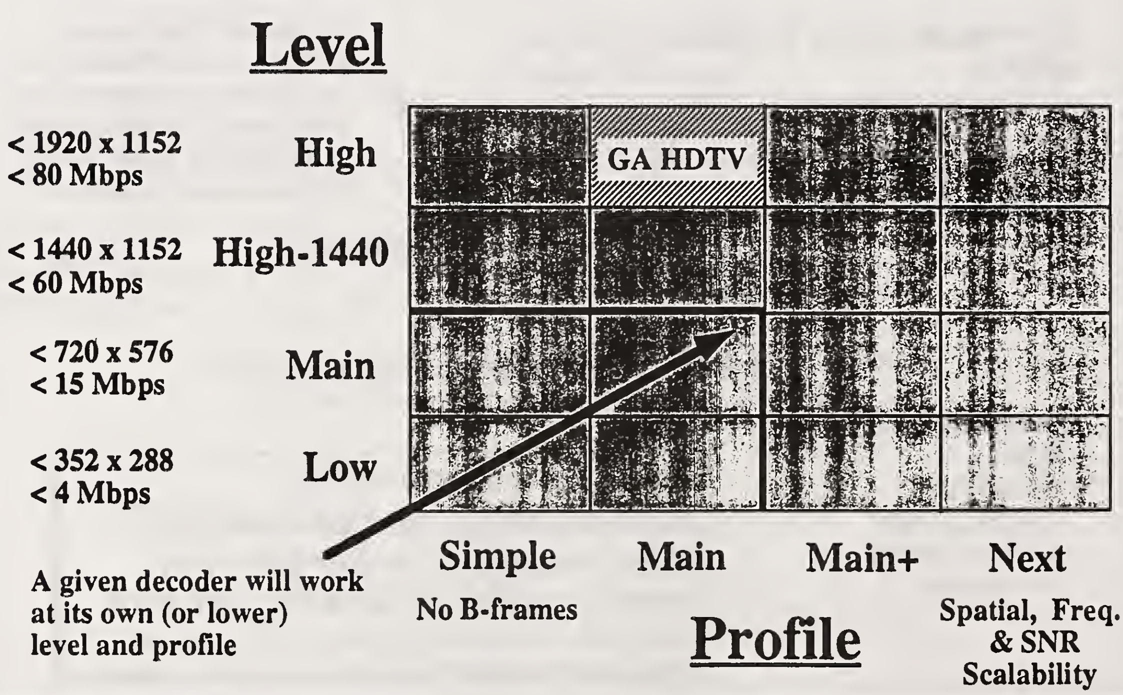
# MPEG-2 Levels and Profiles

*... MPEG-2 is a toolkit that addresses a variety of cost/performance grades...*

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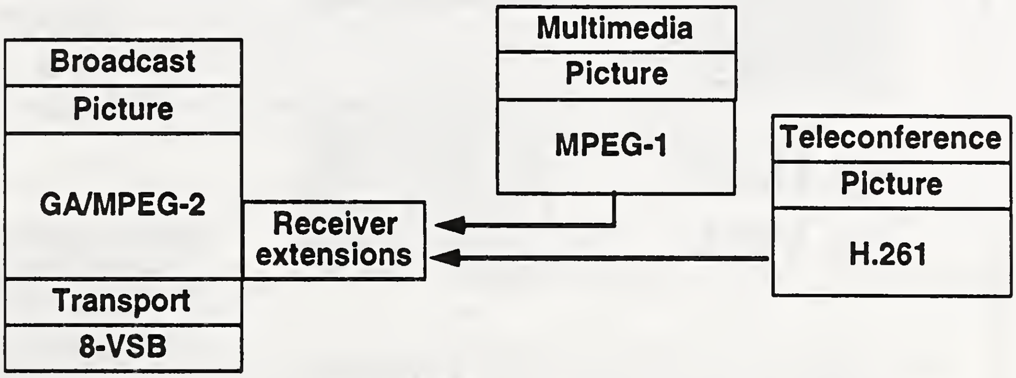
# MPEG and H.261 Interoperability

- **MPEG-2 is similar to MPEG-1 and H.261, and a programmable decoder could be built to handle them all**
- **Market demand will determine if manufacturers build this capability into HDTVs**




- **Interoperability in the reverse direction is less important, since no existing MPEG-1 or H.261 decoder can decode an MPEG-2 stream, much less at HDTV level**

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# Picture Format Relationships

Cable/Satellite
Digital SDTV
based on CCIR-601
and lower
resoultions

Film
analog
progressive
24 frames/sec

NTSC
analog x 480
interlaced
59.94 fields/sec

CCIR 601
720 x 480
interlaced
59.94 fields/sec

CCIR 601
720 x 576
interlaced
50 fields/sec

## U.S. Terrestrial HDTV
Multiple pixel formats and frame rates

US HDTV Production
1920 x 1080
interlaced
59.94/60 fields/sec

SMPTE 240M
1920 x 1035
interlaced
60 fields/sec

Computer Multimedia
*wide variety of image sizes*
square pixels, progressive scan
*wide variety of display frame rates*
VGA 640 x 480

PAL & SECAM
analog x 576
interlaced
50 fields/sec

Euro HDTV Production?
1440 x 1152 ?
interlaced
50 fields/sec

*Multiple formats and frame rates provide interoperability with HDTV production, film, computers and NTSC*

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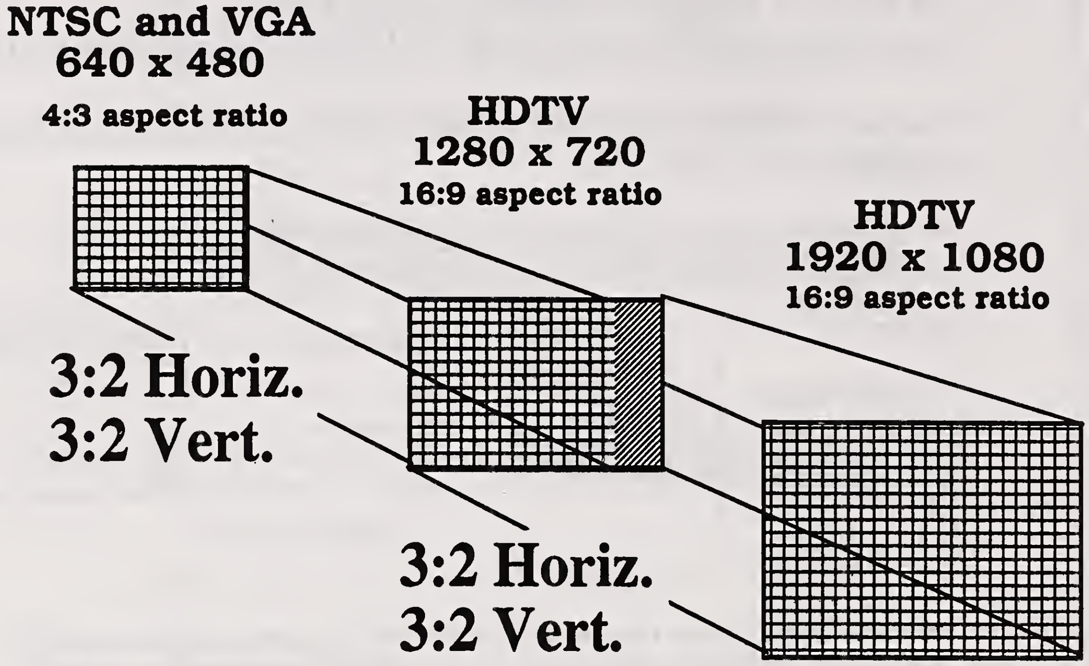
# GA Format Relationships

***...HDTV and other formats have simple conversion...***

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# GA Picture Formats and NTSC

| | Spatial | Temporal |
|---|---|---|
| | 1920 x 1080<br>(square pixels) | 59.94 / 60 interlaced<br>29.97 / 30 progressive<br>23.97 / 24 progressive |
| 3:2 relation<br><br>3:2 relation to "wide-NTSC" | 1280 x 720<br>(square pixels) | 59.94 / 60 progressive<br>29.97 / 30 progressive<br>23.97 / 24 progressive |

- **Initial 59.94 Hz based temporal rates of all formats simplify transcoding and dual standard receivers**
- **3:2 relationship between NTSC and HDTV formats simplifies transcoding and dual standard receivers**

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# GA Picture Formats and Film

| Spatial | Temporal | |
|---|---|---|
| 1920 x 1080 (square pixels) | 59.94 / 60<br>29.97 / 30<br>23.97 / 24 | interlaced<br>progressive<br>progressive |
| 1280 x 720 (square pixels) | 59.94 / 60<br>29.97 / 30<br>23.97 / 24 | progressive<br>progressive<br>progressive |

- The 24 Hz film formats allow efficient encoding of movies
- The 30 Hz film formats provide for higher frame rate progressive capture than conventional 24 Hz film
  - often used in production of commercials

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# GA Picture Formats and Computers

| Spatial | Temporal | |
|---|---|---|
| 1920 x 1080 (square pixels) | 59.94 / 60<br>29.97 / 30<br>23.97 / 24 | interlaced<br>progressive<br>progressive |
| 1280 x 720 (square pixels) | 59.94 / 60<br>29.97 / 30<br>23.97 / 24 | progressive<br>progressive<br>progressive |

- Square pixels and progressive scanning provide interoperability with computers
  - computer graphics in production
  - HDTV receivers as information appliances

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# GA Picture Formats and HD Production

| | Spatial | Temporal | |
|---|---|---|---|
| ↑ 3:2 relation ↓ | 1920 x 1080 (square pixels) | 59.94 / 60<br>29.97 / 30<br>23.97 / 24 | interlaced<br>progressive<br>progressive |
| | 1280 x 720 (square pixels) | 59.94 / 60<br>29.97 / 30<br>23.97 / 24 | progressive<br>progressive<br>progressive |

- For the short term
  - 1080 interlaced production, 59.94 Hz based frame rates
- For the long term
  - square pixels for computer interoperability
  - 60 Hz based frame rates are avantageous
  - 720 and 1080 progressive production

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# Interoperability Summary

*...a layered system with flexibility and interoperability at each layer...*

- Picture Layer
  - multiple formats related to TV, film and computers
  - progressive and interlaced scan
  - square pixels
- Compression Layer
  - choice of MPEG-2 syntax enables international and interindustry exchange of bit streams
- Transport Layer
  - choice MPEG-2 packet format
  - relationship between MPEG-2 and ATM
- Transmission Layer
  - VSB for terrestrial and cable
  - bit stream exchange with other transmission media

GAR

# Conclusions

- Grand Alliance HDTV supports many applications that need to deliver high-resolution video at low data rate (highly compressed) to low cost receivers
  - entertainment HDTV
  - much educational video
  - much electronic publishing

- Essential to universal access and affordability

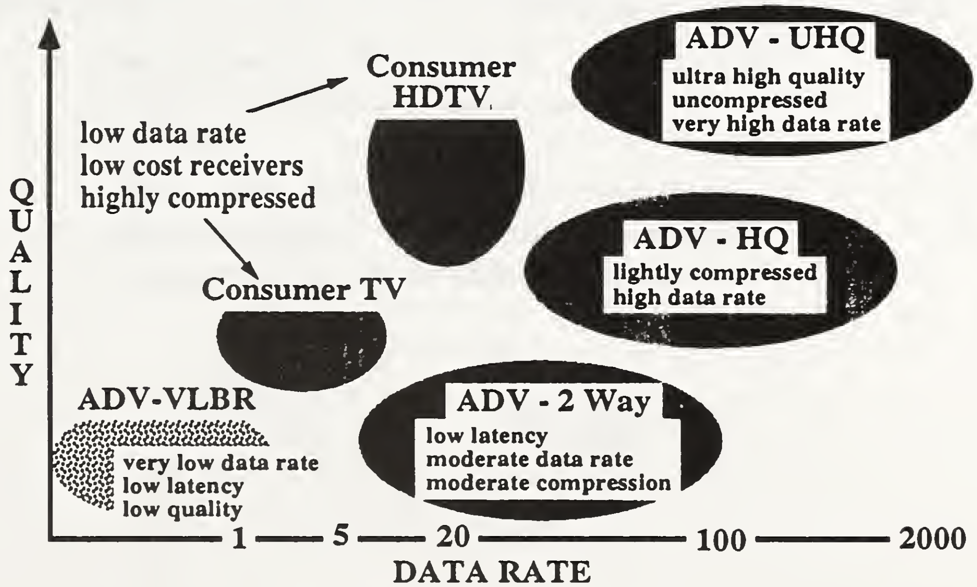
- Other applications have different technical and cost needs
  - resolution, frame rate, color rendition...
  - data rate (communications cost), latency...
  - encoder and decoder cost

- The U.S. HDTV standard will play a large and important role in the future NII - but it cannot be expected to meet the needs of all NII applications

GAR



# Recommendations




To enhance interoperability, additional ADV standards for the NII should be technically related to the U.S. HDTV standard (just as HDTV is related to film, NTSC, computers, etc.)

GAR

# Video Compression Technology

by

Chong Lee
QUALCOMM Incorporated

Workshop on ADV in NII
May 10, 1994

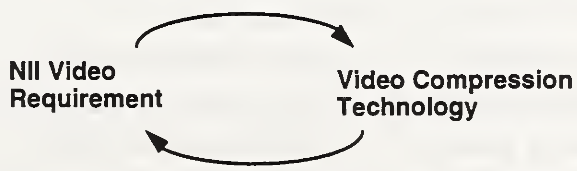




## Video Compression for NII

ADV/NII
Video Compression

- Goal of video within NII
  - Efficient dissemination of visual information
- Video chain:
  - Image capture, storage, transmission, and display
- Efficient storage and transmission needs compression
- Video compression needs are being formulated for NII



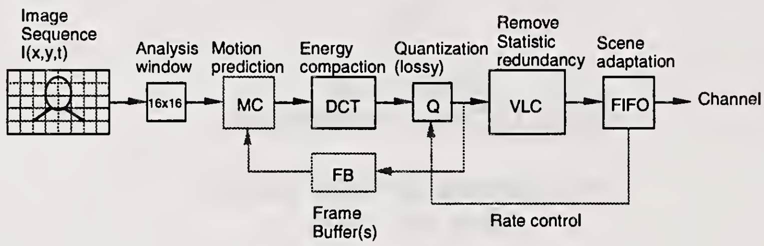

Synergistic Influence

QUALCOMM INCORPORATED

## What is Video Compression

ADV/NII
Video Compression

- Spatio-Temporal redundancy reduction
  - x, y, t (z?)
- Transform (DCT), Sub-band, LOT, VQ, Wavelet, Fractal, etc.
- Industry acceptance:
  - Intraframe: DCT (e.g. JPEG)
  - Interframe: MC Hybrid DCT (e.g. MPEG, GA)




**Typical Video Compressor (JPEG, MPEG, GA, others)**

May 10, 1994

Page 3

QUALCOMM INCORPORATED

## Compression Performance

ADV/NII
Video Compression

- Dependence on image source (entropy and noise)
- Compression ratio ↑:
  - Larger analysis window
  - More apriori knowledge of the source image
  - Better utilization of visual perception
  - More processing (adaptation) and delay (memory)
- Lossless, Near-lossless, Perceptually lossless, Lossy
- Subjective quality and compression ratio:
  - Studio grade (2:1 - 8:1) e.g. Video production, D-5
  - Professional grade (8:1 - 24:1) e.g. Mass viewing, EC
  - Consumer grade (24:1 - 100:1) e.g. GA HDTV, MPEG
  - Communications grade (100:1 - 1000:1) e.g. Picture phone
- Mostly based on DCT

May 10, 1994

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## NII Considerations



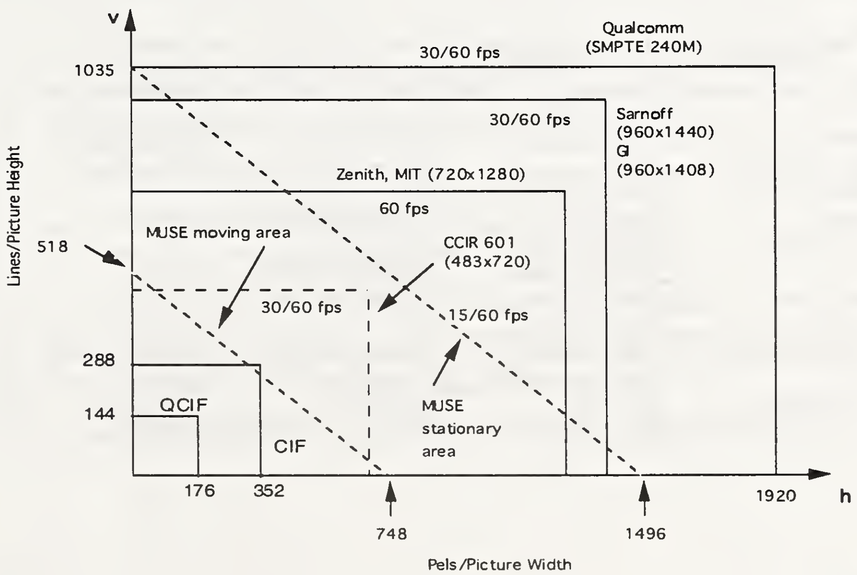
- Wide ranges of resolution and frame rates
- Video source (camera, film, computer generated, etc.)
- Compression ratio vs. quality
- Typical viewing distance and display size
- Flexible, multi- and/or variable rate operation
- 1-way broadcasting, 1-way interactive, 2-way
- Complexity - Asymmetric vs. symmetric compression
- Delay - processing and transmission
- Scalability - resolution, frame rate, SNR
- Fast search/browse capability
- Interoperability - standardization is the key
- Extensibility - manufacturers dilemma
- Other: cost, size, power, error tolerance, etc.





## Resolution & Frame Rate

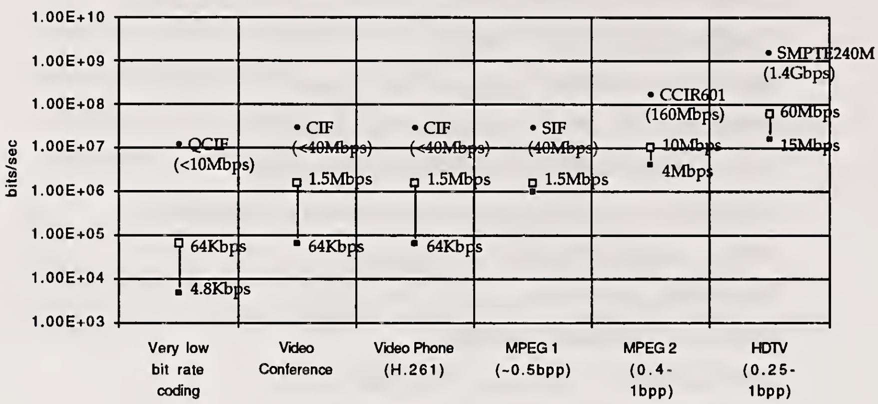




# Video Data Rate



Video Data Rates








# Classification of techniques based on source model



| Level | Source Model | Coded Info | Coding Technique | Comments |
|---|---|---|---|---|
| 1 | Pels | Color of pels | PCM | decreasing compression ↑ |
| | | | | decreasing complexity |
| 2 | Statistically dependent | Color of pels or block | predictive coding | increasing generality |
| | pels | of pels | transform coding | increasing realism |
| 3 | Translational moving | Color of blcoks and | Motion compensated | |
| | blocks | motion vectors | hybrid DPCM/DCT coding | |
| 4 | Moving structures | Mapping parameters | Fractal coding | |
| | | or chape and motion | contour/texture coding | |
| 5 | Moving unknown | Shape, motion and | Analysis/synthesis coding | |
| | objects | color of each object | | |
| 6 | Moving known object | Shape, motion and | Knowledge based coding | increasing compression |
| | | color of known object | | increasing complexity |
| 7 | Facial expression | Action units | Semantic coding | loss of generality |
| | | | | decreasing realism ↓ |

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## Performance Ranges

ADV/NII
Video Compression

- Resolution (25 Kpixels --> 2 Mpixels)
- Frame rate (1 --> 60 fps)
- Compression ratio (2:1 --> 1000:1 or higher)
- Data rate (4.8 Kbps --> 60 Mbps)
- Picture quality (facial animation --> photo realism)
- Coding delay (16 ms --> 1 sec or more)
- Error resilience ($10^{-3}$ --> $10^{-12}$ BER)
- Encoder/decoder asymmetry (2:1 --> 10:1)
- H/W Complexity (1 ASIC --> multi-rack system)
- Power consumption (1 W --> 1 KW)

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## Conclusions

ADV/NII
Video Compression

- NII to provide the connectivity and organization of information
- Existing compression satisfactory for most NII Applications
- Several orders of magnitude in performance ranges
  - Need a family of compression techniques (based on DCT?)
  - Refinement of MPEG-2 could be a starting point
  - Balance between generalization and optimization
- How to deal with upgrades? (e.g. pace in PC market)
- S/W implementation in less cost sensitive applications
  - syntax for down loadable algorithm?
- Synergies between NII requirement and compression research

May 10, 1994

Page 10

## *Advanced Digital Video Over ATM Networks*


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Bellcore
Bell Communications Research

## *MPEG Video and ATM - An Ideal Pair for the NII*

- ATM - What's it good for?
- Mapping MPEG into ATM
- Recovering the TV time base

## *ATM - Asynchronous Transfer Mode*

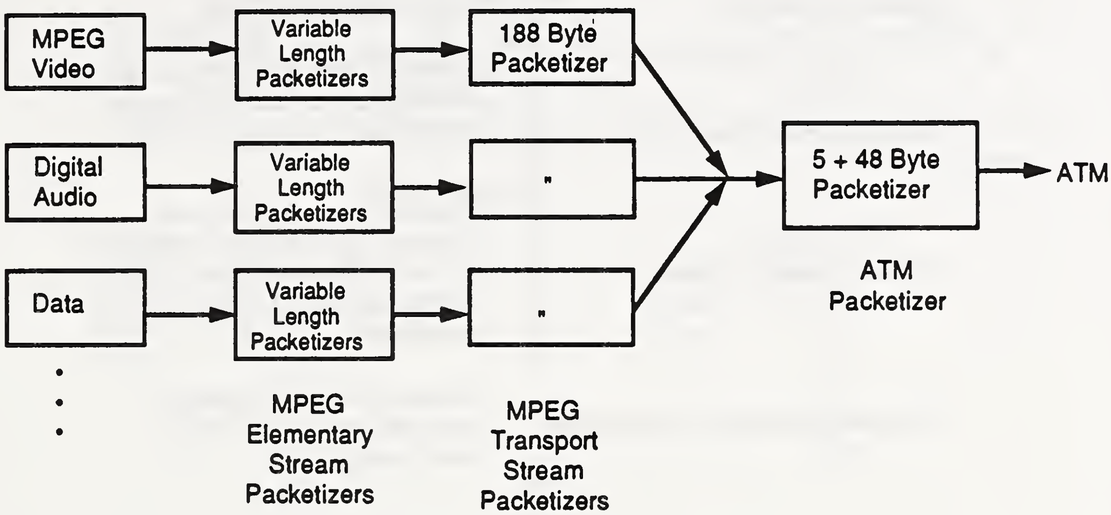
| Header | Payload |
| --- | --- |
| 5 Bytes | 48 Bytes |
| • Channel ID<br>• Path ID<br>• Payload type<br>• Cell loss priority<br>• Header error control | • Information and specific adaptation functions for Data, Voice, Video, .... |

A Universal Labeled Container for All Information

## *The Payoff for ATM*

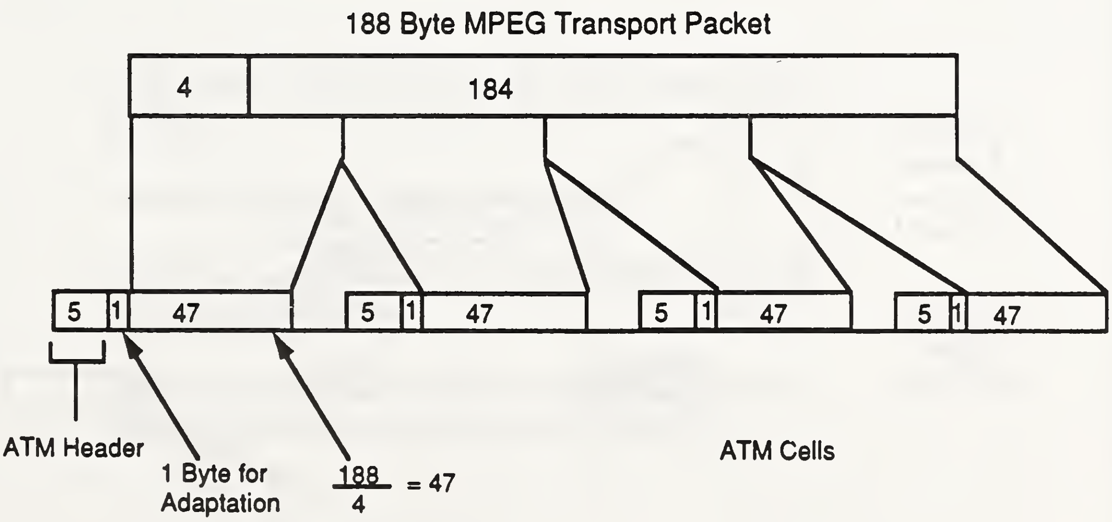
- Efficient multiplexing of services with disparate rates - bandwidth on demand
- Allows for bursty traffic
- Basis for fast packet switching
- Accepted world standard

## *Mapping MPEG-2 Into ATM - Full Functionality Example*




- OTHER ALTERNATIVES HAVE BEEN PROPOSED

## *Match Between ATM Cells and MPEG-2/Grand Alliance Transport Cells*

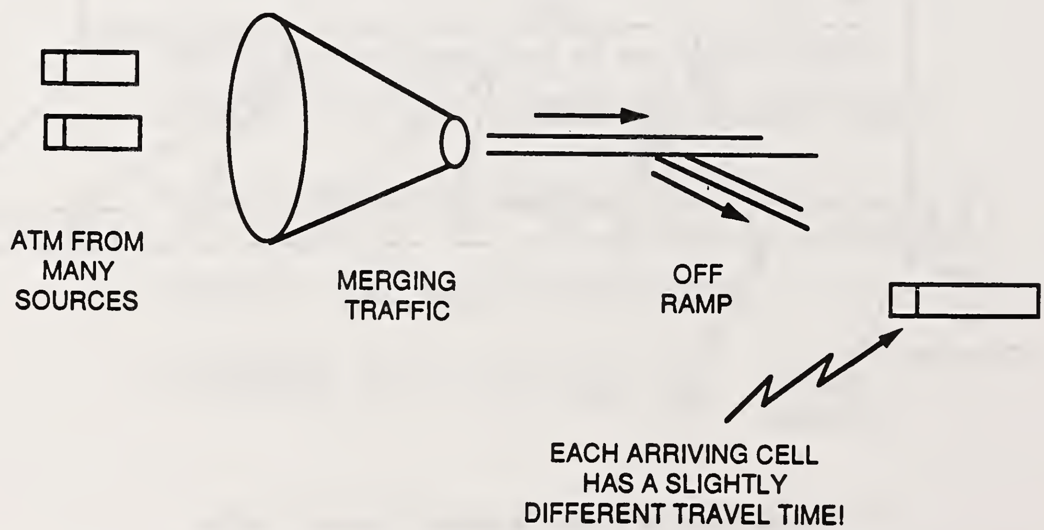



- An example of how MPEG can be efficiently matched to ATM

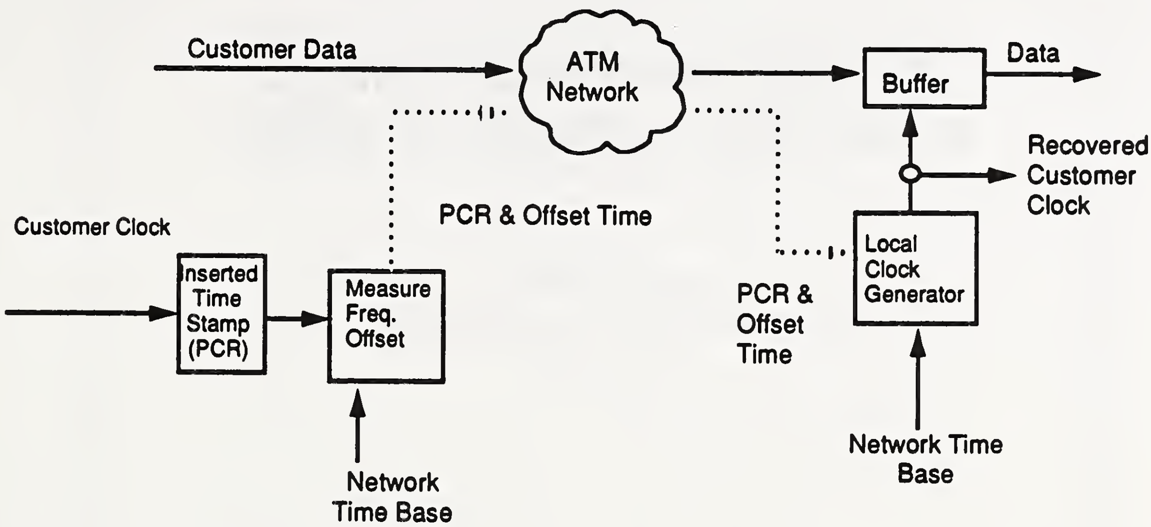
## Split-Up of Functions - Some Examples

| | |
|---|---|
| Elementary Stream | Raw, Compressed Data |
| Packetized Elementary Stream | Stream ID, packet length, ES rate, decoding/presentation time stamp, scrambling control, priority, CRC, ... |
| MPEG-2 Transport Stream | Packet ID, continuity counter, transport error indicator, transport priority, PCR time stamps, scrambling control, splice countdown, ... |
| ATM Cells with adaptation functions | Channel ID, path ID, payload type, cell loss priority, header error control, ... |

## ATM Traveling On The Information Superhighway



## *Eliminating the Effect of Cell Jitter*




PCR = Program Clock Reference

## *Summary*

- ATM offers the flexibility and speed needed for the NII
- ATM is adaptable to all services
- MPEG-2 as proposed by Grand Alliance maps efficiently into ATM
- Technical solutions exist for key MPEG/ATM issues - What's needed is AGREEMENT

# Digital Video in the Internet: Status, Technology, and Issues

John Wroclawski
MIT Laboratory for Computer Science
May 10, 1994

DV-NII JTW 5/9/94

## Today

Digital video represents a small but increasing portion of Internet use today. Examples:

- –UC Irvine Pancreatic Islet Symposium {formal presentation}
- –NASA Select shuttle downlink {broadcast}
- –IETF conference multicasts {informal interactive}

MBONE (video/audio multicast VPN) connects ~900 networks/24 countries.

Perceptual media support seen as a key driver for the future Internet architecture.

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## Multimedia Technology Model

- Peer-to-peer emphasis.
- Group oriented.
- Heterogeneous.
  - –End systems.
  - –Network technology.
  - –Administrative requirements.
- Component of a single larger infrastructure.

DV-NII JTW 5/9/94

## Technologies

- Integrated Services Architecture
- Internet-level Multicast
- Real-Time Transport

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## Key Technology: Integrated Services Architecture

- Extension of the Internet Architecture to support multiple qualities of service:
  - –End-to-End {characteristics seen by an individual flow}
  - –Local Policy {aggregate scheduling policy at a particular node/network/switch}
- Model provides three broad (end-to-end) service classes:
  - –Guaranteed. {nuclear reactor control}
  - –Predictive. {perceptual media - video, audio}
  - –Best Effort. {bulk data transfer - email, FTP}
- Supports relative traffic priority within a flow.
- Strong belief in *adaptive applications* - intelligence in hosts/end-systems.

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## Integrated Services Architecture II

- Resource reservation allocates network resources to an application instance.
- Applications may choose to reserve resources always, sometimes, never. Applications may leave this decision to the user.
- RSVP resource reservation protocol:
  - –Receivers control resources set up for their use.
  - –Reservation types support different application needs:
    - » broadcast, large group, dynamic conversations...
  - –Uses underlying routing infrastructure - wide applicability.
  - –Highly scalable - reservation merging, state minimization.

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## Integrated Services Architecture Status

- "Early"
- Research/development status:
  - –Significant theoretical and simulation experience.
  - –Two experimental implementations demonstrated. Reference implementations of key components available shortly.
  - –Initial real-world usage occurring now.
- Internet standardization activity:
  - –Integrated Services working group charter drafted March 1994. Group responsible for standardization of overall architecture, system interfaces, component requirements. 1995-1996.
  - –RSVP working group chartered March 1994. Responsible for standardization of RSVP protocol. Draft specification available, proposed standard expected 1995.

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## Key Technology: IP Multicast

- Implements the "send-to-group" function.
- Service model: Receiver originated membership, loose coordination.
  - –Receivers explicitly join/leave multicast groups.
  - –Anyone can send to a group (sender and receiver functions are logically separated).
  - –Network infrastructure builds efficient distribution trees.
- Model is highly scalable.
- Model supports a wide variety of higher-level abstractions.
- Model preserves the IP datagram delivery paradigm.
  - –Unicast viewed as special case of m'cast.

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## IP Multicast Status

- **End-system facilities:**
  - –Full Internet standard.
  - –Wide vendor acceptance.
- **Basic routing:**
  - –Suitable for LAN and some WAN environments.
  - –"Proposed Standard" protocols.
  - –Supported by all major IP router vendors.
- **Highly Scalable Routing:**
  - –Technology appropriate for national-scale networks.
  - –Several proposed approaches.
  - –Some experimental deployment.
  - –Initial vendor support.

DV-NII JTW 5/9/94

## Key Technology: Real-Time Transport Protocol

**RTP provides basic services for transporting temporally sensitive data in an internet:**

- –Timing and Synchronization.
  - » Media-specific timing information
  - » Relationship to real-time.
- –Merging, bridging, and translation support.
  - » Supports mixed codings, low-speed links, application gateways, etc.
- –Security functions.
  - » Message integrity, authentication, confidentiality.
  - » Satisfies wide range of security requirements, computational capabilities.
- –Application-specific optional data.
  - » Program identification, copyright, billing, etc.
  - » Optional data may be encrypted.
- –Management and monitoring facilities.

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## RTP Profiles

- RTP profiles specify the use of RTP facilities to transport specific data types.
- RTP facilities support existing standards in the packet-network environment:
  - –H.261
  - –MPEG 1, MPEG 2
    - » MTS level - transparent transport.
    - » ES level - optimized for computer applications.
  - –JPEG
  - –CELL-B (Sun Microsystems)
- RTP used for experimental coding formats.
  - –multi-resolution, resilient to packet loss, etc.

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## RTP Status

- Several experimental implementations deployed, interoperability demonstrated.
- Initial standardization action nearing completion - IETF "Proposed Standard" July 1994.
- Early vendor interest, but no announced products.

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## (Some) Open Technical Issues

- Video data representation and coding.
  - –Bit-rate is not the only concern.
  - –Multi-resolution representation extremely desirable.
  - –Resilience against packet-data loss patterns.
  - –Computationally accessible representations.
- Specification of system components.
  - –What to standardize? What to leave to product implementors?
  - –Behavioral specifications.
  - –Performance tests and rating system.

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## Looking toward the NII

What role will the Internet play in the NII?

What is the relevance of the technology described here?

Contributions:

- Technically feasible Open Data Network.
- Transition path from vertically integrated industries to a national communications infrastructure.
- Utilize a wide range of communication technologies, as appropriate.
- Evolutionary approach - rapid deployment, continued growth and change.

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## NII II

Weaknesses..

- Universal Access
  - –Technical limitations (relatively minor concern)
  - –Business and management limitations (a larger problem?)
- Ease of Use
  - –Lower-level issues: plug and play.
  - –Application Interface concerns.
- Cost Effectiveness
  - –Is a shared open infrastructure cost-competitive with vertically integrated suppliers?
  - –Is the price of heterogeneity too high?
  - –Is the intelligent end-node assumption reasonable?

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## Summary

- Digital video applications are in use in today's Internet.
- Deployment of these applications is driving extensions to the Internet architecture.
- The IS Internet will support a wide range of communication technologies, administrative requirements.
- Deployment, ease-of-use, and cost questions remain open.

DV-NII JTW 5/9/94

## Standards Panel: Old Game, New Rules??

The participants in the Standards Panel were Will Stackhouse, Moderator; Rex Buddenburg, Naval Postgraduate School; Karen Higgenbottom, Apple Computer; Julius Szakolczay, Mitsubishi; and Thomas Stanley, FCC. Each panelist was to define the problem in getting the current standards process to respond to fast-evolving electronic systems, identify impediments to a solution, and offer recommendations. The slides follow. See page 27 for a full summary.

**Rex Buddenberg, Naval Postgraduate School**

Problem: **Cosmology is wrong:**

disagree about what's at the center

wholly diferent views of solar system

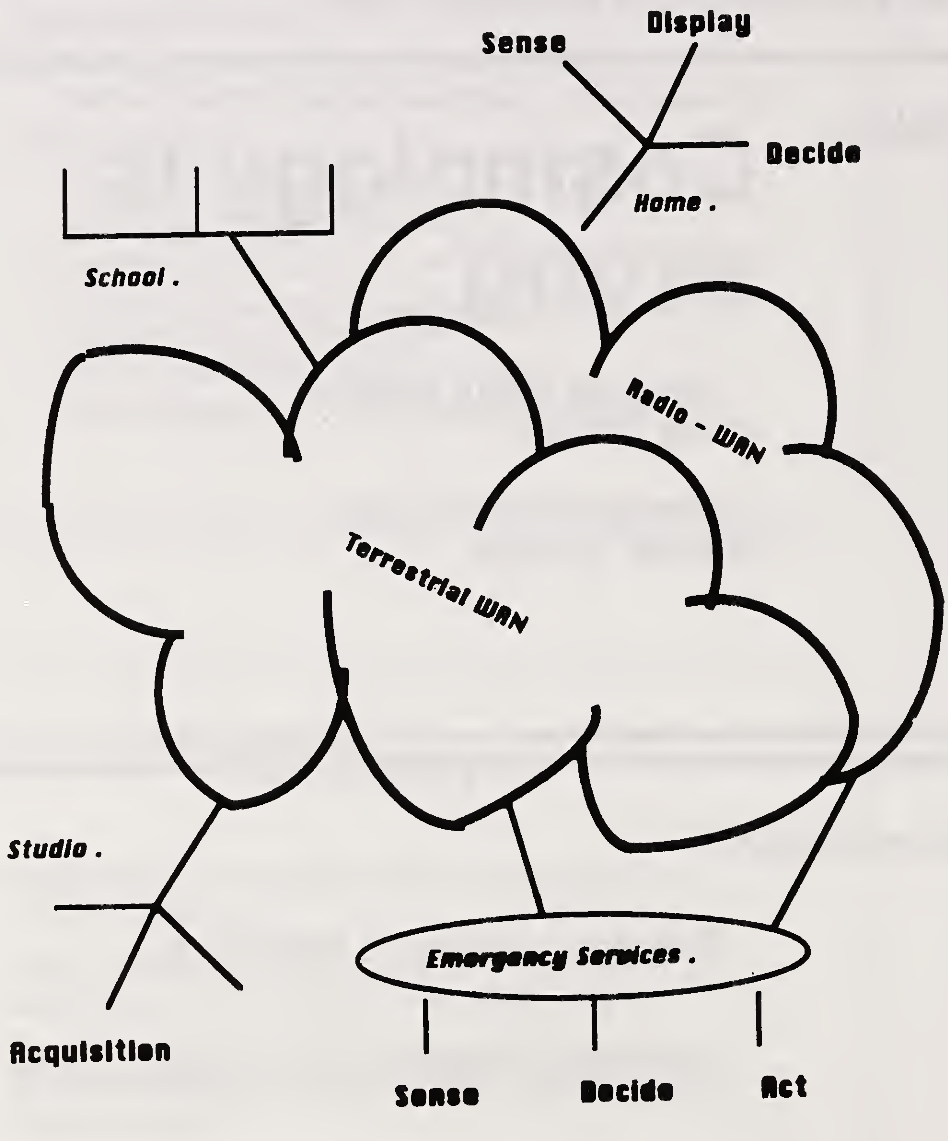
Impediments:

Different 'unions' of engineers

Inadequate rewards for interoperability

Spectrum allocation policy that stresses compatibility, but ignores interoperability

**Recommendation:**
**Put the network at the center.**



Karen Higginbottom, Apple Computer

## Definition of the Problem

- one standard for everyone, everything
- consensus process
- resources
- timeframes and deliverables
- expensive, little ROI
- activities fragmented

## Impediments

- multiple options, standards, problems
- "ya'll come"
- "we're only volunteers"
- no business process for development
- funding / business ties
- personalities

## Recommendations

- customer horizontal requirements
- participants have some $ commitment
- companies have some $ commitment
- deliverables, timelines, post mortems
- business case for what to build
  what will sell
- high level architecture, roles defined

**Julius Szakolczay, Mitsubishi**

Mitsubishi

**The Problem**

- De-Facto standards result in market fragmentation
- Consumers do not tolerate confusion
- Consumers demand compatibility
- Lack of comprehensive policy to digital standards

Mitsubishi

**The Impediments**

- De-Facto standards = $$$
- Multiple standards = poor economics of scale = higher prices = smaller market
- Everybody wants to make a "Box"
- FCC wants no part of the standards battle

Mitsubishi

**The Options**

- Initiate comprehensive policy requiring industry to agree on standards for the critical interfaces
- Standardize only what is necessary to insure interoperability
- Keep the architectures open
- FCC should regulate where it is in the public interest

Julius Szakolczay
V.P. Research & Advanced Development

ATV R&D Lab

## Advancing the National Interactive Communications Systems

*D. Joseph Donahue, Thomson Consumer Electronics Inc.*

The National Information Infrastructure (NII) program offers the opportunity to provide consumers throughout the United States with an in-home system for entertainment, education, business, and even shopping, using the widely publicized digital interactive communications system.

The dynamic growth in usage of the Internet and on-line services clearly verifies that such services are extremely appealing to the computer-literate consumer. On the other hand, market research reveals that consumer interest ranges from movies-on-demand to on-line services with the top three choices being movies-on-demand, TV-on-demand, and on-line video games. In other words, entertainment is the key to consumer acceptance.

A nine-month field trial of an AT&T interactive system confirms that consumers want an entertainment system. The exercise also revealed that the hardware and services of the network must be much simpler than today's PC or on-line services. Why? Because 40 percent of users in the field trials behaved like typical consumers and refused to read the operating instructions.

All of these findings are supported by market research conducted by Thomson Consumer Electronics. Consumers want a home entertainment system with interactive services that are both simple to understand and operate. Furthermore, they prefer a system with a viewing area like today's TV and a viewing distance of approximately 14 feet.

Based on this research, we are convinced that the NII approach should be the evolutionary development of both a home computer center and a digital TV center. Such an approach would take advantage of the strong consumer interest in TV as well as the growing interest in computer services.

In our view, the computer center hardware will evolve with that of the computer industry and will include full digital audio and digital video compatibility. The digital video TV center will start with a digital set-top box such as the RCA-brand Digital Satellite System receiver which will be available at retail this Fall.

This dual approach will provide NII services for different skill levels and different interests, thus providing the quickest evolution of technology, services, and content and a win-win solution for both hardware and service providers as well as consumers.

Only one major hurdle must be cleared in order to accelerate development of the NII system -- how do we address interoperability between all the potential systems, standards, and services? Consumers, after all, have a long history of rejecting multiple standards.

The answer, and the only standard that has been designed to meet the needs of broad industry segments from broadcast to computer, is the Grand Alliance Digital HDTV standard, a standard which has received the preliminary endorsement from the FCC Advisory committee on Advanced Television Service.

The Grand Alliance system produces spectacular video and audio, providing an opportunity to expedite the implementation of interactive hardware and services in the home. Early adoption of the HDTV standard by the FCC and early initiation of HDTV broadcasts will contribute by limiting `de facto' standards that might appear.

The combined U.S. strength in computers, software, Internet, ICs, on-line services, digital HDTV, entertainment programming, and other services is awesome. Maximum development and use of these strengths through a strong NII program will prove to be a profound national asset. The real benefits to society -- jobs, education, productivity, entertainment, improved health care, and quality of life -- can be realized only through implementation of NII in our homes, as well as in our offices, schools, businesses, and health care facilities.

RCA

# ADVANCED DIGITAL VIDEO IN THE NATIONAL INFORMATION INFRASTRUCTURE

## WHAT WILL THE HOME INFORMATION APPLIANCE LOOK LIKE? and HOW CAN NII IMPLEMENTATION BE EXPEDITED IN AMERICAN HOMES?

D. Joseph Donahue
Senior Vice President
Technology and Business Development

Thomson Consumer Electronics, Inc.
Suite 601, 1200 19th Street, N.W., Washington, D.C. 20036

Telephone: (202) 872-0670
Facsimile: (202) 872-0674

**The New York Times Magazine**

MAY 1, 1994 / SECTION 6

THE
INFORMATION
FUTURE

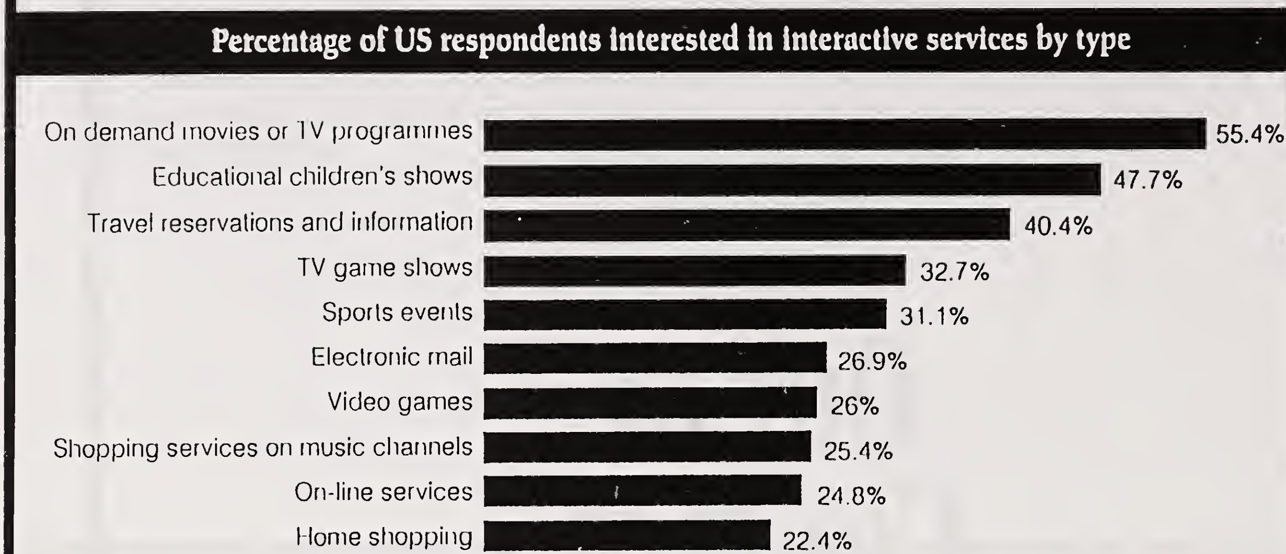
# OUT OF CONTROL

(And it's a good thing, too.)

## FOUNDATION NII SERVICES

AUDIO
COMPUTING
TELEVISION
FAX
VIDEO PHONE
ON-LINE SERVICES
PAGING
TELEPHONE
INTERNET
SHOPPING
EDUCATION
INTERACTIVE VIDEO
GAMES
STORAGE & RETRIEVAL
E-MAIL
PSC
RADIO
CELLULAR
INFORMATION SERVICES
VIDEO-ON-DEMAND
SHOPPING

# ADVERTISING AGE CONSUMER SURVEY




*Source: Advertising Age 1993*

# AT&T FIELD TRIAL OF INTERACTIVE SERVICES
## KEY CONCLUSIONS

- Content & Interaction must be "Entertaining".
- Interaction must be "Easy To Use".
- Preferred viewing distance was 14 feet.
- Graphics must be large.
- Refresh must be rapid.
- Content, such as shopping, must be updated frequently.

## NII HOME OF THE FUTURE

| | ENTERTAINMENT ORIENTED DIGITAL TV CENTER | TASK ORIENTED COMPUTER CENTER |
|---|---|---|
| Environment | Relaxing - Social | Work |
| Interface | Easy to Use Remote | Functional |
| Display Size | 26" to 100" | 12" - 26" |
| Display Location | Across The Room | Desk |

PORTABLE PRODUCTS

## NII SERVICES IN THE HOME

**Digital TV Center**
- Television
- Interactive Television
- Video-On-Demand
- Games
- On-Line Services
- Phone-Picture Phone

**Computer Center**
- Computing
- Word Processing
- On-Line Services
- Internet
- Electronic Mail
- Games
- Phone-Fax-Picture Phone
- Audio-Video

**Portable Interface**

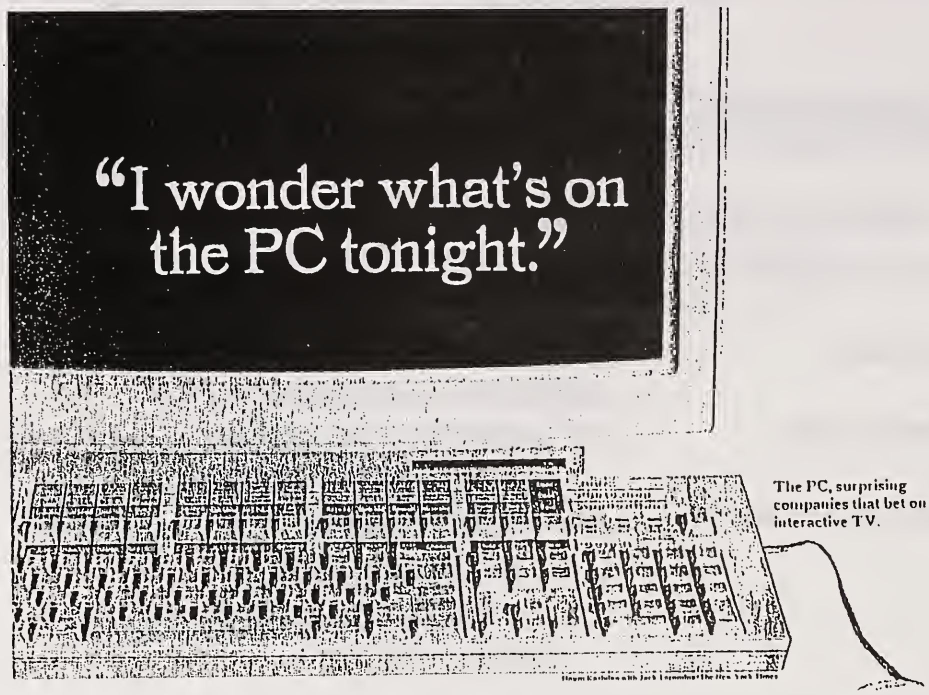
| | |
|---|---|
| Telephone | Radio |
| Cellular | Audio |
| Pager | Television |
| Computer | Interactive Products |

The New York Times

**Business**

Sunday, May 8, 1994

Section 3




The PC, surprising companies that bet on interactive TV.

## CONCLUSIONS

1. The use of separate computer and digital television centers in the home:

   - Provides best match to human behavior patterns.
   - Provides for NII interactive services for all respective levels of competence.
   - Takes advantage of respective consumer interest in television and in computers.
   - Maximizes development of NII type hardware, networks and software.
   - Provides for the most rapid introduction, and thus benefits, for advanced NII Services to all segments of our society.

## CONCLUSIONS

2. Expeditious Adoption of the Grand Alliance HDTV standard:

   - Provides for a universal 20 Mbps packetized platform that is optimized for a maximum number of applications and media.
   - Minimizes the plethora of incompatible de facto digital video standards and services.
   - Allows the strong consumer interest in television to be used to implement the installation of a flexible 20 Mbps service into homes.
   - Helps preserve free over-the-air television.

## CONCLUSIONS

3. A crash program to utilize the 1996 Olympics to demonstrate the attractive features of HDTV and interactive NII:

   - Will draw attention to the merits of NII and HDTV.
   - Will expedite development of a variety of products and services.
   - Will allow the U.S. to maintain strong worldwide leadership in NII and HDTV.
   - And, will expedite the broad adoption of NII and HDTV.

# The National Information Infrastructure and the Grand Alliance ATV System

## A Commentary on Some Aspects of Interoperation

*Peter D. Symes, Grass Valley Group*

## 1. INTRODUCTION

Two major advances in technology are in the planning process in the United States. The National Information Infrastructure (NII) will make a wealth of information easily accessible to industry, educators, and the public; the proposed "Grand Alliance" (GA) Advanced Television System (ATV) will allow the distribution of high quality pictures in digital form, and of other digitally encoded information. Both systems are digital in nature, and both are designed to be accessible to the public at large. It is recognized that efficient dissemination of information frequently requires a combination of images and other data. There is, therefore, enormous potential benefit if the two systems can work together effectively.

Much discussion of this issue has concentrated on the image scanning formats proposed for ATV, and how these relate to the requirements of computer displays. Detail on these issues have been documented elsewhere. This paper discusses some fundamentals of images and displays, and contrasts the requirements of a "real world" imaging system with those of a computer workstation.

The NII will be general purpose and will support a diverse and ever growing set of applications. Many of these applications will require display of text and graphics as on a workstation; some will require real world imaging; others will have very specialized display requirements.

The proposed ATV system addresses a very specific objective, and provides an excellent mechanism for transmission of real world images. As such, the GA system can be a key component of the NII. The paper discusses possible uses of the GA system by NII applications, and also suggests ways in which ATV could provide a part of the NII infrastructure.

## 2. IMAGES AND DISPLAY: DIFFERENCES IN OBJECTIVES BETWEEN ATV & THE NII

### 2.1. The Nature of Images

Computer systems and television systems both produce images on a display. However, the two systems are optimized for different types of image, and this leads to different design parameters and different compromises.

Television systems are designed to capture images (usually moving images) of the real world and to convey these images to a viewer - a concept similar to that of photography. To achieve pleasing results, artifacts resulting from the system used to sample the image must have low visibility to the viewer (for example, under normal viewing conditions, the viewer should not be aware of the line structure of the display). This requires that a television system limit fine detail in the image to that which can be accurately represented by the sampling system, without significant artifacts (the Nyquist rule). Television systems must not produce significant artifacts when fine detail moves across the sampling structure in any direction.

Computer images are usually generated by the computer from primitives. The primitives may be text characters from a font, or graphic objects such as lines, circles etc. The primitives are "rendered" by the display system into an array of memory elements (pixels), appropriate to the resolution of the display. The display system, can take advantage of its "knowledge" of the display to place the primitives in an exact relationship to the pixel array. This technique allows, to a limited degree, the use of finer detail than would be permitted by a Nyquist limited system. Computer applications take advantage of this approach to permit the display of, for example, single pixel lines.

The example of a single pixel line highlights one difference in objectives between television and computer imaging systems. The single pixel line is displayed correctly on a computer display only if it is exactly horizontal or vertical. If the line is rotated slightly, its display is heavily artifacted. Similarly, if single pixel lines or objects with very sharp edges are moved on the display, there is a high level of motion artifacting. In the computer world, this is a small price to pay for the additional precision possible in such applications as engineering drawings. In the world of television and natural imagery, a line should appear the same whether it is horizontal or nearly horizontal, and strong artifacts are not acceptable when an object moves.

It must be emphasized that neither solution is "right" or "wrong." There is a fundamental difference between a "scene" that a viewer will "watch" and an information rich image where the viewer is expected to "study" detail in small areas. Each approach represents an appropriate optimization of cost effective technology for a particular application. However, such differences must be considered when deciding how the technologies can best be used together.

### 2.2. The Nature of Displays

Both computer and television systems use some form of video display. However, not only are there differences in the nature of the image to be displayed (as discussed above) but the assumed viewing conditions are quite different for the two applications.

A computer display (the "workstation display") is designed to be "read." Typically, the viewing distance is less than two feet, and frequently the viewer will lean forward to study detail in part of the image. All parts of the image must have nominally the same quality. These conditions impose very strict requirements on the display - the dot pitch must be very small, brightness uniformity must be excellent, and registration, geometry and focus must be consistently good over all areas of the screen. With today's CRT technology these factors mandate the use of small deflection angles (90° or less). Interlaced displays are generally not acceptable for computer applications. Because the information being displayed is not Nyquist filtered, edges show pronounced flicker. An obvious example is the single pixel line discussed above - such a line will be displayed only on alternate fields.

The domestic television display (the "armchair display"), on the other hand, is designed for a typical viewing distance of seven to ten feet - a good distance for relaxed viewing. The displays must be bright, but relatively large dot pitches may be used. The human psycho visual system is quite tolerant of variations in picture brightness and quality. A typical television display will be much less bright at the edges than the center, and convergence, focus and geometry will all be substantially worse at the edges and corners than in the center. These compromises greatly reduce the cost of the display, and permit the use of wide deflection angles in the CRT (110 or more). This factor alone is important for television receivers as it permits quite large screen sizes with reasonable cabinet depths - an important factor in the living room environment. The use of interlaced scan also helps reduce the cost of the display, and will likely be chosen for many domestic displays even in the future. Such a display provides a very cost effective solution for entertainment viewing of television programs, but is quite unsuitable for computer applications.

Some measure of the significance of these factors can be obtained by looking at today's market. A 20" diagonal NTSC television receiver is regarded as quite small, and can be purchased for $200 - $300. A 20" diagonal computer display is regarded as quite large, and will cost $2,000 -$3,000. Some of this difference is attributable to the much larger volume of television receivers, but much results from the fact that the computer display is a precision instrument.

It may be argued that these distinctions are a function of CRT technology. Certainly at some time in the future directly addressable flat screen displays will be the norm for both television and computers, and issues such as geometry and convergence should disappear. However, the question of dot or pixel size will remain. For a given number of pixels and equal apparent size and sharpness, a display for a viewing distance of eight feet will be four times the size of one designed for viewing from two feet, and the pixel size and pitch will be four times greater in each direction. The workstation display will still be too small for entertainment viewing, and the armchair display will still be unsuitable for close viewing.

### 2.3. Interoperability - Video on Computer Displays

Despite the above, television and computer systems can interoperate to a useful degree, provided the limitations of the systems and the display environments are taken into account.

Neither the display nor the architecture of most computer systems is optimized for the display of video images. Nevertheless, many computer systems can display these images, usually in a window. Given the relatively small size of this window on a typical workstation display, the video information is frequently decimated for display (reduced to one fourth or less of the total pixels), and this substantially reduces the load imposed on the system while providing acceptable results. All modern computer displays utilize square pixels, so the computational load is much less if the video to be displayed uses square pixels. All proposed ATV formats have square pixels.

High quality workstation displays have a nominal display refresh rate of 75 Hz or above (some European administrations require 76 Hz or greater). Note that in most computer systems, all applications run asynchronously with respect to the display, and this is generally true for video display also. This results in display flicker with a frequency equal to the difference in the video frame rate and the display refresh rate. This is generally not disturbing if the frequency difference is 15 Hz or greater - a condition that is met with a video rate of 60 Hz and a display refresh rate of 75 Hz or more. It is important to recognize that if the video rate were to be increased to 72 Hz or 75 Hz as advocated by some parties, artifacts would be far worse as flicker rates of a few Hertz (or a fraction of one Hertz) are very disturbing. Acceptable results would be obtained only if computer display architectures were changed to synchronize the display refresh rate to the video frame rate (and this solution would be viable for only one video at a time).

### 2.4. Interoperability - Computer Information on Television Displays

Computer text and graphics can be carried by a television system and displayed on a television receiver provided the limitations of both are recognized and observed. On NTSC receivers the low luminance resolution and the very low chroma resolution have imposed severe limitations, and a resolution of 320 x 240 is the most that can be used with any degree of success. However, the viewing environment must also be considered; to the viewer of an armchair display interoperability is achieved only if the information being displayed can be used from the armchair. Successful interoperability of computer technology and NTSC receivers is characterized by applications such as on-screen programming of VCR's, where the information density is very low. (It should be noted that this comment applies to the general case of computer text and graphics. Even in NTSC, a system designed specifically for television can produce very useful graphics.)

In the ATV environment, the increased resolution of the system, and the likely improvement in display quality and size, mean that significantly greater information densities can be considered. Television transmission and display will be best utilized if text and graphics information is appropriately filtered. It is probable that computer generated information with a resolution of 640 x 480 can be carried effectively by any of the proposed Grand Alliance transmission formats, and displayed by most ATV receivers. Note that this is the resolution used by the majority of computer displays today.

The Nyquist filtering does impose some limitations. Information designed to exploit the characteristics of a computer display system and a workstation display will not be as effective when displayed on a television receiver. For example, a single pixel line will be made wider but less intense by the Nyquist filtering. (However, if such a line is rotated or moved, aliasing will be dramatically less than on a workstation display.) A progressive display will provide a more pleasing result than an interlaced display, but the Nyquist filtering will remove the gross artifacts that make interlaced displays unacceptable in workstation applications.

## 3. OTHER DIFFERENCES BETWEEN ATV AND THE NII

### 3.1. Specificity

The ATV system is designed for a very specific goal; to provide transmission of high quality moving pictures. Further, the system is optimized for "real world" scenes and so is designed to reproduce a sequence of bit-map images. Note that this is a very inefficient way to transmit computer generated (non "real-world") images. In the proposed Grand Alliance system, extensions are provided to permit the system to be used for more general purposes.

The NII, by its very nature, is general purpose. The intent is to provide access from businesses, schools and homes to any information that can be conveyed in digital form, wherever that data is located. Images represent just one possible data type, and real world scenes just one subset of that type. The ATV system can be a key element of the NII by providing the mechanism for conveying real world images when these are required.

### 3.2. Directionality

The ATV system is a broadcast system, designed to convey information from one point to many points. As such, the system design assumes that many users in different locations will want the same information. The system is uni-directional—no mechanism is provided for reverse information flow. However, 2-way protocols may be layered around the GA system when required, and cable systems could provide a reverse data path.

The NII will be useful only if a user can obtain the specific information he or she requires. Bi-directional information flow is a prerequisite. (Note that the required data bandwidth will almost always be asymmetric. In general a small amount of information from the user will result in a large amount of information being conveyed to the user. This will be discussed below.)

### 3.3. Delivery Mechanisms

The ATV system is designed for transmission over a 6 MHz terrestrial television channel, or over a channel of a cable system. As an extension, the proposed Grand Alliance system is designed to permit delivery of ATV data streams over suitable high speed data networks such as ATM.

The NII will have to use a wide range of transport mechanisms ranging from high speed Sonet backbones to local end POTS or conventional modems. It will be able to employ the ATV system as a part of its delivery infrastructure.

## 4. COMPLEMENTARY USES OF ATV AND THE NII

Much discussion on interoperability between ATV and the NII has focused on how ATV can be made to conform to the requirements of the NII and computer applications. As discussed above, there are many fundamental differences between the objectives of the two systems, and total conformity may not be possible. Some parameters are critical to ease of interoperation, most notably the use of square pixels which are now incorporated in all formats of the proposed Grand Alliance system.

Conformity may not only be impossible; it may be unnecessary and undesirable. Greater benefit may result from recognition of the fundamental differences and by appropriate complementary use of the systems, taking advantage of their differences.

### 4.1. Real World Scenes as an NII Data Type

This is perhaps the most obvious cooperative application of the systems. When there is a need to transmit real world video scenes over the NII, the Grand Alliance system provides a mechanism for encoding this information. The manufacture of ATV receivers should mean that GA decoders are available at reasonable prices for inclusion in computer systems. The GA system includes provision for re-packaging GA data into ATM packets for transmission over NII infrastructure. (It is possible that future definition of a direct MPEG/ATM interface may offer greater efficiency.)

Note that any of the Grand Alliance video scanning formats may be used. If the highest possible resolution at the highest possible temporal rate is required, service providers could use the 1920/1080/60/2:1 interlaced format. If interlace artifacts are not acceptable, the choice may be made between lower spatial resolution (1280/720/60/1:1) or lower temporal resolution (1920/1080/30/1:1 or 1920/1080/24/1:1).

If the images are to be displayed on a workstation display, the GA decoder will likely be incorporated into the display system, perhaps permitting a variety of window sizes. In such an implementation large quantities of uncompressed video data will not need to be passed over the processor bus. If the images are to be displayed on an ATV receiver (perhaps in a classroom environment), the compressed data stream may be passed directly to the receiver provided a suitable data interface is standardized.

Some applications may not tolerate the artifacts that will result from the GA compression system, and lossless coding schemes may be required (a possible example is remote diagnosis). However, the GA system may be appropriate for still images even in critical applications - after a few frames the level of artifacts should be very low. The GA should be used within the NII when it represents the best tool for the job.

### 4.2. NII Data as Supplementary Information to Television Programs

Providers of educational programming (for example) may wish to supplement the video/audio material with other data types originating from the NII. The viewer might to choose to display this data on a separate workstation, or to superimpose it on the program video. If the supplemental information is transmitted as ancillary data over the ATV system, either choice could be made.

## 4.3. ATV as a Part of the NII Infrastructure

One of the most challenging aspects of the NII is the provision of suitable data paths to the community. Plans exist to provide such paths, but it will be many years before high speed data services are available at reasonable cost to most US households.

As noted above, the data bandwidth requirements for service of an NII user are typically asymmetric. A low data rate (and low cost) modem connection will usually be more than adequate for the information flowing from the user (and often for text based information going to the user). Images, even still images, and other large files require a higher bandwidth if they are to be transmitted to the user in a reasonably short time.

The ATV system has the potential to provide an important part of the NII infrastructure during the early years. Even when transmitting high definition video, a television station could provide perhaps 1 Mb/s for ancillary services. If the video is derived from a lower definition standard (as will be common in the early years of ATV), or from film (with its lower temporal rate), more data bandwidth could be made available. When the station is transmitting stills or graphics, a large part of the 19 Mb/s could be used for other data. If proposals to increase broadcasters' options for use of the ATV channel are adopted, very large data bandwidths might be available for part of the day. A cable operator may choose to dedicate one or more channels to data delivery. A single (RF) cable channel can provide 38 Mb/s.

All these services are broadcast, so the data capacity is available only once (per channel) to the whole community served. However, NII users requirements will be sporadic rather than continuous, so given a priority-based charging system, useful service could be provided. A market with five television stations could provide an average data rate of perhaps 10 Mb/s (about 100 Gigabytes/day) total to serve households not connected to high speed data services or cable.

The Grand Alliance has described a method for transmission of ATM packetized data within the ATV data stream. If ATM is to be the standard NII interface for personal computers, this would represent an appropriate mechanism. However, it may be preferable to strip ATM headers and re-packetize data addressed to an NII user. Simpler interfaces could then be used from the ATV decoder to a personal computer.

## 4.4. Graphics Services

Bit map representation of an image is appropriate for real world scenes, but very inefficient for most computer generated visual information. The NII will need to transmit a great deal of graphical information and, in general, the software application that generated the information will not be available at the receiving computer. There is a need therefore for an NII Standard, perhaps consisting of a set of graphics primitives, that will be implemented by all NII compliant terminals. (an existing standard such as X-Windows may be chosen).

Television broadcasters and cable companies need to superimpose graphics (logos etc.) over network video feeds. A conventional approach to this problem would require that the network signal be decoded at the local station, and re-encoded after adding the graphic. This process is expensive, and will cause significant signal degradation. An alternative is to add the graphic at the receiver. If the receiver decoder incorporated graphics primitives, the logo information could be sent over an ancillary data channel and the bit-map generated in the receiver. There may be an opportunity for the television industry to use a subset of NII graphics primitives within ATV receivers.

## 5. CONCLUSIONS

### 5.1. Concentration on a Common Display for ATV and the NII is Counterproductive

As discussed above, there are fundamental differences in requirements for workstation displays and armchair displays. A display that is large enough for entertainment viewing would be unacceptably expensive if it also had to meet the requirements of a high quality workstation display. In fact, such a display is likely to be more expensive than two separate displays, each optimized for its application.

Most users of the NII will require a personal computer with its own display. The goal of widespread use in US households will not be met if NII access inhibits simultaneous viewing of entertainment television. The ability to display NII information on an ATV receiver will certainly help to achieve initial penetration of the NII, but this can be achieved if the ATV system can utilize a resolution of 640 x 480 for NII applications. This format must be supported by the NII as it represents the majority of computer displays in the market today. (Note that for maximum accessibility the NII should also be accessible via a low-cost adapter feeding an NTSC receiver, probably using a resolution of 320 x 240. There are well over 100 million such receivers in the USA today.)

It must be emphasized that there can be no single display format for the NII. The minimum requirements should be as low as possible to maximize accessibility, but some applications will require much higher quality than the minimum. Users of such applications will need to have a suitable display.

### 5.2. Interoperability is Not the Same as Conformity

Some common ground is essential for interoperability, but the greatest benefits of cooperative use are obtained by exploiting the strengths of each technology. The NII will use many tools, and ATV will be most useful as an NII tool if it is optimized for the transmission of real world images.

### 5.3. ATV Interlace in No Way Inhibits Interoperability with the NII

No NII application has to use the interlace format. As discussed above, an NII service provider can and should choose the format most suited to the application.

Interlaced displays would likely be used on some ATV receivers even if the interlaced transmission format were to be abandoned. Receiver manufacturers will offer a range of models with different compromises on size, quality and cost.

Quite apart from the views expressed by the computer community, there are many in the television industry who would prefer that the ATV system include only progressive scan transmission formats. The forthcoming tests of the Grand Alliance system should provide good data on viewers' preferences for higher resolution with interlace, or lower resolution progressive. The tests will use many different types of source material and should reveal whether there is benefit in retaining an interlaced format. Whatever the outcome, this decision should be left to the television industry, and this can be done without detriment to the NII.

### 5.4. Cooperative Use of ATV and the NII Can Provide Many Benefits

The Grand Alliance compression scheme can be used within the NII for coding video and audio data types. Terrestrial broadcast and cable systems transmitting ATV may be able to provide a valuable contribution to the NII infrastructure and improve the accessibility of the NII, particularly in the early years.

Appropriate interoperability can greatly enhance television programming services, particularly for education. Use of NII technology may assist broadcasters in deployment of ATV.

### 5.5. Interfaces Must be Defined

Provisions have been made for conveying ATV data over ATM systems, and for conveying NII data over the ATV system. Cooperative use of ATV and the NII will require connection of ATV receivers to personal computers and/or computer networks. Rapid definition of hardware and software interfaces is essential if these connections are to be possible with early ATV receivers. The television and computer industries should work together closely to ensure that the potential benefits are not lost.

# A Commentary on Requirements for the Interoperation of Advanced Television with the National Information Infrastructure

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## 1.0 A HISTORICAL PERSPECTIVE

As a reader of this commentary it is highly likely that you are an active participant in the process of re-engineering several critical infrastructures that will have a profound affect on life in the 21st Century. We are experiencing, and perhaps affecting, a fundamental restructuring of the industries that facilitate mass and interpersonal communications, and those that create the lion's share of the entertainment and information products consumed today.

A rapid geometric progression in the performance of digital processors, together with a similar progression in digital storage and network bandwidth, is the driving force behind the re-engineering of our existing electronic communication and information infrastructures. The industries responsible for developing these infrastructures have evolved during the "industrial age" to become part of the fabric of our lives and an indispensable component of the world's economic and political systems.

It would, however, be a costly and time consuming mistake to base decisions about the emerging digital world on the characteristics of the analog world of the first century of electronic communications. These infrastructures and the industries that they spawned are mere infants in the history of communications. Their current form is heavily influenced by the immaturity of electronic technology upon which they are based and the fervor of the privileged few to control the flow of information for economic and/or political benefit.

Enabled by digital technology, we are participants in the first skirmishes of a revolution in communications that will fundamentally change every assumption upon which these industries are based. The technical gurus and boardroom captains of these industries are nearly powerless to control their destinies. History has proven that fundamental changes such as those we are currently experiencing tend to favor the innovators rather than those with well entrenched interests to protect.

Word of mouth and handwriting existed for thousands of years before the invention of movable type by Johann Gutenberg in the fifteenth century. According to *Funk & Wagnalls New Encyclopedia of Science*: "Printing soon became the first means of mass communication. It put more knowledge into the hands of more people at a faster and cheaper rate than ever before."

Perhaps Gutenberg envisioned the day when everyone would have access to a printing press to publish their ideas, but the institutions of that era quickly learned about the power of this new communications tool. It's not surprising that the first book to be printed was the Bible, or that The Church attempted to control the flow of information. The Inquisition became the first of many institutions to ban the publication of ideas that threatened the prevailing views upon which their power was based.

The Renaissance is now viewed as a historical period that heralded the modern age, characterized by the rise of the individual, scientific inquiry and geographical exploration, and the growth of secular values. The invention of printing by Gutenberg provided a powerful instrument for the spread of learning and Reformation ideas, bringing the Renaissance period to an end. Yet, for nearly five centuries the "few-to-many" paradigm of mass communications prevailed, as those who controlled the presses managed the flow of information.

With the introduction of electronic mass communications in the 20th Century the few-to-many model has enjoyed a brief renaissance. Not unlike the classical Renaissance, the 20th Century may be remembered as a historical period that heralded a new age, characterized by the rise of the individual, personal inquiry and geographic exploration, and the growth of minority values. History will note the technology that enabled this modern renaissance, also led to its undoing. While it provided institutions with vastly more powerful tools than the printing press to control the flow of information, it also provided the first instrument of long-distance interpersonal communications, the global telecommunications network.

It is doubtful that Gutenberg could have predicted that the personal computer and laser printer would enable a revolution in personal publishing. Or that the inter-networking of these personal computers might obviate the need for the printing press altogether!

While Gutenberg was content to turn lead into type, most of the technologists of his era were busy trying to turn it into gold. History now teaches us that the alchemists were working with the wrong raw material. Today's alchemists are transforming silicon into products that are orders of magnitude more valuable that their weight in gold.

For example, the Video RISC Processor developed by C-Cube Microsystems has demonstrated the feasibility of MPEG compression. It takes two of these $4,000 chips to encode 1.5 Mbps SIF resolution (320x240x30 fields/sec) MPEG streams in real-time. Eight chips are required for near CCIR-601 imagery (4:2:0)--the result is MPEG 1.5 encoders that cost about $80,000. Recently a manufacturer of one of these encoders informed me that FIFTEEN of these chips will be required to handle the enhanced encoding capabilities of MPEG-2. Let's put this into perspective: an ounce of gold is worth about $300; fifteen silicon wafers, which would blow away in a light breeze, currently sell for $60,000; meanwhile; digital NTSC/PAL decoder AND encoder chips currently sell for about $30.

While this example may not sound like the stuff revolutions are made of, it's important to note that MPEG is still in the embryonic stage. It is also important to note that the highly asymmetrical nature of MPEG encoding is optimized for the few-to-many model of mass communications. Meanwhile, other embryos are developing rapidly. The quality of video that can be compressed and decoded using software codecs, programmed to run on general purpose CPUs, is approaching the quality of 1.5 Mbps (SIF) MPEG-1 coding.

The virtue of any compression approach is not in question here, as each will succeed or fail based on the dynamics of the marketplace rather than the elegance of the implementation. What's important is that digital compression is now accepted as a fact of life, and robust markets for the application of this technology are developing. In the process we are creating vast new reserves of a scarce resource...BANDWIDTH.

The scarcity of this resource during the first 100 years of electronic communications has to a large extent dictated the few-to-many paradigm of mass communications. Meanwhile, tariffs based on scarcity, have limited access to broadband point-to-point communications services.

The rapidly developing abundance of this resource and the pending deregulation of many communications industries will provide vastly improved access to communications services for institutions and individuals by the dawn of the new millennium.

At the recent NIST ATV/NII Workshop we learned that only 5% of the fiber-optic cables installed in the U.S. are currently "lit." What's more, this reserve communications capacity is just the tip of the iceberg. It is estimated that an additional $300-500 billion will be invested in new communications bandwidth in the U.S. by the end of this decade. Worldwide the total will exceed a trillion dollars.

The digital revolution concerns the ways in which society will put this resource to work:
- It's about access to bandwidth--for the providers and consumers of media content (entertainment, education, information, etc.);
- It is about people communicating with people--a shift in the balance of power from few-to-many to many-to-many;
- It is about personal choice--What You Want Is What You See;
- It is about empowering the individual to ASK rather than being TOLD.

### 1.1 The "REAL WORLD"

What I have just described is the "real world" that participants must consider in the process of designing the National Information Infrastructure (NII) and one of its important components--Advanced Television (ATV). Unfortunately, at the recent NIST ATV/NII Workshop, attention continued to be focused on justifying differences in the objectives of ATV as proposed by the Grand Alliance and the requirements of the NII.

It was said that the GA System is optimized for the delivery of "real world" imagery to consumers in a home entertainment environment while the NII must be optimized for personal interaction and the delivery of other information types such as text and graphics, currently epitomized by the computer workstation. The requirements for television and computer workstation displays were declared to be justifiably different, while the impending convergence of these requirements was again denied.

Broadcast television as we know it, however, is a poor substitute for a "real world" communications system. In addition to the optical filters which it introduces so that visual images can be delivered to a rather limited transducer (a composite video display), the content is also filtered by the producer. The observer has limited, if any, ability to explore the environment where the camera exists or to interact with the people who are there. The proposed ATV system does little to change this picture--while the cost of the system's transducers increase dramatically, the improvement in features &benefits for broadcasters and their consumers will be at best marginal.

The justification of ATV scanning formats being optimized for real world imagery also ignores the fact that much of the information conveyed by today's television systems is not found in the real world--text, graphics, animation and manipulated raster images do not exist there. And the television industry rarely generates this kind of imagery by pointing a camera at it. Instead they rely upon imaging tools optimized for the world of computer workstations.

I'll concede that the ultimate challenge for these computer based visualization tools is to create the illusion of reality--a task they have handled for the past several years at television resolution. In the past year Hollywood has demonstrated that high resolution image rendering is both feasible and economically viable for many of their applications.

Most unfortunate, is the fact that little time was spent at the NIST workshop discussing the technical, economic and social realities of the "real world" of the NII and ATV. This commentary will attempt to focus on these issues.

## 2.0 TECHNICAL VIABILITY

While a great deal of attention is focused on the specific objectives of ATV, it is important to note that the proposed system will fall far short of these objectives for many years after the introduction of digital broadcasting. In fact, the ACATS process is now starting to explore alternate uses of the proposed digital broadcast channels--such as multiple lower resolution programs--to supplement the GA formats.

The GA system proponents are quick to point out that it took nearly fifty years to realize the full potential of NTSC broadcast system, and that reasonable headroom for extensibility must be provided in the ATV standard. The proponents of an interoperable, scalable and extensible system counter that digital technology is inherently programmable and scalable--that there is no need to encumber the system or the consumer with the transmission of information that will for all intents and purposes be thrown away by the vast majority of consumers.

Suitable display technology does not currently exist to deliver the "HDTV viewing experience" to the mass home entertainment market. The only display technology capable of delivering this experience in the typical viewing environment that exists today--a family room with an average viewing distance of seven to ten feet--is a projection system that currently cost more than $25,000. Direct view CRT displays can deliver the required resolution, but at a viewing distance that has more in common with a desktop workstation than the family room sofa or recliner--and the price of such a display is still unreachable by the vast majority of consumers.

### 2.1 Viewing Requirements

The place to begin a discussion about display requirements for ATV and computer workstations is with the basic physics of human visual perception. This was the approach taken in the SMPTE Task Force Report on Digital Image Architecture (DIA), to which I would refer anyone who is interested in a more detailed explanation of this subject.

Viewing distance is one of several critical variables that must be taken into account when determining the display requirements for a specific application. Field-of-view and resolution requirements are the other major variables in this equation. Beyond certain minimum thresholds, brightness limits the maximum ambient lighting of the environment in which the display can be viewed. Assuming the application dictates the viewing distance, field-of-view and resolution requirements, it is a simple matter to determine the size of the display and the dot size of the picture elements. This is not to say that it is a simple matter to build large high resolution displays.

A state of the art NTSC home entertainment rear projection display with a 50 inch diagonal viewed at a distance of 9 feet, provides approximately 10 cycles per degree (cpd) of perceived horizontal resolution over a 25 degree field-of-view (vertical resolution is somewhat lower). The specific objective of ATV--the HDTV viewing experience--has been defined to be a perceived resolution of greater than 20 cpd, over a 30 degree field of view, at approximately 3 picture heights. At the same viewing distance of 9 feet, such a display would require a screen diagonal of about 6 feet. By comparison, the typical 14 inch computer display with 640 x 480 picture elements, when viewed at the recommended viewing distance of 30 inches, has a perceived horizontal resolution of 20 cpd and a field of view of less than 20 degrees.. The specific objective of ATV exceeds by a considerable margin the requirements for mass market personal computer displays--this objective is comparable to the performance of high end 2 megapixel workstation displays, which currently cost more than $20,000.

The personal computer and HDTV viewing experience share another important characteristic that is largely missing in television today. People tend to employ visual search techniques when working with a computer, acquiring high resolution views of certain information on the display. As pointed out in the DIA Task Force report, the human visual system needs time to acquire image detail--it typically takes several hundred milliseconds to acquire a high resolution image, whether it exists in the real world, or on an information display.

The same is true of the HDTV viewing experience. The wide field of view and increased resolution change the viewing experience from a passive couch potato event to one that attempts to simulate reality. A major factor in determining the parameters for the HDTV viewing experience were studies to measure the human threshold for the induction effect--the size of screen, viewing angle, and viewing distance required to induce the sensation of reality. When this threshold has been passed the viewer must employ visual search techniques, as there is too much information in the field of view to be processed as a single high resolution "human" image grab. The induction effect is an important aspect of the cinema experience, a feature that movie producers often take into consideration when creating their "virtual realities."

In his paper, The National Information Infrastructure and the Grand Alliance ATV System--A Commentary on Some Aspects of Interoperation, Peter Symes reviewed other compromises in the current generation of consumer television displays. "A typical television display will be much less bright at the edges than the center, and convergence, focus and geometry will all be substantially worse at the edges and corners than in the center."

If consumers continue to view entertainment displays from seven to ten feet that cover only a small viewing angle--as will be the case for direct view CRT based ATV displays--we can continue the practice of giving them displays with poor focus, poor convergence, poor geometry, and lower brightness near the edges. While I doubt that these are specific objectives of the ATV process, it appears that they are a necessary compromise to meet the real world objective of affordable receivers for the GA system. If, however, we give the viewer the true HDTV experience, including the option to search the image for detail, they will see all the defects that Symes describes. If the display is bright enough to operate in a normally illuminated family room, it is likely that viewers will begin to perceive 60 Hz broad area flicker as more extra-foveal image receptors will be stimulated because of the increased field of view.

It is important to reiterate that for a given application the laws of physics dictate the display parameters. If we want a television system with the resolution and field of view that have been established as the specific objective of the GA system, we will need to provide a display that exceeds the performance of the majority of today's computer displays. If we can't afford to pay the price of meeting *this* objective, perhaps we need to consider a less ambitious objective that matches up today's technology.

Such an objective need not be an interim solution or a substitute for ATV. Rather, it is an important part of a digital imaging hierarchy that will always be required to meet the price/performance objectives of certain applications. It will be the first step in an extensible digital system that will enable a graceful transition to higher resolutions as the enabling technologies are developed.

**2.2 Interlace, Progressive Scan, Nyquist & Kell**

One must ask why this issue will simply not go away? It's as if nature is playing a cruel hoax--trying to restore the ATV process to equilibrium, by consuming time that would be better spent discussing the potential of the applications of the precious bandwidth we have gained through digital video compression, with this endless controversy over an irrelevant throwback to the dark ages of television--the first half of the 20th Century. Yet the debate continues to consume vast amounts of our time..."another day's useless energy spent" (Moody Blues--Days of Future Passed).

It would seem that this issue boils down to a single pixel line. A progressive scan displays accommodate their use while on an interlace scan display they may create obnoxious artifacts, especially when they appear in only one interlaced field. Nyquist figured all of this out way back in the dark ages, yet he is routinely cited as supporting the claims of both sides in this debate. How can this be?

Nyquist, and one of his disciples, Kell, studied the physics of scanned CRT displays and determined the limits of detail that can be sampled and presented using interlace and progressive scanning. Their work does not tell us that you can't present certain types of information on one display and not the other, it just warns us that the customer may not be please with the results, because of the real culprit...aliasing.

Fact is, that a single pixel horizontal line can be presented on both interlaced and proscan displays--it's just that the flicker will drive the viewer crazy on the interlaced display and they won't watch your program. It's also a fact that when Nyquist's limits are observed to prevent aliasing, on both entertainment and computer displays, they behave pretty much the same--except for the aliasing artifacts caused by interlace.

In his commentary, Peter Symes correctly states that NTSC provides a useful resolution of 320 x 240--this is consistent with the Nyquist/Kell limits on vertical resolution for interlaced displays and Symes' requirement that lines not exhibit aliasing artifacts at any angle. In the television world, lines do not look the same at all angles of presentation unless they are uniformly filtered to the lowest Nyquist limit of the display. If Nyquist's rules are followed for an interlaced display nearly half of the potential horizontal resolution must also be sacrificed--otherwise vertical lines might appear sharper than horizontal lines, or an angled line might exhibit aliasing artifacts as it moves in a vertical direction. The success of VHS as a consumer videotape format is based in part on the fact that the system delivers approximately equal vertical and horizontal resolution, which is well matched to the current generation of interlaced displays. Based on the artifacts seen in graphics and sports coverage on TV today, it seems that most video producers deal with Nyquist in much the same fashion as you and I observe the speed limits on the interstate...pushing things a bit past the limit.

Symes concedes that a 640 x 480 computer display can be said to have more resolution if we don't follow Nyquist's rules--but this is not really the case. Such a display can present higher frequencies--with the accompanying aliasing--only because the use of progressive scanning eliminates the objectionable flicker. The interlaced display can also present these single pixel horizontal lines...we just don't want to watch them. ON the other hand, if we want a 640 x 480 computer display to present a line at any angle without aliasing, we must anti-alias (filter) it, reducing the apparent resolution of the display to 320x240. This is a common technique in image processing and rendering programs.

Many computer applications take advantage of the fact that they can exceed the Nyquist limits to display highly detailed information such as CAD drawings, graphics for electronic pre-press, and visual databases. The aliasing that results is small price to pay for the precision achieved. Not only does it works for many applications, but commercial attempts to incorporate inexpensive anti-aliasing hardware in the video display sub-systems of computer workstations HAVE NOT been successful.

What's more, the discussion of when the use of Nyquist filtering is appropriate for an application is not relevant to the discussion of the convergence of computer and television technologies. Many computer-based image processing applications must deal with Nyquist resolution limits, as well as field based rendering of moving elements, restricted color gamut's and other limitations when images are rasterized for use on interlaced television displays.

These arguments point out one critical fact: An interlaced display can handle properly Nyquist filtered "real world" images, but it falls short for the presentation of many other types of information. On the other hand, a progressively scanned display can deal with Nyquist limited images--with a significantly higher vertical resolution--and the raster-aligned imagery found in computer applications.

One fact cannot be denied--coherent image sampling and display provide increased resolution and reduced display artifacts when Nyquist's rules are observed, and even higher resolution when Nyquist's rules do not apply to the information being conveyed.

Could this be the reason that the computer industry and many video professionals like myself, who desire improved interoperability, are so insistent about progressive scan?

**2.3 Spatio/Temporal Sampling and Display Refresh Rates**

The issue of temporal sampling and display refresh rates is another barrier to NII and ATV interoperability. The ATV proponents have conceded that multiple temporal acquisition rates are both feasible and desirable in a digital television system--there is little benefit in encoding information that is duplicated in processes such as the 3/2 pull-down used to prepare 24 fps film for NTSC broadcast.

Support for multiple formats by the Grand Alliance acknowledges one of the major strengths of a digital system--the ability to scale the spatial and temporal sampling characteristics of the acquisition system to conform to application requirements, and the ability of a digital display system to adapt to these scalable parameters. Unfortunately, the choice of formats, especially the temporal rates, was heavily weighted for interoperability with existing our existing analog transmission systems.

As with the decision to perpetuate the use of interlace, the current choice of temporal rates carries many potential artifacts into the future, especially when interoperation with the NII is taken into consideration.

I'll not attempt to rehash the debate that has taken place on this issue in this commentary. Let me simply state that a display refresh rate above 70 Hz will be required for many NII applications and to eliminate broad area flicker on large, bright, scanned displays.

One area that does deserve a few comments here is the ability of ATV and NII displays to present multiple asynchronous video streams. While interoperation with multiple video streams that originate at different frame rates may cause artifacts, few such applications require perfect synchronization. It's nearly impossible for a human observer to track multiple temporal events synchronously--we typically employ visual search (foveal vision) to track a single event, and use extra foveal vision to alert us to other temporal events that enter our field of view.

It's important to note, however, that the use of integer relationships between the members of a temporal family will significantly reduce the level of artifacts--at little or no cost--when multiple image streams are decoded at a single asynchronous location. Computers display systems typically employ buffering techniques that permit asynchronous operation.

Internal and external (communications and peripheral) data bus bandwidths will increase dramatically in the next generation of multimedia and desktop computer workstations, enabling the processing of very high bandwidth and/or multiple video streams. The increasingly widespread use of programmable display adapters and multisync displays by the computer industry are making it relatively easy to accommodate a new temporal rate family, should such a family be determined to be desirable for the interoperation of ATV and the NII.

When a serious discussion about the optimization of ATV for the transmission of real world images takes place, consideration must be given to additional image formats with both lower spatial and higher temporal resolution. The system must be capable of delivering imagery at multiple levels of quality to serve a range of information appliances at various price/performance levels.

### 2.4 Interoperability

Any discussion about interoperability should begin by noting that interoperation with current television standards is now a reality for many of today's most popular multimedia computer systems--one of the fastest growing segments of the consumer electronics industry. Stripped down versions of these multimedia PC's--including SGI Indy's and Macintosh A/V's--are being used in field trials of interactive digital cable.

At the professional level, video streams can be displayed quite acceptably at full NTSC or D-1 resolutions as we saw in many nonlinear editing and video server products at NAB. NTSC and D-1 video streams are now routinely rendered by desktop workstations--the resulting images are as good or better than those produced by any camera. What's more, these systems are scalable, accommodating applications from low resolution videoconferencing all the way up to photo-realistic film animation.

One of the most important aspects of interoperation with ATV displays will be the limiting resolution of the lowest common denominator display. Although the system may be capable of much higher levels of performance, content producers must decide if they want to serve everyone or a subset of what could turn out to be a limited market.

Given the proposed formats, and the limitations of current display technology, it is probably safe to say that the 1920 x 1080 interlaced format will be the lowest common denominator. Peter Symes correctly states that an interlaced display optimized for this format could present any information prepared for a 640 x 480 proscan display. As an ATV display would be wider (16:9), it would be fairer to say that it could deliver a resolution of about 854 x 480, roughly the same horizontal resolution as today's 17 inch computer displays (832 x 624 Mac) or (800 x 600 PC's). These displays now cost less than $1,000 and are rapidly overtaking 14-15 inch (640 x 480) displays in sales. Most of these 17 inch displays can also handle 1024 x 768 resolution, however, for most applications the information density is too great, even at a 30 inch viewing distance. This mode is useful for looking at high resolution stills such as photographs and medical images and large documents in CAD and electronic pre-press applications--the excessive resolution serves as an anti-aliasing filter.

One must ask, if 854 x 480 is the level of resolution that *most* ATV receivers can handle effectively, what benefit are we gaining by making the system carry all the overhead for the delivery of 1920 x 1080 pixel resolution? Is the additional horizontal resolution of this format an adequate justification for the cost?

At the NIST Workshop, it was noted that any of the Grand Alliance video scanning formats may be used. The Grand Alliance pointed out that 1280 x 720 x 60 x 1:1, would provide an interoperable, square pixel, progressive scan format for many potential NII applications.

This is well and good if the application demands the performance of this format, and the content need not be filtered for presentation on the lowest common denominator display. If, however, the application does not require this level of performance, the GA system provides no mechanism to scale down the required hardware--it must process the data used by the most capable display system. This completely ignores the real world of broadcasting, not to mention the NII, in which a wide range of price/performance alternatives will be necessary to serve various markets and applications. The unwarranted specificity of the GA system is it's Achilles heel.

There were significant discussions at the NIST Workshop about the potential applications for the transmission of ancillary data to supplement the visual content of an ATV transmission. For example, providers of educational programming could supplement ATV video/audio material with NII simul-datacasts or the data could be transmitted as ancillary data over the ATV system. The viewer might choose to display this data on a separate workstation, or to superimpose it on the program video.

Unfortunately, the ability to carry and display this type of supplemental information as ancillary ATV data is only feasible if interoperable standards are established for ATV and the NII. ATV receivers would then need to conform to a common set of standards for the synthesis and display of this information. These features do not currently exist in the GA proposal.

It was also mentioned that the ATV system has the potential to provide an important part of the NII infrastructure during the early years. If proposals to increase broadcasters' options for use of the ATV channel are adopted, very large data bandwidths might be available for part of the day. The use of broadcast channels for content distribution does not preclude interactivity with the program content, it only limits the ability to negotiate transactions for the delivery of specific content. Broadcasting may prove to be a very efficient method of data distribution in forward-and-store applications where a receiving device can be programmed to monitor broadcasts for specific information. It is also likely that data broadcasting will be useful for a variety of subscription services that may include motion video.

The weak link in digital broadcasting is the lack of a return data path to request the transmission of data. This provides a compelling argument for the interoperation of ATV with other NII infrastructures--both wired (cable/telco) and wireless (Personal Communications Systems). Such a collaborative approach could significantly enhance the value of data broadcasting, enabling a multitude of new subscription services.

Bandwidth and symmetry considerations are likely to be significant differentiating factors among NII service providers. Asymmetry will be a service assumption for many components of the NII, forcing the service provider to focus on certain applications. It is fair to say that broadcast applications will most likely be asymmetric, though it is likely they will be carried by networks that offer symmetrical services.

Currently, there is a perception that broadcasts are only available to consumers at the time of transmission (once per channel to the community served). Not only does this ignore the reality of time-shifting through the use of a VCR, it ignores one of the major benefits of adding intelligence to consumer information appliances--the use of intelligent agents. A personal computer or an intelligent ATV receiver--could be programmed to accumulate a database of user specified information from broadcasts and update this database as new information arrives--it would then be accessible on demand. Some data services might be repetitive, as is the case with CNN Headline News and the Weather Channel, while other services would be focused on real-time data casting, such as a stock quotation service.

## 3.0 ECONOMIC VIABILITY

The proposed GA system fails to meet several viability tests that preclude its adoption as a key component of the NII. IF the ATV system is deployed as currently defined, it is likely to be just one of many imaging systems competing in a rapidly evolving marketplace.

To begin with, the specific objective for which it is being optimized cannot be met with existing technologies at anything close to a price that would stimulate the development of a market. Only >$20,000 projection systems (plus the cost of an ATV decoder) can produce something that approaches the HDTV experience.

The Grand Alliance demonstration at the NIST workshop utilized a CRT based projector that costs more than $25,000. The LCD based projector prototype while promising, showed visible artifacts--commercially available LCD displays with this resolution currently cost more than $100,000. At a nominal viewing distance of 8-10 feet, the GA direct view CRT displays looked no sharper than the 525 proscan display in the other demonstration room.

An economic fact of particularly relevance to the NII is that a multi-million dollar investment is required to acquire, produce and distribute program content for the proposed GA system. This is clearly at odds with the need for an affordable digital imaging system for the NII. When will my son's high school or my doctor be able to afford an ATV camera?

A great deal of energy has been spent discussing the compromises that would be required to achieve interoperability between ATV and the NII. It's important to note that COST is typically the driving force in the compromises that determine the features of any standard or product that supports it. Using the characteristics of existing products to justify the perpetuation of differences is absurd, especially when technology is changing so rapidly. A feature that is cost prohibitive in one generation becomes standard in the next. The rapid evolution of personal computers is a case in point...or perhaps a sore point?

Once again, it may prove beneficial to contrast two points of view regarding product features versus cost. According to Peter Symes, "A 20 inch diagonal NTSC television receiver is regarded as quite small, and can be purchased for $200 - $300. A 20 inch diagonal computer display is regarded as quite large, and will cost $2,000 -$3,000. Some of this difference is attributable to the much larger volume of television receivers, but much results from the fact that the computer display is a precision instrument."

Manufacturing volume is a certainly a contributing factor to the difference in cost, however, the fact that the 20" computer display is capable of presenting about four times the information to the viewer at the designed viewing distance is probably more significant. With the addition of a $30 composite video decoder chip (mentioned in the introduction) to the computer's "video" circuitry, a 20 inch multisync computer display can also present the information in an NTSC data stream to a viewer at seven to ten feet with better results than a 20 inch television display.

One cost calculation that is typically overlooked when comparing single purpose information appliances, such as a television, with programmable multi-purpose appliances, is the perceived value to the consumer. Sales of cartridge based game systems have declined significantly, and new game systems with CD-ROM capabilities have not been successful, as parents are making the decision to invest in much more expensive multimedia PC's with CD-ROM drives. These systems can handle a variety of personal productivity tasks, play games, play audio CD's, and navigate through Multimedia CDs with information such as encyclopedias. They also allow individuals to explore cyberspace, by linking to the interactive global communications network. How do we determine costs and perceived value, when the integration of functionality provides new features and benefits not available with separate devices?

The convergence of ATV and NII technologies will be especially important to educational applications. Schools will need the financial leverage afforded by mass produced information appliances. Students will need to access educational programming and reference materials at home. Parents and teachers will benefit from the ability to communicate using enhanced NII capabilities. The current ATV proposals do not address any of these requirements.

## 4.0 INTER-PERSONAL-OPERABILITY

By now you may have questioned why I spent so much time in the introduction discussing the historic and social implications of the revolutionary changes we are experiencing, yet for the most part resisted the opportunity to draw parallels with this process.

I have learned a great deal from my involvement with this process. For years I ignored it, listening only to what I was *told*. Then one day, I *asked* someone who was involved in the process what he though about one of my ideas, which at the time I thought was original. He introduced me to other people with similar ideas, and soon I too was involved in the process. The more I asked, the more I learned. The fascinating part was that all of this took place through the global telecommunications network!

There are those who may feel that my contributions to this process have been counter-productive. That I have used the communications tools at my disposal--including the printing press--to attack the process and promote Utopian ideals. And there are those who feel my efforts are productive, focusing attention on critical issues and educating both the participants and the communites that are directly impacted by these decisions. Fortunately we live in a time and a place where this is possible.

I believe that ATV and the NII should empower the individual to ask for information rather than being told; that convergence is not only possible, it is necessary and desirable. It is my belief that greater benefit will result from recognition of the fundamental similarities of ATV and the NII and by appropriate complementary use of the systems, taking advantage of the flexibility of digital technology to adapt to specific applications.

Rather than spending our time justifying why these systems should be different, we should be considering how to merge both short and long term ATV and NII requirements, so that potentially vast new markets for visual communications products can be enabled. This approach cannot guarantee the successful launch of ATV services, but it has a far better chance at economic viability. In the process we will define an extensible path to future requirements such as the in-home theater with the full HDTV experience. We may even enable people to interact with distant environments and people...

as if *YOU* are really there!

# Arguments in Support of Embedded Multiresolution Signaling Strategies for HD Video Transmission

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The first and most obvious argument in support of embedded multiresolution signaling strategies is that it is absolutely necessary in order to implement a scalable HD video delivery concept. There are additional arguments in support of such an approach which are a bit more subtle. For example, one argument against embedded multiresolution signaling schemes is that this results in increased signaling constellation sizes and that, since higher SNR is required as the alphabet size grows to achieve a specified bit-error probability, this will result in higher transmitted power with associated increases in co-channel interference into existing NTSC channels. This argument, however, is only strictly correct for uncoded transmission. Properly designed modulation/coding schemes can provide reliable transmission while holding this increase in co-channel interference to a minimum. Furthermore, this interference can be made to look like wideband noise to the NTSC channel and thus results in a graceful degradation of the NTSC service. Finally, and perhaps more importantly, by employing an embedded multiresolution, signaling strategy, it is possible to keep transmitted power levels to a minimum. For example, by requiring fringe users to achieve full-resolution decoded video, as is the case for single-resolution signaling schemes, the system is over-designed for the good user. More specifically, the good user has more SNR than needed to provide full-resolution video decoding. This results in excessive co-channel interference for existing NTSC users. The embedded multiresolution signaling scheme, on the other hand, uses only enough transmitted signal power to allow video decoding with a resolution consistent with prevailing reception conditions and thus can minimize the associated co-channel interference. Again, this will require careful design of the signaling constellation and the error-control coding approach.

Similar arguments can be made for the physical layer of the network hierarchy. For example, the LED transmitter on an optical fiber can be operated in a multilevel manner in either intensity or pulse-width to convey bits with a graded probability of error. Since the bits in a compressed video stream are not all of equal visual importance, there can be some advatage to such a graded signaling strategy. For example, header, motion vector, intra-frames, and low spatial frequency data require low probability of error (or cell loss) while high spatial frequency data can tolerate a much higher probability of error before the errors become visible. A network designed to transport video should consider and take advantage of this property of compressed video data.

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