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GUIDELINE FOR IMPLEMENTING ADVANCED DATA COMMUNICATION CONTROL PROCEDURES (ADCCP)

CATEGORY: HARDWARE
SUBCATEGORY: DATA TRANSMISSION

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Foreword

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Abstract

This publication guides Federal agencies in the selection and implementation of Advanced Data Communication Control Procedures (ADCCP) contained in FIPS 71.

Key words: Advanced data communication control procedures; ANS X3.66; bit-oriented; code independence; data; data link control procedures; data transparency; Federal Information Processing Standards Publication; interoperability; teleprocessing; transmission.

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ANNOUNCING THE

GUIDELINE FOR IMPLEMENTING ADVANCED DATA COMMUNICATION CONTROL PROCEDURES (ADCCP)

Federal Information Processing Standards Publications are issued by the National Bureau of Standards pursuant to Section 111 (f)(2) of the Federal Property and Administrative Services Act of 1949 as amended, Public Law 89-306 (79 Stat. 1127), Executive Order 11717 (38 FR 12315, dated May 11, 1973) and Part 6 of Title 15 Code of Federal Regulations (CFR).

Name of Guideline: Guideline for Implementing Advanced Data Communication Control Procedures (ADCCP).

Category of Guideline: Hardware, Data Transmission.

Explanation: This Guideline is intended to assist in the planning, acquisition, and operation of ADCCP. It provides guidance for selecting an ADCCP class of procedures. The use of ADCCP is required under certain conditions specified in FIPS 71.

Approving Authority: U.S. Department of Commerce, National Bureau of Standards (Institute for Computer Sciences and Technology).

Maintenance Agency: U.S. Department of Commerce, National Bureau of Standards (Institute for Computer Sciences and Technology).

Cross Index:

(a) Federal Information Processing Standards Publication (FIPS PUB) 71: *Advanced Data Communication Control Procedures.*

(b) Federal Standard 1003: *Telecommunications: Synchronous Bit-Oriented Data Link Control Procedures (Advanced Data Communication Control Procedures).*

(c) American National Standard X3.66-1979: *Advanced Data Communication Control Procedures (ADCCP).*

(d) International Standard 3309: *Data Communications—High-level Data Link Control Procedures—Frame Structure.*

(e) International Standard 4335: *Data Communications—High-level Data Link Control Procedures—Elements of Procedures.*

(f) Addendum 1 to International Standard 4335: *Data Communications—High-level Data Link Control Procedures—Elements of Procedures.*

(g) Addendum 2 to International Standard 4335: *Data Communications—High-level Data Link Control Procedures—Elements of Procedures.*

(h) International Standard 6159: *Data Communications—High-level Data Link Control Procedures—Unbalanced Classes of Procedure.*

(i) International Standard 6256: *Data Communications—High-level Data Link Control Procedures—Balanced Class of Procedure.*

(j) CCITT Recommendation X.25-1980: *Interface Between Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE) for Terminals Operating in the Packet Mode on Public Data Networks.*

(k) CCITT Recommendation X.75-1980: *Terminal and Transit Call Procedures and Data Transfer Systems on International Circuits Between Packet-Switched Data Networks.*

Applicability: This Guideline recommends three combinations of classes of procedures and optional functions for general use throughout the Federal Government. Their use is encouraged, but is not mandatory.

Implementation: This Guideline should be referenced by Federal agencies having requirements for the use of ADCCP as specified in FIPS 71.

Specifications: Federal Information Processing Standards Publication 78 (FIPS PUB 78), Guideline for Implementing Advanced Data Communication Control Procedures (ADCCP), (affixed).

Qualifications: This Guideline is based upon the knowledge obtained by NBS staff members from various departments and agencies of the Federal Government, in addition to input received from other sources both within and without the Government.

All comments and recommendations are welcomed and will be considered in any future revisions. These comments should be addressed to:

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Specifications for

GUIDELINE FOR IMPLEMENTING ADVANCED DATA COMMUNICATION CONTROL PROCEDURES (ADCCP)

CONTENTS

1.0 TECHNICAL SUMMARY

* The terminology and abbreviations used in this document are defined in American National Standard (ANS) X3.66-1979: *Advanced Data Communication Control Procedures (ADCCP).*

* Three combinations of classes of procedures and options are recommended for most link configurations, as shown below:

link configuration / class options			CLASS A UN,7	CLASS B BA,2,7,8	CLASS C BA,2,3,7,8,10
POINT TO POINT			Yes	Yes	Yes
MULTI-POINT	Centralized Control	Specified Transmission Opportunity	Yes	No	No
		Unspecified Transmission Opportunity	No	Yes	Yes
	No Centralized Control		No	No	No

* All equipment should be capable of operating in a two-way simultaneous manner.

* When timers are to be set, a random value within a small range of values should be used.

* The maximum information field length should be 4096 bits (512 octets).

* XID, UI, SIM, RIM, UP, and RSET are not recommended.

* Techniques for improving the undetected error performance of ADCCP should not be used unless the cost of these techniques is less than the benefit of a lower undetected error rate for the application under study. In any event, such equipment should be able to also operate with the standard 16-bit frame check sequence. See section 7.8 for a more detailed discussion and concluding recommendations.

* The information necessary to specify the operation of an ADCCP link is contained in section 8.

2.0 INTRODUCTION

Advanced Data Communications Control Procedures (ADCCP) has been adopted for use as the data link control procedure within the Federal Government under the circumstances detailed in FIPS 71.

This document is intended to guide the system designer in the selection of ADCCP options and other parameters. Certain options for ADCCP operations are recommended so that equipment and services purchased by the Government can be used and reused in the largest possible variety of applications. A greater degree of compatibility at the data link control level will reduce the overall cost of Federal data communications and automated data processing (ADP) equipment and services.

3.0 ADCCP CLASSES OF PROCEDURES

Currently, three basic classes of procedures have been identified in American National Standard (ANS) X3.66-1979 section 11 to provide efficient operation in particular data link configurations. When the current structure of ADCCP was first proposed in 1971, there were only two classes of procedures. These two classes are now called "unbalanced normal" (UN) and "unbalanced asynchronous" (UA).

UN is designed so that one primary station can control one or more secondary stations. It is called "unbalanced" because the bulk of responsibility for beginning and terminating the transfer of user information resides in the primary station. Actions by the primary station also serve to trigger error recovery on the data link. "Normal" is a historical term reflecting the originally proposed link control concept, where a secondary can transmit only after receiving permission from the primary.

UA also applies to one primary station and one or more secondary stations. "Asynchronous" here means that each secondary station is free to transmit without receiving specific permission from the primary station. Secondary station transmissions are not synchronized by the primary station, as in UN. Nonetheless, the bulk of responsibility for data link control remains in the primary station.

Later in the development of ADCCP, it was recognized that many point to point communications links are between equipment equally capable of handling link control. The "balanced asynchronous" (BA) class of procedures was developed as a result. Here a pair of stations share equal responsibility for link operation—hence, the term "balanced." Transmissions are made by each station without waiting for explicit permission from the remote station ("asynchronous" responses). Both stations have attributes found in secondary stations and primary stations and are thus called "combined" stations.

In retrospect, the BA class of procedures can be used on most data links for which the UA class was originally intended. BA operates with equal or better link efficiency and, by its nature, employs more uniform equipment design and operation. As a result, UA will probably be rarely used.

UN, UA, and BA share a basic repertoire of commands, responses, and related procedures with but two exceptions. First, each class has a unique mode setting command. A station receiving one of the mode setting commands immediately knows which class of procedure to employ during the following exchange of user information. If it cannot operate in that class, the incompatibility is easily identified before the transfer of user information begins.

Secondly, the ANS X3.66-1979 states that the BA basic repertoire contains an additional command Reset (RSET). During subsequent development of related international standards by the International Standards Organization (ISO), RSET was removed from the BA basic repertoire. This ISO decision was made when it was too late to make a corresponding change in ANS X3.66-1979. FIPS 71 is written to be consistent with the ISO standards on this point; the next version of the ANS X3.66 is also expected to be consistent with the ISO standards on this issue.

Certain optional features, also defined in ANS X3.66-1979 section 11, can be used with each class of procedures. Recommended classes and options are discussed in the next section.

4.0 RECOMMENDED IMPLEMENTATIONS OF ADCCP

Since ADCCP may be employed in a wide range of applications using synchronous digital transmissions, a single class of procedures will not handle all applications efficiently and economically. Within the Federal Government, however, the need to interconnect diversely manufactured equipment, to reuse that equipment, and to interconnect networks requires that the diverse combinations of classes of procedures and options be limited to a consistent set as much as practical. *Three combinations of classes of procedures and optional functions are recommended for use:*

Class A: Defined as UN with option 7.

Class B: Defined as BA with options 2, 7, 8, and no RSET command; and,

Class C: Defined as BA with options 2, 3, 7, 8, 10, and no RSET command.

It is strongly recommended that all equipment be capable of operating in a two-way simultaneous manner, even though some applications will employ half-duplex transmission facilities.

The application of classes A, B, and C to various common data link configurations is outlined below.

4.1 Recommendation for Multipoint Link, Central Station, Specified Transmission Opportunities

See figure 1. Here, a central point (the primary station) is responsible for the overall control of the link. It specifies when each of the secondary stations may transmit. A central host computer communicating directly with several cathode ray tube terminals over a shared synchronous data link, telling each terminal when it may transmit, is an example of such a configuration.

Class 4 is recommended for this link configuration. In this class, ADCCP poll (P) bits are sent by the primary station to tell each secondary station when it may transmit.

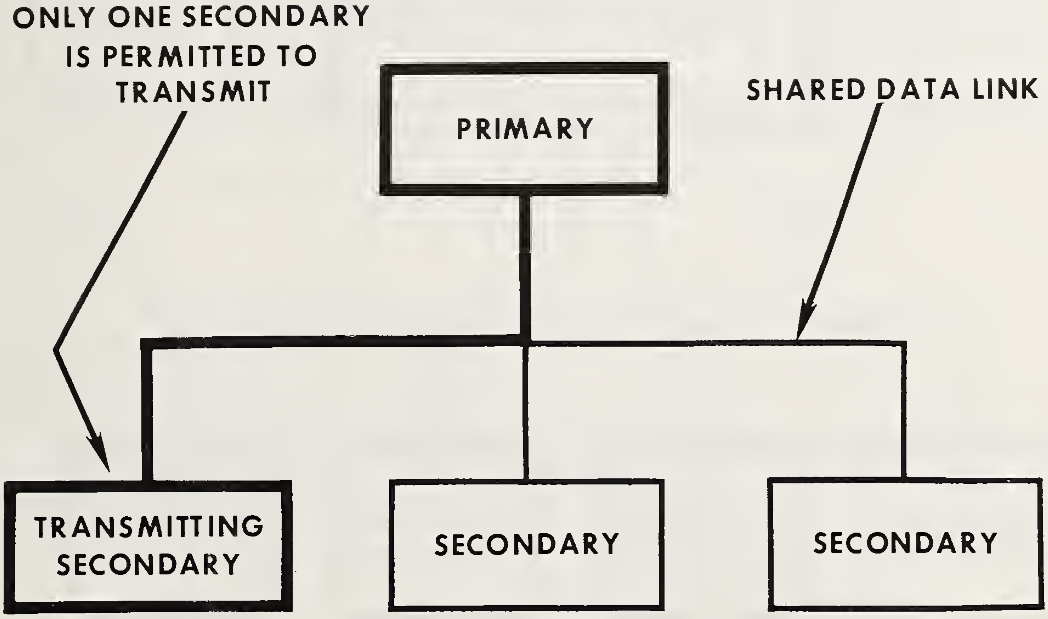

Figure 1. Multipoint, central station, specified transmission times.

4.2 Recommendation for Multipoint Link, Central Station, Unspecified Transmission Opportunities

See figure 2. Here the various stations sharing the data link communicate with only the one common central station. The central station, however, does not specify when each of the other stations may transmit; contention may occur. For example, a computer may communicate with several data collection devices over a shared data link. Each individual data collection device might have data to report only at infrequent intervals (every half hour, for example), making contention a relatively rare event. The central computer does not explicitly tell each device when it may transmit. Special techniques such as slotted Aloha (where stations are permitted to transmit only at certain time intervals) might be used to prevent or reduce contention when this is necessary. Such contention avoidance or resolution techniques operate below the data link control layer.

While the asynchronous response mode (ARM) described in ANS X3.66-1979 can operate in this environment, asynchronous balance mode (ABM) is preferred. ABM satisfies the requirement in the same manner as ARM, and ABM is useful in other data link configurations.

Class B or C is recommended for this link configuration. Here the central station is logically paired with each of the remote stations in a balanced link; all pairs share the same physical data path. Each station can transmit under whatever rules, if any, that have been imposed on the shared physical data path to prevent or reduce contention; these rules are considered to be outside the scope of the ADCCP data link control procedure. Unique link addresses must be chosen for the two stations on each logically independent, balanced link sharing the physical data path. The central station will, thus, have several addresses (one for each remote station).

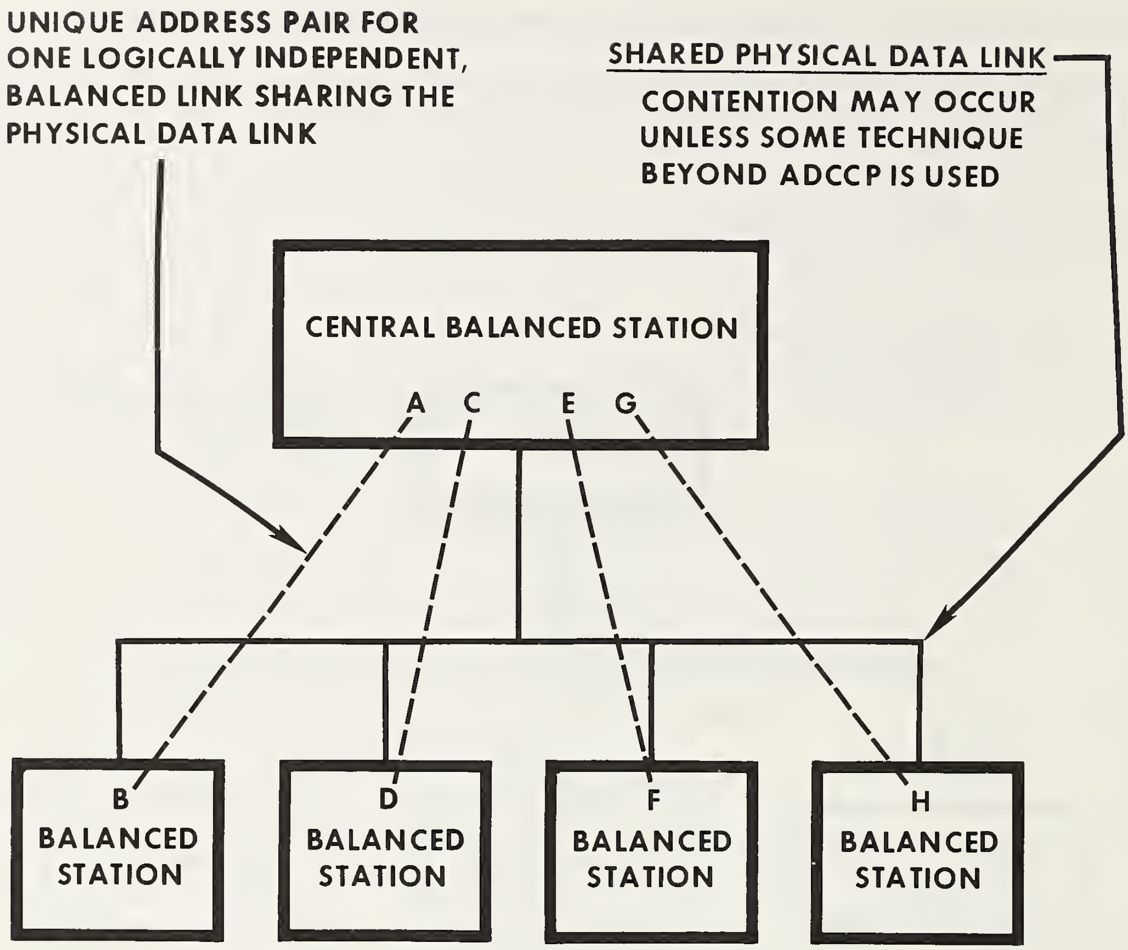

Figure 2. Multipoint, central station, unspecified transmission times.

4.3 Recommendation for Multipoint Link, No Central Station

See figure 3. Here there is no central controlling station. Each station sharing the data link may communicate directly with any other station sharing the link. In many implementations of this type of data link, each station can hear the transmissions of all other stations; e.g., cable bus nets such as MITREBUS, NBSnet. The allocation of transmission time and the resolution of contention is performed outside the data link control procedure.

ADCCP has not been specifically designed to accommodate this link configuration. A station connected to the data link needs to not only identify which frames to receive, but also to identify who transmitted those frames. Two addresses are required in the frame: (a) the address of the intended recipient, and (b) the address of the sender. This dual-address capability is not available in ADCCP.

ADCCP, with its single address field, is not suitable for this style of link operation.

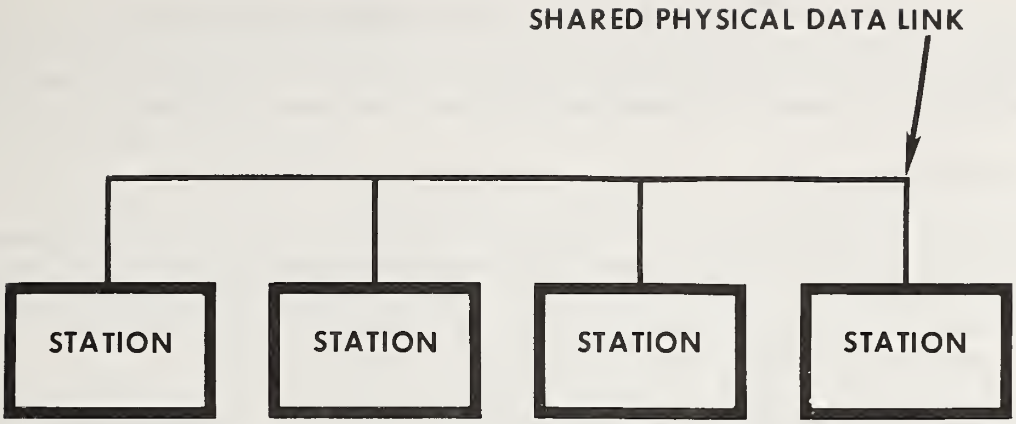

Figure 3. Multipoint, no central station, unspecified transmission times.

4.4 Point To Point Link

See figure 4. Here only two stations operate on a data link.

Class A, B, or C may be used for this link configuration, depending on the relative capabilities of each station.

Class B is compatible with the International Telegraph and Telephone Consultative Committee (CCITT) Recommendation X.25-1980 Link Access Protocol B (LAPB) and CCITT Recommendation X.75-1980 when the link addresses specified in these Recommendations are used.

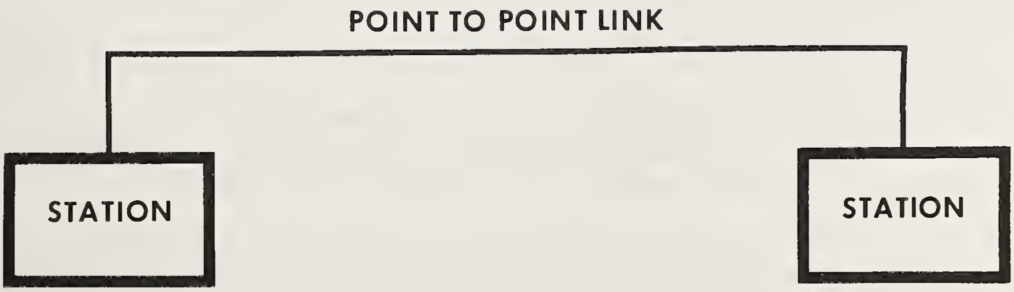

Figure 4. Point to point.

5.0 OPTIONS USED IN RECOMMENDED CLASSES

Certain options are used in the recommended classes A, B, and C discussed earlier. This section discusses each functional option and the rationale for its inclusion in one or more of the recommended classes.

5.1 Reject (REJ) (option 2)

REJ permits prompt initiation of the recovery of missing Information (I) frames when the asynchronous respond opportunity (ARO—see ANS X3.66-1979 section 6.2.1) is used (recommended classes B and C). Without REJ, a station using ARO would rely on checkpointing to recover missing I frames (see ANS X3.66-1979 section 8.2.1). A combined station has no way to *report* a lost I frame to the remote station if REJ is not implemented. Rather, it must wait for the remote station to notice that no acknowledgment was received for that frame.

REJ is not required when normal respond opportunity (NRO—see ANS X3.66-1979 section 6.2.2) (recommended class A) is used with two-way alternate operation, or half-duplex transmission facilities. In NRO, the poll/final bit is set to one at the end of each station's transmission, triggering checkpoint recovery. Once triggered, checkpoint recovery (like REJ recovery) relies on the retransmission of the oldest unacknowledged I frame, followed by all subsequent I frames.

5.2 Selective Reject (SREJ) (option 3)

By reducing the number of needlessly retransmitted frames, SREJ recovery further improves the efficiency of a data link while recovering missing I frames. To fully realize this advantage, however, the station which missed an I frame should buffer subsequent I frames until the missing frame is received. This generally imposes additional buffering and housekeeping requirements on the receiving station. Based on the buffers available and the number of I frames to recover, the receiving station can decide when to use SREJ recovery. The SREJ option imposes no additional buffering requirements on the station transmitting I frames. In fact, the transmitting station will see its I frames acknowledged sooner when SREJ is used to recover missing frames; transmitting buffers, therefore, will be released sooner. This is because no time is wasted in retransmitting I frames already correctly received. When SREJ is used, the receiving station can acknowledge the retransmitted frame *and all subsequent buffered I frames* as soon as successful retransmission of the missing I frame has occurred. When REJ is used, subsequent I frames are not acknowledged until they, too, have been successfully resent—even if there were no errors in their original transmission. This wastes time and delays acknowledgment of the entire batch of I frames.

Note that the *full* realization of the efficiency available from SREJ depends on the receiver buffering *all* frames received correctly, and on having a sufficiently large sequence number modulus (see section 5.4). However, SREJ recovery is more efficient than REJ recovery even when the receiver can buffer just one or two correctly-received I frames following the I frame(s) received with errors.

5.3 Multiple Octet Addressing (option 7)

ANS X3.66-1979 defines two addressing modes. The basic address contains only a single octet; the address assigned to a station may be any of the 256 possible bit combinations for the octet.

Option 7 allows the use of one or more address octets. The low order bit of each octet is used as an extension indicator. When this bit is zero, the following octet is also part of the address. When the bit is one, this octet is the last octet of the address. Thus, a single octet address may be indicated by setting the low order bit to one in the first (only) octet of the address field.

FIPS 71 requires that one-octet addresses always have the low order bit set to one. An address composed of one octet is thus compatible in format with multiple octet addresses. Transmissions on the data link may then use either one or multiple octet addresses without confusing attached equipment.

5.4 Extended Control Field Format (option 10)

The extended control field format provides modulo 128 sequence numbers; modulo 8 sequence numbers are provided by the unextended control field format.

When data links are routed through geosynchronous satellites, a long propagation delay is encountered. Depending primarily on the size of I frames, the transmission speed, the number of retransmissions required, the type of retransmission technique used (REJ, SREJ, etc.), and processing times for frames, modulo 8 sequence numbers may not be adequate to allow continuous transmission of I frames. The modulo 128 sequence numbers available with the extended control field format will generally prevent a station from running out of send sequence numbers before acknowledgments are received.

The following formula may be used to estimate the minimum modulus of send sequence numbers required to allow continuous transmission. It is assumed:

* the two stations are connected by a point-to-point link (see section 4.4);
* no transmission errors occur, or errors are recovered by checkpoint or REJ recovery;
* the remote station is also continuously sending I frames.

$$M_l = 2 + \frac{S_l\,(T_{l-r} + T_{r-l} + T_{rproc} + T_{lproc})}{I_l} + \frac{3\,I_r S_l}{2\,I_l S_r}$$

I_l = local station's average I frame length, including flags, address field, control field, and frame check sequence (bits).

I_r = remote station's average I frame length, including flags, address field, control field, and frame check sequence (bits).

M_l = minimum modulus of sequence numbers necessary to support continuous I frame transmissions by the local station.

S_l = local station's transmission speed (bits per second).

S_r = remote station's transmission speed (bits per second).

T_{lproc} = time required by local station to process a received frame (seconds).

T_{l-r} = propagation time from local to remote station (seconds).

T_{rproc} = time required by remote station to process a received frame (seconds).

T_{r-l} = propagation time from remote to local station (seconds).

If the result M_l is a fraction, it should be rounded up to the next higher integer.

When the average I frame lengths and transmission speeds for each station are different, M_l should be calculated with one station designated the "local station," and again with that station designated as the "remote station." The higher value of M_l should be used.

Example 1: Two stations operate at 2400 bits/s, using a terrestrial leased channel with a delay of 50 ms. Each station transmits I frames averaging 2400 bits in length. Each station processes a received frame in 1 ms. The formula yields $M_l=3.602$, which is rounded to 4. In this example, modulo 8 sequence numbers will allow continuous transmission.

Example 2: The same transmissions are rerouted through a satellite, with a propagation delay of 0.25 s each way. $M_l=4.002$ which is rounded to 5. Modulo 8 sequence numbers are still adequate.

Example 3: The transmission speed of the satellite circuit is increased to 56 kbits/s. $M_l=16$ (rounded). Modulo 128 sequence numbers are required.

Example 4: The transmission speed of the satellite circuit is again increased to 1.544 Mbits/s. $M_l=455$. The capacity of the circuit cannot be fully used by one logical pair of ADCCP stations unless the average frame length is made longer or a shorter delay channel (i.e., terrestrial) is used.

When SREJ recovery is used, each attempt at retransmitting an I frame received with errors may be followed by more new I frames with additional send sequence numbers. For a given number of attempts before the bad frame is finally received correctly without error, the following formula estimates the sequence numbers required to allow continuous transmission:

$$M_I = 5A + 2 + \frac{S_I(A+1)(T_{I-r} + T_{r-I} + T_{rproc} + T_{Iproc})}{I_I} + \frac{(A+3)I_rS_I}{2I_IS_r} + \frac{ARS_I}{I_IS_r}$$

A = number of retransmissions required before I frame is successfully received.

R = length of SREJ frame, including flags, address field, control field, and frame check sequence (bits).

Example 5: Two stations operate at 2400 bits/s, using a satellite leased channel with a delay of 0.25 s each way. Each station transmits I frames averaging 2400 bits in length. Each station processes a received frame in 1 ms. (This is the same situation as example 2.) The designer wishes to allow continuous transmissions through at least one SREJ retransmission attempt. $M_I = 11$, rounded; therefore, modulo 128 sequence numbers are required.

Note that in example 2 modulo 8 sequence numbers were adequate. To allow one attempt at SREJ recovery and yet not halt the transmission of new I frames, modulo 128 sequence numbers will be required. However, SREJ recovery is much more efficient than REJ or checkpoint recovery.

Two concerns have been expressed when implementers initially consider using extended control field formats: increased transmission overhead and an apparent requirement to provide 127 I frame buffers.

In applications where I frames average 800 bits or more in size, the extended control field format adds less than 1 percent to the I frame transmission time. Supervisory and unnumbered frames without information fields will expand by 8 bits. Supervisory and unnumbered frames, however, are not sent unless:

* the data link is being established or logically disconnected; e.g., set mode commands. Usually, the data link is established and logically disconnected infrequently; the frames transmitted for this reason are but a tiny fraction of the total bits transmitted across a link.

* there is no information to send; e.g., Receiver Ready (RR). At times when there is no information to be sent, any additional overhead in frame formats is moot.

* a busy condition is being reported or cleared; e.g., Receiver Not Ready (RNR). Under normal operation of a properly-designed link, busy conditions occur infrequently.

* error recovery is being initiated; e.g., REJ. Unless there is a very low mean time between errors, the transmission of frames to initiate error recovery is also infrequent; in any event, the extra 8 bits required by the extended control field format is a small amount compared to the total overhead required by retransmission of missing frames.

* other types of status must be reported which cannot be conveyed in an I frame; e.g., Frame Reject (FRMR). This is also an infrequent occurrence.

The range of available sequence numbers does not require a station to provide MODULUS-1 buffers for I frame reception or transmission. The range of available sequence numbers does limit the number of I frames which can be transmitted before an acknowledgment is received. However, the transmitting station is not required to be capable of sending MODULUS-1 I frames before waiting for an acknowledgment. The receiving station is also not required to be capable of receiving MODULUS-1 I frames before entering a busy condition.

5.5 I Frames Transmitted Only As Commands (option 8) for Combined Stations

During the development of the CCITT Recommendation X.25 in the mid-1970's, a data link control procedure called "LAP" (link access procedure) was devised. LAP was based on partially completed work by ISO on International Standards 3309 and 4335. Later, ISO and ANSI developed the concept of combined stations and the BA class of procedures. At this point, CCITT's LAP operations did not match any of the data link control procedures being developed by ISO and ANSI. As a result, a new data link control procedure for X.25 was selected by CCITT from the ISO standards and designated "LAPB." LAPB uses combined stations and the BA class of procedures. To make LAPB as similar as possible to the older LAP, and thus simplify the transition from LAP to LAPB, LAPB constrains combined stations to send I frames only as commands.

The inability to send I response frames reduces data link efficiency only when (a) it is necessary for a combined station to send a response frame with the final bit (F) set to one and (b) there is user data which could be sent in an I response. In this particular case, the F bit will have to be sent in a supervisory response frame; this delays the transmission of additional I frames by the time necessary to send the supervisory response (40 bits in length if a one octet address field and a one octet control field are used). Such a delay is relatively small when compared with time typically wasted by transmission errors and recovery.

It is not possible to further modify CCITT's LAPB to eliminate option 8. Furthermore, LAPB has become a widespread implementation of the BA class of procedures.

In order to achieve a greater compatibility between Federal combined stations, *the use of option 8 by all combined stations is recommended.* This is reflected in the options specified above for classes B and C.

6.0 ADDITIONAL RECOMMENDATIONS

Besides the combination of class of procedure and functional options, the following information is used to describe an ADCCP link.

6.1 Timer Values

Sections 6.2 and 9 of ANS X3.66-1979 discuss the timers necessary for successful operation. Each timer can be categorized as:

* a P/F timer, employed when frames with the P/F bit set to one are exchanged; or,
* a no-answer timer, used when a station transmits one or more frames (e.g., I frames) for which a particular answer (e.g., acknowledging N(R)) is expected.

The use of timers whose values differ at different stations is recommended for all stations implementing the asynchronous respond opportunity (used to control transmission opportunities under classes B and C). By specifying these unequal timers, Federal equipment and services can operate on either two-way simultaneous or two-way alternate links. *One recommended technique for guaranteeing unequal timers is to set the timer to a random value within a certain range of values.* For instance, a no-answer timer may be specified to be between 2 and 3 s in length. Each time that timer is set, its value will be picked from within that range. The remote station(s) on the data link would rarely select the same random timer value at the same instant.

The actual specific range of values to be used for timers on a particular link depends on link parameters such as propagation delay, processing time at each station, and delays in obtaining transmission opportunities when polling or contention is used. Thus, *the range of timer values should be easily changed to allow reconfiguration for different links.*

6.2 Maximum Information Field Length

The generally recommended maximum information field length is 4096 bits. This is large enough to accommodate most conventional buffer sizes; e.g., 512 byte disk sectors. However, when the bit error rate is worse than 10^{-5}, a shorter information field length should be employed. Longer information fields could be used on channels with less frequent errors, but the probability of undetected errors increases as information field lengths are increased.

7.0 OPTIONS NOT RECOMMENDED

The functional options listed below are NOT recommended. This section discusses the rationale against their general use.

7.1 Exchange Identification (XID) (option 1)

XID can be used by stations to exchange descriptions of their identification and data link control capabilities. Such descriptions would be contained in the information field of the XID frame. While several proposals have been submitted to ANSI and ISO suggesting standardized content and formats for this information field, no clear consensus has yet developed. Furthermore, CCITT did not choose to include XID in its LAPB data link control procedure.

It is expected that the vast majority of Federal ADCCP stations will be communicating with other stations of known capability.

Because (a) no standards have been developed for the XID information field and (b) most ADCCP stations communicate with others of known capability, XID is not recommended.

7.2 Unnumbered Information (UI) (option 4)

The use of Unnumbered Information (UI) frames is not recommended for several reasons.

Briefly, UI frames contain no sequence numbers and therefore cannot be acknowledged or recovered in the same manner as I frames. A UI command may be transmitted by a primary or combined station with the poll bit set to one (as long as no other poll bit is outstanding). If a response with the final bit set to one is received, the primary/combined station can assume the UI command was received. If no response with the final bit set to one is received before the poll timer expires, the primary/combined station can assume the UI command was not received. Note that a response is required only because the poll bit was set to one; UI commands transmitted with the poll bit set to zero and UI responses will not trigger any transmissions from the remote station. This technique to force a response from the remote station when a UI command is received allows only one UI frame to be sent at a time. A secondary station cannot use this technique at all. Information cannot be transferred across a link in a reliable manner with UI frames in most applications.

International and American National Standards for ADCCP do not currently agree on how busy conditions affect UI frames. ANS X3.66-1979 clearly states that UI frames shall not be sent during busy conditions. However, International Standards now approved by ISO do not specify if UI frames are affected by busy conditions. Equipment using UI frames and manufactured according to the ISO documents might or might not transmit UI frames during a busy condition. Revisions to both American and ISO documents will state that UI frames are not affected by busy conditions, a change to the description now in ANS X3.66-1979. This state of confusion is another reason to avoid the use of UI frames.

Because UI frames cannot be flow controlled by the use of a busy condition or by sequence numbers, a station transmitting UI frames cannot determine if the intended receiving station(s) have retained the contents of the frame. For example, assume a primary transmits a UI command with the P bit set to one and addressed to a single secondary. The addressed secondary may receive the UI command correctly and transmit a response with the F bit set to one. Because of internal buffering constraints, however, that secondary may have to discard the information contained in the UI frame. There is no procedure in ADCCP which the secondary can employ to stop the transmission of further UI frames temporarily (no equivalent of an RNR busy condition) nor to obtain a retransmission of the discarded information (no equivalent of REJ/SREJ).

ADCCP does not describe the relationship between data contained in UI frames and data contained in I frames. A procedure outside the scope of ADCCP (perhaps at a higher architectural level) must be defined to determine if data from UI and I frames can be intermingled when it is delivered to higher levels. Similarly, procedures must be defined to identify which data may be transmitted in UI frames and which data must be transmitted in I frames. As a result, equipment with otherwise compatible data link control procedures may not be able to successfully exchange user data.

7.3 Initialization Mode (option 5)

The initialization mode is not required for basic link operation. This option provides for possible initialization sequences which might be required by equipment which may not have a complete, self-contained link control. Such equipment, for example, might have only a subset of ADCCP capability when first turned on and require a downline load. The minimum allowable initialization subset has not been standardized by ANSI. While the ANSI task group which developed ADCCP has reviewed some proposals for downline load and dump during the initialization state, no standard procedures for these operations have been defined. Equipment which is permitted to use this state will probably employ equipment-peculiar data exchanges. Such characteristics would reduce the ability to use and reuse Federal equipment in the largest possible range of applications. *As a result, the initialization mode and its associated frames (Request Initialization Mode (RIM) and Set Initialization Mode (SIM)) are not recommended.*

7.4 Unnumbered Poll (UP) (option 6)

The Unnumbered Poll (UP) command is used to poll one or more stations. Polling is necessary only when the normal respond opportunity is used (see section 6.2 of ANS X3.66-1979).

When only a single station is to be polled, any I, supervisory, or unnumbered command with the P bit set to one may be used.

Groups of stations may be polled, without using UP, by issuing a set of individual polls. At first glance, the concept of individual polling appears inefficient. Upon further examination, this turns out not to be the case.

Consider a multipoint link with a central primary station. Assume that the primary station has individually polled each secondary by sending command frames to these secondary stations with the P bit set to one. Each may respond with an I, supervisory, or unnumbered response frame:

* If an I frame response is made, the primary station ought to either (a) acknowledge that I frame or (b) initiate recovery. The acknowledgment or recovery requires transmitting a command frame which can also reissue the poll for that station; i.e., the P bit is set to one.

* If a supervisory response is made, the primary may indicate busy conditions and delayed I frame acknowledgments if it does not use UP.

* If an unnumbered response is made, some sort of data link control operation is going on which is probably not directly related to transferring data; e.g., the station has suddenly disconnected or is going through a mode-setting procedure. The primary station can then issue a subsequent command (with the P bit set to one), which serves to repoll.

UP is also defined in ADCCP as an "optional" poll; that is, the P bit is set to zero and the polled station(s) need not respond. However, suppose the polled station were to send I frames. If the polling station does not receive those I frames or chooses not to acknowledge them immediately, and reissues the UP command with the P bit again set to zero, the polled station will not know what happened to those previously transmitted I frames. Recovery can only be done by waiting through a time-out period and retransmitting one of the unacknowledged I frames.

UP can provide increased link efficiency in certain types of configurations where large numbers of low activity stations share the physical path and some means is provided to resolve contention. The use of UP should be carefully compared to operating with one of the recommended classes A, B, or C. Relative efficiencies should be examined and weighed against the reduction in equipment compatibility when an option such as UP is considered in link design. *The use of UP is discouraged where nearly equal or better performance can be obtained by using one of the recommended classes A, B, or C.*

During group polling, the method of preventing or reducing collision between responses from the polled stations is not specified by ADCCP. Methods of reducing this contention, such as those discussed earlier for link configurations using unspecified transmission opportunities, must be specified for each implementation. Differences in these procedures between implementations may reduce the ability to interconnect Federal equipment and services, and to reuse equipment and services for different applications.

7.5 One-Way Information Transfer (options 8 and 9) for Primary and Secondary Stations

These options eliminate the ability to send I frames as a command or as a response. These options, when used with primary and secondary stations, result in equipment which either cannot send or cannot receive information. Using both of these options together results in equipment which can neither send nor receive I frames!

As far as data link control procedures are concerned, there is little or no difference between a primary or secondary station which cannot send I frames and such a station which never has I frames to send. These options need not be used, then, to specify a "receive only" station. The reason for not sending I frames is that the equipment has no user information to send; constraining the class of procedures to exclude I commands or responses is a secondary effect.

A primary or secondary station which has no capability to receive I frames may transmit a FRMR when an I frame is sent to it. An alternate view of the "send only station" is one which has no mechanism to process user data units. Rather than implement the ADCCP one-way information transfer option(s), such a station might be implemented to receive and acknowledge I frames; the data contained in the I field can then be ignored or higher level indications of error can be generated.

Equipment or services which do not send or do not receive information tend to be specialized; e.g., badge readers, clock displays, and river level gauges. When this kind of equipment is connected to a data link, it is reasonable to expect the remote controlling station has been designed to account for this special characteristic. The data link control procedures are not responsible for enforcing one-way information flow. Higher level programs which generate or receive information should be designed to treat such a source or destination of information as a "one-way" device. *Thus, these options are not recommended for primary and secondary stations.*

7.6 I Frames Transmitted Only As Responses (option 9) for Combined Stations

While option 8 (I frames transmitted only as commands) was recommended for combined stations to be compatible with CCITT Recommendations, there is not a similar rationale to justify the use of option 9 for combined stations.

When a combined station may transmit I frames as commands, it may tag an I command by setting the P bit to one. If a response with the F bit set to one is subsequently received, checkpoint recovery can begin if required. This ability for a combined station to force checkpoint recovery by sending an I command in this manner is lost when option 9 is employed.

7.7 RSET (International Standard 6256 and FIPS 71 option 11)

RSET is used only by combined stations (BA class of procedures).

Currently, the basic repertoire of commands and responses for combined stations in the American National Standard includes the RSET command. International standards and FIPS 71, however, include RSET as an option, not as part of the basic repertoire.

The functions performed by the RSET command are also available with the Set Asynchronous Balanced Mode (SABM) and Set Asynchronous Balanced Mode Extended (SABME) commands; therefore, *the RSET command is not recommended.* Depending on whether the ANSI or ISO document is being followed, option 11 should or should not be designated in order to *remove* the RSET command. Note that FIPS 71 follows the ISO document in its description of this option.

RSET is used in connection with recovery after an invalid receive sequence number N(R) has been received. An invalid N(R) means that a sequence number has been received which either: (a) acknowledges an I frame which was never sent or (b) points to an I frame previously acknowledged. An invalid N(R) can occur because:

* a software error occurred in the station sending the invalid N(R), causing variables to be set to improper values; or
* a software error occurred in the station receiving the N(R), causing the received N(R) value to be garbled (e.g., overwritten); or
* an undetected transmission error occurred which happened to garble the N(R) in the received frame; or
* a hardware failure occurred in the station sending the N(R), causing the improper value to be used before the frame check sequence (FCS) had been calculated (e.g., memory fault); or
* a hardware failure occurred in the station receiving the N(R), causing an improper value to be stored after the FCS had been verified (e.g., memory fault).

All of these possible causes occur with very low frequency in properly implemented equipment.

When a combined station receives a frame with an invalid N(R), it may follow one of these procedures:

* transmit FRMR, reporting that an invalid N(R) was received. The remote combined station, which receives the FRMR, may send an RSET, SABM, or SABME command to recover. RSET will reset the sequence number state variables associated with only the direction of information transfer impacted by the invalid N(R). SABM or SABME will reset the sequence number state variables associated with both directions of information transfer.
* transmit FRMR followed by SABM or SABME.
* transmit only SABM or SABME.

No interoperability problems occur when a station which implements RSET is connected with a station which does not implement RSET. In the event an invalid N(R) condition occurs, one of the following exchanges will occur:

* an RSET command will be sent (by the station which implements RSET) during the course of recovery. The remote station (which does not implement RSET) will transmit a FRMR whenever a RSET command is received, indicating that an invalid command was received. To recover from an invalid command exception condition, a SABM/SABME must be sent by either station. This causes the invalid command condition to be cleared as well as resetting the state variables. Recovery from the invalid N(R) condition is thus complete.
* an RSET command will not be sent during the course of recovery from the invalid N(R) condition. In this case, a SABM/SABME command will have been used to complete recovery.

Because invalid N(R) conditions are expected to occur so infrequently, the ability to reset the sequence number state variables associated with only one direction of information transfer (using RSET) provides miniscule gains in operating efficiency when compared with resetting the sequence number state variables associated with both directions of information transfer (using SABM/SABME). When SABM/SABME is used to recover, information flow in both directions must be suspended while the SABM(E)-Unnumbered Acknowledgment frame exchange occurs; even on a satellite circuit this exchange will take less than 1 s. The RSET command allows the stations not to suspend information transfer in the direction not affected by the invalid N(R), a savings of 1 s whenever an invalid N(R) occurs.

Given these facts, the overall savings from RSET use can be estimated. For instance, assume the undetected transmission error probability is about 10^{-10} (one error in every 10^{10} bits transmitted) over a typical leased circuit (bit error rate of about 10^{-5}). For an undetected transmission error to garble an N(R), it must affect the 3 bits of the frame which constitute the N(R). If the average frame is 1000 bits in length, the probability of garbling N(R) becomes about 10^{-12}. On a circuit operating at 9600 bits/s such a garble will occur about once every 10^8 s (more than 3 years). The efficiency gained in using RSET to recover from invalid N(R) caused by undetected transmission errors is about 0.000001 percent or lower.

Hardware failures may occur more frequently than once every 3 years. However, even if a hardware failure occurs once a week, the resultant savings using RSET is 1 s in over 500,000 or less than .002 percent. Such savings must be weighed against the additional cost of implementation of RSET, of storage required to contain RSET software, associated maintenance and documentation costs, and other similar factors.

For this reason, the implementation of the RSET command is *not* recommended. For FIPS 71, this is accomplished by *not* selecting option 11; i.e., RSET is *not* in the basic repertoire.

7.8 Provisions for Improved Error Protection

The frame check sequence used in ADCCP has undergone considerable analysis within ANSI, ISO, and (more recently) other groups interested in specific applications of ADCCP. A general summary of important results is given here.

The algorithm used for detection of transmission errors is based on a cyclical redundancy check (CRC). Because of the nature of CRC's and of ADCCP, certain patterns of transmission errors will escape detection. The exact probability of such undetected transmission errors depends on many factors, including:

* the generator polynomial for the CRC;
* the signalling method used on the link (NRZI, etc.);
* the rate and characteristics of transmission errors introduced by the transmission media;
* the bit length of the frames;
* sensitivities introduced by the bit-stuffing technique used to achieve transparency; and,
* sensitivities introduced by the technique for flagging the start and end of a frame.

While an exhaustive set of calculated probabilities for all types of data links has not been developed, sufficient independent analyses have been done to provide estimates of the probability of undetected errors.

a. One contribution to undetected errors is the probability that a pattern of transmission errors will be introduced within a frame which cannot be detected by the 16-bit frame check sequence (FCS). The undetected bit error rate from this source may be estimated from table A below:

Table A. Approximate undetected bit error rate resulting from error patterns within frames.

bits in frame	bit error rate 10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}
100	1×10^{-8}	1×10^{-9}	1×10^{-10}	1×10^{-11}	1×10^{-12}
300	9×10^{-8}	9×10^{-9}	9×10^{-10}	9×10^{-11}	9×10^{-12}
1000	7×10^{-9}	5×10^{-10}	4×10^{-11}	4×10^{-12}	4×10^{-13}
3000		2×10^{-11}	1×10^{-12}	1×10^{-13}	1×10^{-13}
10000		1×10^{-10}	2×10^{-11}	2×10^{-12}	2×10^{-13}
30000		$\sim 10^{-5}$	$\sim 10^{-6}$	$\sim 10^{-7}$	$\sim 10^{-8}$

b. Another source of undetected errors are transmission errors which destroy a flag separating two frames. The receiving station will interpret these frames as a single, longer frame. There is a chance the last 16 bits of this longer received frame will be the correct FCS bit pattern, and the error will escape detection. The maximum undetected bit error rate from this source may be estimated from table B below:

Table B. Approximate maximum undetected bit error rate resulting from scrambled single flag between frames.

bits in frame	bit error rate 10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}
100	1×10^{-9}	1×10^{-10}	1×10^{-11}	1×10^{-12}	1×10^{-13}
300	4×10^{-10}	4×10^{-11}	4×10^{-12}	4×10^{-13}	4×10^{-14}
1000	1×10^{-10}	1×10^{-11}	1×10^{-12}	1×10^{-13}	1×10^{-14}
3000	4×10^{-11}	4×10^{-12}	4×10^{-13}	4×10^{-14}	4×10^{-15}
10000	1×10^{-11}	1×10^{-12}	1×10^{-13}	1×10^{-14}	1×10^{-15}
30000	4×10^{-12}	4×10^{-13}	4×10^{-14}	4×10^{-15}	4×10^{-16}

c. Similarly, the contents of a frame may be garbled into a flag pattern in the middle of the frame, dividing it into two shorter received frames. Again, there is a chance the last 16 bits of either of the two shorter frames will be the correct pattern to pass the FCS check, allowing an undetected error to occur. The undetected bit error rate from this source may be estimated from table C below:

Table C. Approximate maximum undetected bit error rate resulting from fictitious flag introduced in mid-frame.

bits in frame	bit error rate 10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}
100	9×10^{-8}	9×10^{-9}	9×10^{-10}	9×10^{-11}	9×10^{-12}
300	3×10^{-7}	3×10^{-8}	3×10^{-9}	3×10^{-10}	3×10^{-11}
1000	9×10^{-7}	9×10^{-8}	9×10^{-9}	9×10^{-10}	9×10^{-11}
3000	3×10^{-6}	3×10^{-7}	3×10^{-8}	3×10^{-9}	3×10^{-10}
10000	9×10^{-6}	9×10^{-7}	9×10^{-8}	9×10^{-9}	9×10^{-10}
30000	3×10^{-5}	3×10^{-6}	3×10^{-7}	3×10^{-8}	3×10^{-9}

It should be noted that, in most cases, the "address" and "control" fields of the second portion of the frame will not be correct; that part will then be ignored or rejected by the receiver.

d. Zero bits are inserted into the transmitted frame's bit stream after five consecutive one bits. This "bit-stuffing" prevents the ADCCP flag pattern from occurring in the middle of the frame. A transmission error in the 5 bits prior to an inserted zero bit will cause the receiver to leave this inserted bit in the frame, rather than to delete it. There is a chance the last 16 bits of such a lengthened frame will be the correct pattern to pass the FCS check, allowing an undetected error to occur. Similarly, a group of bits may be garbled into "111110," and the receiver will delete the final zero bit. The maximum undetected bit error rate from these sources may be estimated from table D below:

Table D. Approximate maximum undetected error rate resulting from zero bits inserted but not deleted and bits erroneously deleted.

bits in frame	bit error rate 10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}
100	2×10^{-7}	2×10^{-8}	2×10^{-9}	2×10^{-10}	2×10^{-11}
300	9×10^{-7}	9×10^{-8}	9×10^{-9}	9×10^{-10}	9×10^{-11}
1000	3×10^{-6}	3×10^{-7}	3×10^{-8}	3×10^{-9}	3×10^{-10}
3000	1×10^{-5}	1×10^{-6}	1×10^{-7}	1×10^{-8}	1×10^{-9}
10000	3×10^{-5}	3×10^{-6}	3×10^{-7}	3×10^{-8}	3×10^{-9}
30000	1×10^{-4}	1×10^{-5}	1×10^{-6}	1×10^{-7}	1×10^{-8}

These calculations were made assuming the bits of the frame could assume any random pattern. The use of character sets such as ASCII to represent data within the information field will reduce the undetected bit error rates of tables C and D; certain bit combinations will not occur as frequently in alphanumeric character data as in random binary patterns.

e. Synchronous signal detectors which are used on the link (e.g., modems) may slip bit synchronization. The likelihood of such a slip varies, depending on the signalling system used and the design of the equipment. Such bit slips will add or delete bits from a frame and its flag(s). Such a modified frame may pass the FCS check. Bit slips can also cause a related undetected error. During the recalculation of the FCS on an incoming frame, the register holding the interim result will occasionally contain all zeros. Neither the deletion of a bit nor the insertion of a zero bit at this point will be detected. For analog signalling systems, the likelihood of a bit slip introducing an undetected error is much less than 10^{-15}. Commercial pulse coded modulation (PCM) systems operating at 56 kbits/s introduce undetected errors due to bit slips at a rate of less than 3×10^{-15}. The contribution from these slips to the overall undetected error rate is orders of magnitude smaller than the other factors considered above.

The sum of these undetected bit error rates is a reasonable estimate of the overall undetected error rate which can be expected on a particular link, shown below in table E:

Table E. Approximate overall undetected bit error rate.

bits in frame	bit error rate 10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}
100	3×10^{-7}	3×10^{-8}	3×10^{-9}	3×10^{-10}	3×10^{-11}
300	1×10^{-6}	1×10^{-7}	1×10^{-8}	1×10^{-9}	1×10^{-10}
1000	4×10^{-6}	4×10^{-7}	4×10^{-8}	4×10^{-9}	4×10^{-10}
3000		1×10^{-6}	1×10^{-7}	1×10^{-8}	1×10^{-9}
10000		4×10^{-6}	4×10^{-7}	4×10^{-8}	4×10^{-9}
30000		$\sim 10^{-5}$	$\sim 10^{-6}$	$\sim 10^{-7}$	$\sim 10^{-8}$

Using figure 5, this bit error rate can be converted to an average time between undetected errors.

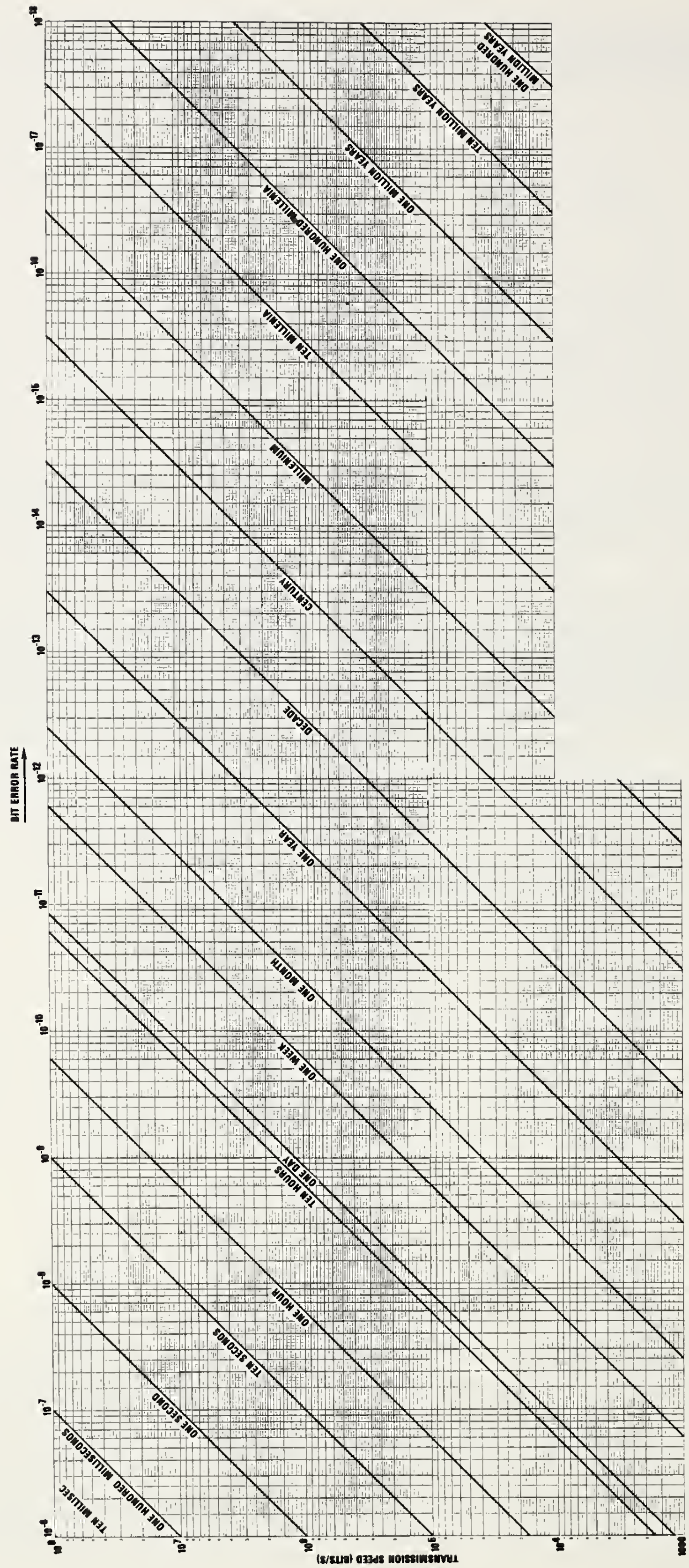

Figure 5. Relationship between bit error rate, transmission speed, and average time between errors.

These error producing mechanisms can be ranked in order of importance as follows:

* bit stuffing/detecting errors;
* erroneous flags introduced inside frames;
* undetected error patterns;
* scrambled single flag between frames (when only one flag between frames is used); and,
* bit slips.

However, undetectable errors can also be introduced by memory and media faults, I/O bus errors, and other hardware glitches. The evaluation of error performance of a communications system must also take these sources and the requirements of the system user into account in order to accurately determine which, if any, sources of error should be reduced.

Several steps may be taken when better undetected bit error rates are required for a specific application.

Many applications involve the transfer of I fields which always end on an octet boundary. In this case, the length of all frames will be 8N bits, where N is an integer representing the number of octets in the frame. If the receiving station discards frames which do not end exactly on an octet boundary, a reduction in undetected errors will occur. Undetected errors described in (c) above would be reduced by about an order of magnitude, since erroneous flags would have to be introduced exactly on an octet boundary. Undetected errors described in (d) and (e) above would be reduced to an ignorable level; an integral multiple of eight such errors would be required in order for the frame to pass this octet-aligned test. An improvement in the overall undetected error rate of 10^{-2} results when this constraint is applied.

Supervisory and unnumbered format frames of the wrong length should be discarded by the receiver. I frames which exceed the maximum established length may also be discarded by the receiver. Policing the length of information fields can also be done outside the scope of the ADCCP standards by including an indication of the length of the information field within the information field. The information field could be discarded if its length is incorrect, greatly reducing undetectable errors of all categories except undetectable pattern errors. Transmission overhead is increased by the inclusion of a length indicator.

When alphanumeric data is included, the use of parity bits provides a further protection against undetected errors outside the scope of ADCCP. Specific users employ data validity checks as a further guard before processing information (check digits, range limits, etc.).

All of the sources of undetected transmission errors described above can be reduced by about 10^{-5} if a 32-bit FCS is used. The use of a 32-bit FCS increases transmission overhead by 16 bits (16% for a 100-bit frame and 0.4% for a 4096-bit frame). However, existing integrated circuits for ADCCP operation support only the 16-bit FCS; these integrated circuits could not be used on links operating with a 32-bit FCS. The following 32-bit FCS generating polynomial has been incorporated into the draft revision of ANS X3.66-1979:

$$2^{32} + 2^{26} + 2^{23} + 2^{22} + 2^{16} + 2^{12} + 2^{11} + 2^{10} + 2^{8} + 2^{7} + 2^{5} + 2^{4} + 2^{2} + 2^{1} + 1.$$

This 32-bit FCS generating polynomial might become available in integrated circuits supporting ADCCP in the future.

It is strongly recommended that equipment using the 32-bit FCS should be able to also operate with the 16-bit FCS in order to maintain compatibility.

A careful study of the requirements of the system users, all sources of errors, and costs and benefits of using any error-reducing technique is required to justify the use of any error detection mechanisms beyond the standard ADCCP 16-bit algorithm.

8.0 SPECIFICATION OF AN ADCCP LINK

An ADCCP link is specified in four parts:

* document references;
* a description of the link configuration;
* a designation of the classes of procedures and options; and,
* a description of other characteristics.

Note, however, that these four parts describe only the data link control procedures to be used on the link. Other specifications are necessary to completely describe the operation of a data communications connection; e.g., physical signalling methods and interfaces, and message formats. Other standards are available to help characterize a data communications connection.

8.1 Documents

FIPS 71 should be cited when applicable.

8.2 Description of Link Configuration

The data link must be described by:

* identifying the stations (equipment) that participate in link operations;
* specifying each station as a primary, secondary or combined station; and,
* identifying the configuration of stations on the link, as described earlier.

8.3 Classes of Procedures and Options

The classes of procedures and options used by each station on the link must be specified. *It is recommended that one of the three combinations of classes of procedures and options (class A, B, or C) discussed earlier be specified.* Section 11 of ANS X3.66-1979 describes how to designate classes of procedures in terms of their basic repertoire of commands and responses and any additional options.

8.4 Other Characteristics

* As discussed earlier, certain link configurations may require that procedures to reduce or avoid contention during transmission be described.
* The ability to operate under two-way alternate or two-way simultaneous link procedures must be specified.
* The maximum information field length must be specified.
* The use of a 32-bit frame check sequence (FCS) must be specified and described when it is required.
* The addressing assignments must be listed. If addresses are assigned dynamically during link operation, the procedures for making address assignments must be described.
* The contents and format of the information field of XID frames must be described when XID is used. (The use of XID is not recommended.)
* When the initialization state is to be used on the link, the procedures to be used in that state must be fully described. This description must include the formats of bit streams transferred during that state, and how operations within the initialization state are terminated. (The use of initialization state is not recommended.)
* When UP frames or group addressing are to be used to simultaneously poll groups of stations, procedures for avoiding contention between the responses of polled stations, if any, should be described. (The use of UP is not recommended.)
* When UI frames are used, the relationship between the information field of I and UI frames must be specified. The effect of busy conditions on UI frames must be clarified. (The use of UI is not recommended.)
* The values of required timers, or the method of assigning timer values, must be described. Section 9 of ANS X3.66-1979 lists the required timers.
* The value and operation of any other timers not required by ANS X3.66-1979 must be described. Timer operations need to be described by indicating when a timer is to be set, when the timer is to be reset, and action to be taken when the timer expires.

APPENDIX A—List of Abbreviations

ABM	asynchronous balanced mode
ADCCP	advanced data communication control procedures
ANS	American National Standard
ANSI	American National Standards Institute
ARM	asynchronous response mode
ARO	asynchronous respond opportunity
ASCII	American Standard Code for Information Interchange
BA	balanced asynchronous
CCITT	International Telegraph and Telephone Consultative Committee
CFR	Code of Federal Regulations
CRC	cyclical redundancy check
DCE	data circuit-terminating equipment
DTE	data terminal equipment
F	final (bit in control field)
FCS	frame check sequence
FIPS	Federal Information Processing Standard
FIPS 71	Federal Information Processing Standard Publication 71: *Advanced Data Communication Control Procedures*
FRMR	frame reject
I	information
I/O	input/output
ISO	International Organization for Standardization
LAP	link access procedure
LAPB	link access procedure B
N(R)	receive sequence number
NBS	National Bureau of Standards
NRO	normal respond opportunity
NRZI	non-return to zero inverted
P	poll (bit in control field)
P/F	poll/final
PCM	pulse coded modulation
REJ	reject
RIM	request initialization mode
RNR	receiver not ready
RR	receiver ready
RSET	reset
SABM	set asynchronous balanced mode
SABME	set asynchronous balanced mode extended
SIM	set initialization mode
SREJ	selective reject
UA	unnumbered acknowledgment; unbalanced asynchronous
UI	unnumbered information
UN	unbalanced normal
UP	unnumbered poll
X.25	CCITT Recommendation X.25-1980: *Interface Between Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE) for Terminals Operating in the Packet Mode on Public Data Networks*
X.75	CCITT Recommendation X.75-1980: *Terminal and Transit Call Procedures and Data Transfer Systems on International Circuits Between Packet-Switched Data Networks*
X3.66	American National Standard X3.66-1979: *Advanced Data Communication Control Procedures (ADCCP)*
XID	exchange identification

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DIMENSIONS/NBS—This monthly magazine is published to inform scientists, engineers, business and industry leaders, teachers, students, and consumers of the latest advances in science and technology, with primary emphasis on work at NBS. The magazine highlights and reviews such issues as energy research, fire protection, building technology, metric conversion, pollution abatement, health and safety, and consumer product performance. In addition, it reports the results of Bureau programs in measurement standards and techniques, properties of matter and materials, engineering standards and services, instrumentation, and automatic data processing. Annual subscription: domestic $11; foreign $13.75.

NONPERIODICALS

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National Standard Reference Data Series—Provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated. Developed under a worldwide program coordinated by NBS under the authority of the National Standard Data Act (Public Law 90-396).

NOTE: The principal publication outlet for the foregoing data is the Journal of Physical and Chemical Reference Data (JPCRD) published quarterly for NBS by the American Chemical Society (ACS) and the American Institute of Physics (AIP). Subscriptions, reprints, and supplements available from ACS, 1155 Sixteenth St., NW, Washington, DC 20056.

Building Science Series—Disseminates technical information developed at the Bureau on building materials, components, systems, and whole structures. The series presents research results, test methods, and performance criteria related to the structural and environmental functions and the durability and safety characteristics of building elements and systems.

Technical Notes—Studies or reports which are complete in themselves but restrictive in their treatment of a subject. Analogous to monographs but not so comprehensive in scope or definitive in treatment of the subject area. Often serve as a vehicle for final reports of work performed at NBS under the sponsorship of other government agencies.

Voluntary Product Standards—Developed under procedures published by the Department of Commerce in Part 10, Title 15, of the Code of Federal Regulations. The standards establish nationally recognized requirements for products, and provide all concerned interests with a basis for common understanding of the characteristics of the products. NBS administers this program as a supplement to the activities of the private sector standardizing organizations.

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Order the **above** *NBS publications from: Superintendent of Documents, Government Printing Office, Washington, DC 20402.*

Order the **following** *NBS publications—FIPS and NBSIR's—from the National Technical Information Services, Springfield, VA 22161.*

Federal Information Processing Standards Publications (FIPS PUB)—Publications in this series collectively constitute the Federal Information Processing Standards Register. The Register serves as the official source of information in the Federal Government regarding standards issued by NBS pursuant to the Federal Property and Administrative Services Act of 1949 as amended, Public Law 89-306 (79 Stat. 1127), and as implemented by Executive Order 11717 (38 FR 12315, dated May 11, 1973) and Part 6 of Title 15 CFR (Code of Federal Regulations).

NBS Interagency Reports (NBSIR)—A special series of interim or final reports on work performed by NBS for outside sponsors (both government and non-government). In general, initial distribution is handled by the sponsor; public distribution is by the National Technical Information Services, Springfield, VA 22161, in paper copy or microfiche form.

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FIPS PUBLICATION CHANGE NOTICE

CHANGE NUMBER	2 - 71
Change Number	1 - 78
DATE OF CHANGE	1994 July 29
FIPS PUBLICATION NUMBER	71 & 78

PUBLICATION TITLE

FIPS PUB 71, Advanced Data Communication Control Procedures (ADCCP)

FIPS PUB 78, Guideline for Implementing Advanced Data Communication Control Procedures (ADCCP)

THIS OFFICE HAS A RECORD OF YOUR INTEREST IN RECEIVING CHANGES TO THE ABOVE FIPS PUBLICATION. THE CHANGE(S) INDICATED BELOW HAVE BEEN PROVIDED BY THE MAINTENANCE AGENCY FOR THIS PUBLICATION AND WILL BE INCLUDED IN THE NEXT PUBLISHED REVISION TO THIS FIPS PUBLICATION. QUESTIONS OR REQUESTS FOR ADDITIONAL INFORMATION SHOULD BE ADDRESSED TO THE MAINTENANCE AGENCY:

Department of Commerce
National Institute of Standards and Technology
Computer Systems Laboratory
Gaithersburg, MD 20899

CHANGE ITEM(S)

Attached is a reprint from the June 22, 1994, FEDERAL REGISTER (59 FR 32186) which announces that the Secretary of Commerce has approved the withdrawal of two Federal Information Processing Standards (FIPS): FIPS PUB 71, Advanced Data Communication Control Procedures (ADCCP) and FIPS PUB 78, Guideline for Implementing Advanced Data Communication Control Procedures (ADCCP).

FIPS 71 and 78 are withdrawn because they are no longer needed by the Federal government. Commercial products supported by this technology are no longer needed.

This withdrawal of the standards is effective June 22, 1994.

Please remove each FIPS listed above and insert this change notice.

Attachment

Copies of FIPS are available from:

National Technical Information Service (NTIS)
ATTN: Sales Office, Sills Building
5285 Port Royal Road
Springfield, VA 22161

Phone - (703) 487-4650

Office Hours - 7:45am to 5:00pm

ELECTRONIC FORM

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federal register

Wednesday
June 22, 1994

National Institute of Standards and Technology
NOTICES
Information processing standards, Federal:
Advanced data communication control procedures; withdrawn, 32186

National Institute of Standards and Technology

[Docket No. 931057–4117]

RIN 0693–AA38

Approval of Withdrawal of Federal Information Processing Standard (FIPS) 71, Advanced Data Communication Control Procedures (ADCCP) and FIPS 78, Guideline for Implementing ADCCP

AGENCY: National Institute of Standards and Technology (NIST), Commerce.

ACTION: Notice.

SUMMARY: The purpose of this notice is to announce that the Secretary of Commerce has approved the withdrawal of Federal Information Processing Standard (FIPS) 71, Advanced Data Communication Control Procedures (ADCCP) and FIPS 78, Guideline for Implementing Advanced Data Communication Control Procedures (ADCCP).

On November 16, 1993, notice was published in the Federal Register (58 FR 60425) proposing withdrawal of Federal Information Processing Standard (FIPS) 71, because the technical specifications that they adopt are obsolete and are no longer supported by industry. NIST also stated that if FIPS 71 were withdrawn, FIPS 78 would be withdrawn as well.

The written comments submitted by interested parties and other material available to the Department relevant to this standard was reviewed by NIST. On the basis of this review, NIST recommended that the Secretary approved the withdrawal of FIPS 71 and 78, and prepared a detailed justification document for the Secretary's review in support of that recommendation.

The detailed justification document which was presented to the Secretary is part of the public record and is available for inspection and copying in the Department's Central Reference and Records Inspection Facility, Room 6020, Herbert C. Hoover Building, 14th Street between Pennsylvania and Constitution Avenues, NW., Washington, DC 20230.

EFFECTIVE DATE: This withdrawal is effective on June 22, 1994.

FOR FURTHER INFORMATION CONTACT: Ms. Shirley Radack, National Institute of Standards and Technology, Gaithersburg, MD 20899, telephone (301) 975–2833.

Authority: Federal Information Processing Standards Publications (FIPS PUBS) are issued by the National Institute of Standards and Technology after approval by the Secretary of Commerce pursuant to Section 111(d) of the Federal Property and Administrative Services Act of 1949 as amended by the Computer Security Act of 1987, Public Law 100–235.

Dated: June 17, 1994.

Samuel Kramer,

Associate Director.

[FR Doc. 94–15189 Filed 6–21–94; 8:45 am]

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