AX.25 NETWORK **SUBLAYER** PROTOCOL RECOMMENDATION

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Introduction

This is the first of four papers that make up a protocol recommendation for AX.25 at Level 3A, the Network Sublayer.

This series of papers is being generated by AMRAD after a series of meetings between AMRAD members Paul Rinaldo, W4RI, Terry Fox, WB4JFI, Dave Borden, K8MMO, Eric Scace, K3NA, and Gordon Beattie, N2DSY.

These papers are first drafts, and are being released to the amateur community for comments and suggestions. Anyone wishing to comment is invited to write to the author at the above address, or write to the AMRAD Newsletter at the following address:

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The protocol recommendation that follows is based on the CCITT X.25 Level 3 specification. Since many amateurs may not have the CCITT documents available to them, it was decided to replicate the entire document, with additions or deletions necessary to apply the protocol to the amateur enviroment.

This paper will discuss some of the basics of the Network Sublayer, along with operating procedures. The next paper will describe the actual packet formats. The third in the series will describe optional user requested facilities, and the fourth paper will include the Annexes mentioned throughout the previous three papers.

2 AX.25 Network Sublayer Recommendation

3.0.1 Network Sublayer Basics

The Network Layer of the IS0 Reference Model is generally broken into two different parts, each responsible for separate, distinct functions.

The Network Sublayer is responsible for the proper operation of a local, or metropolitan group of interconnected packet devices. These interconnected devices make up a network of packet users, who wish to communicate either with each other, or possibly with others outside of the metropolitan network. How the data is transferred outside of the metropolitan network is a function of the Internetwork Sublayer, and as such, falls outside the domain of this recommendation.

The Network Sublayer relies on a lower level protocol (usually the AX.25 Link Layer protocol) to cause data at the Network Layer to be transferred from one device to another. While the Link Layer protocol is responsible for the user data to transverse a physical medium properly, the Network Sublayer is responsible for the accurate transfer of data through the metropolitan network. This is usually accomplished by having individual devices interconnected to a master device (called a network controller, network hub, packet switch, or DCE). Any packet user wishing to communicate with another user (either within the metropolitan network, or outside it) does this through this master device.

Subject for further study is how two stations communicate at the Network Sublayer in the absence of a packet switch. One proposal is to have the two stations arbitrate which one will become the packet switch by a simple comparison of callsigns.

3.0.4 Network Sublayer Responsibilities

The Network Sublayer is responsible for taking data from the 'higher level protocols and sending that data to the intended destination device, through the lower level protocols that may be implemented.

Since the recommended protocol is connection oriented, in order to pass data over the network, a "virtual" connection must first be made with the destination device through a network controller, or packet switch. This recommendation handles the establishment, proper operation, recovery from errors, and tearing down of these connections necessary to pass data, along with the actual data transmissions.

This protocol is also responsible for passing along certain status information of the network or lower levels to the higher level protocols.

3.0.5 Device Descriptions

At the Network Sublayer there are two types of devices presently defined. Their descriptions have been adjusted slightly to take into account the amateur enviroment. Neither one of these devices are usually "real" devices, rather they are usually a software implemented "machine".

3.0.5.1 Data Terminating Equipment

At the Network Sublayer, the Data Terminating Equipment device, hereafter called the DTE, is generally considered the individual packet user, be it an actual user, a remote network gateway, or a large computer device running programs available to other users.

3.0.5.2 Data Circuit-Terminating Equipment

At the Network Sublayer, the Data Circuit-Terminating Equipment 'Equipment device, hereafter called the DCE, is either the packet switch device or if there is no packet switch device available, one of the DTE devices wishing to communicate. The arbitration of the second possibility is undefined at this point, and is a subject for further study.

3.0.6 Units of Data Transferred at the Network Sublayer

The basic unit of data that is transferred across a DTE/DCE interface is called a "packet". This packet is contained within the information field of Link Layer frames. All packets must contain an integral number of octets. In addition, the data field of data packets must also contain an integral number of packets.

3.0.7 Types of connections available

Amateur X.25 defines only one type of connection at the metropolitan network level, that of the virtual call. Permanent virtual circuits and datagrams are not supported by by AX.25 as presently defined.

3.1 Logical Channels

To enable multiple simultaneous virtual calls to exist, logical channels are used. Each virtual call is assigned a logical channel group number (LCGN) (less than or equal to 15 decimal) and a logical channel number (LCN) (less than or equal to 255 decimal). A logical channel group number and a logical channel number is assigned during the call set-up phase. The actual range of logical channel numbers available is established by the network, and agreed upon at the time of connection to the network. Annex A shows the recommendation of LCGN and LCN values used.

3.2 Basic Structure of Packets

Every packet transferred across the DTE/DCE interface consists of at least three octets. Within these three octets are a general format identifier, a logical channel identifier, and a packet type identifier. Additional packet fields may be appended as appropriate. Packet types are shown in Table 5/AX.25.

From DCE to DTE	From DTE to DCE
Call set-up and clearing	
Incoming call	Call request
Call connected	Call accepted
Clear indication	Clear request
DCE clear confirmation	DTE clear confirmation
Data and interrupt	
DCE data	DTE data
DCE interrupt	DTE interrupt
DCE interrupt confirmation	DTE interrupt confirmation
Flow control and reset	
DCE RR	DTE RR
DCE RNR	DTE RNR
Reset indication	Reset request
DCE reset confirmation	DTE reset confirmation
Restart	
Restart indication	Restart request
DCE restart confirmation	DTE restart confirmation
Diagnostic	
Diagnostic	

Table 5/AX.25 AX.25 Packet types

3.3 Procedure for Restart

The restart procedure is used to initialize or re-initialize the network level DTE/DCE interface. The restart procedure clears all virtual calls at the DTE/DCE interface.

3.3.1 Restart by the DTE

The DTE may at any time request a restart by sending a restart request packet across the packet interface. This will then place each logical channel in the DTE restart request state (r2).

The other device (DCE or possibly another DTE) will confirm the restart by sending a DCE restart confirmation packet and placing the logical channels used between the two devices in the ready state (p1).

The DCE restart confirmation packet only applies to virtual calls between the requesting DTE and the receiving DCE. This restart has no affect on virtual calls with any other device. Time spent in the DTE restart request state (r2) shall not exceed time-limit T20 (see Annex D).

3.3.2 Restart by the DCE

The DCE may initiate a restart of the packet interface by sending a restart indication packet. All virtual calls for the specified packet interface are then placed in the DCE restart indication state (r3). While in this state the DCE will ignore all packets received from the DTE involved except for restart request and DTE restart confirmation packets.

The DTE will confirm the restart by sending a DTE restart confirmation packet, and then place all virtual calls between it and the DCE in question in the ready state (p1).

The action taken by the DCE when the DTE does not confirm restart within time-out T10 is given in Annex D.

3.3.3 Restart Collision

Restart collision occurs when both the DCE and DTE simultaneously send a restart request and a restart indication packet. When this happens, the DCE will consider the restart completed. The DCE will not expect a DTE restart confirmation packet and will not send a DCE restart confirmation packet. This places all virtual calls between the affected DTE/DCE interface in the ready state (p1).

3.4 Error Handling

Table C-1/AX.25 indicates the reaction of the DCE when certain error conditions are encountered. Error conditions other than those specified in the table are discussed in sections 4 and 5.

3.4.1 Diagnostic Packet

The diagnostic packet may be used to indicate error conditions when the usual methods (ex. reset, clear and restart with cause and diagnostic) are inappropriate. A diagnostic packet from a DCE should provide information on the error situations that are considered unrecoverable at the packet layer. This information permits analysis of the error, and recovery by higher levels at the DTE, if possible.

A diagnostic packet is issued only once per particular instance of an error condition. A DTE receiving a diagnostic packet is not required to confirm reception. After a DCE sends a diagnostic packet, it will same in the same state for that logical channel(s) as it was when the diagnostic was generated.

3.5 Effects of the Physical and Link Layer on the Packet Level

Changes of operational states of the Physical and Link Layers do not implicity alter the state of each logical channel at the packet level. When changes that affect the packet level do occur, they are explicitly indicated at the packet level by the use of restart, clear, or reset procedures, whichever is appropriate.

A failure at the Physical and/or Link Layers is defined to be when the DCE cannot transmit or receive any frames because of abnormal conditions at the Physical and/or Link Layer.

When a failure on the Physical and/or Link Layer is detected, virtual calls will be cleared, and further action may be taken as described in section 4.6.

When the failure of the Physical and/or Link Layer is recovered, the DCE will send a restart indication packet with the cause "Network operational" to the DTE. Any further action to be taken is defined in section 4.6.

In other out-of-order conditions on the Physical and/or Link Layer, the DCE will clear all virtual calls using the affected link.

Note: An out-of-order condition on the Link Level includes reception of a disc command or a transmission of a disc command by the DCE, in the case of a single link procedure.

4 Procedures for virtual circuit services

4.1 Procedures for virtual call service

Figures B-1/AX.25, B-2/AX.25, and B-3/AX.25 in Annex B show the state diagrams which give a definition of events at the packet level DTE/DCE interface for each logical channel used for virtual calls.

Annex C gives details of the action taken by the DCE on reception of packets in each state shown in Annex B.

The call set-up and clearing procedures described in the following paragraphs apply independently to each logical channel assigned to the virtual call service at the DTE/DCE interface.

4.1.1 Ready state

If there is no call in existance, a logical channel is in the ready state (p1).

4.1.2 Call request packet

The calling DTE shall indicate a call request by sending a call request packet across the DTE/DCE interface. The logical channel selected by the DTE is then in the DTE waiting state (p2). The call request packet includes the called DTE address. The calling DTE address shall also be used.

Note 1. A DTE address shall be encoded as described in Annex F of this document.

Note 2. In order to minimize the risk of call collisions, the call request packet should use the logical channel with the highest number in the range allowed in Annex A that is in the ready state.

4.1.3 Incoming call packet

The DCE will indicate that there is an incoming call by sending across the DTE/DCE interface an incoming call packet. This will place the logical channel in the DCE waiting state (p3).

The incoming call packet will use the logical channel in the ready state with the lowest number in the range allowed in Annex A. The incoming call packet shall include the DTE calling address and the called DTE address fields encoded as described in Annex F.

4.1.4 Call accepted packets

The called DTE shall indicate its acceptance of the call by sending a call accepted packet across the DTE/DCE interface. This call accepted packet will specify the same logical channel as that of the incoming call packet. This places the specified logical channel in the data transfer state (p4).

If the called DTE does not accept the call by sending a call accepted packet or does not reject it by sending a clear request packet as described in paragraph 4.1.7 within time-out T11 (see Annex D), the DCE will consider it as a procedure error from the called DTE and will clear the virtual call aceording to the procedure described in paragraph 4.1.8.

4.1.5 Call connected packet

The reception of a call connected packet by the calling DTE specifying the same logical channel as that specified in the call request packet indicates that the call has been accepted by the called DTE by means of a call accepted packet. This places the specified logical channel in the data transfer state (p4).

The time spent in the DTE waiting state (p2) will not exceed time-out T21 (see Annex D).

4.1.6 Call collision

Call collision occurs when a DTE and DCE simultaneously send a call request packet and an incoming call packet specifying the same logical channel. The DCE will proceed with the call request and cancel the incoming call.

4.1.7 Clearing by the DTE

The DTE may indicate clearing at any time by sending a clear request packet across the DTE/DCE interface (see paragraph 4.5). The logical channel is then in the DTE clear request state (p6). When the DCE is prepared to free the logical channel, it will send a clear confirmation packet across the DTE/DCE interface specifying the proper logical channel. This logical channel is then placed in the ready state (p1).

The DCE clear confirmation packet has only local significance, it does not affect calls outside the one logical channel cleared (such as end-to-end calls). The time spent in the DTE clear request state (p6) will not exceed time limit T23 (see Annex D).

It is possible that subsequent to sending a clear request packet and prior to the reception of a DCE clear confirmation packet, the DTE will receive other types of packets (depending of the state of the logical channel).

The calling DTE may abort a call by clearing it before it has received a call connected or clear indication packet.

The called DTE may refuse an incoming call by clearing it as described above instead of sending a call accepted packet.

4.1.8 Clearing by the DCE

The DCE will indicate clearing by transmitting across the DTE/DCE interface a clear indication packet (see 4.5). The logical channel is then in the DCE clear indication state (p7). The DTE shall respond by sending a DTE clear confirmation packet. The logical channel is then placed in the ready state (p1).

The action taken by the DCE when the DTE does not confirm clearing within time-out T13 is given in Annex D.

4.1.9 Clear collision

Clear collision occurs when a DTE and DCE simultaneously send a clear request packet and a clear indication packet specifying the same logical channel number. When this happens, the DCE will consider the clearing completed and will not expect a DTE clear confirmation packet. The DCE will not send a DCE clear confirmation packet. The logical channel will be placed in the ready state (p1).

4.1.10 Unsuccessful call

If a call cannot be established, the DCE will send a clear indication packet specifying the logical channel indicated in the call request packet to the calling DTE.

4.1.11 Call progress signals

The DCE will be capable of transferring to the DTE clearing progress signals as specified in a future document (AX.96).

Clearing call progress signals will be carried in clear indication packets which will terminate the call to which the packet refers. The method of coding clear indication packets containing call progress signals is detailed in paragraph 6.2.3.

4.1.12 Data transfer state

The procedures for the control of packets between DTE and DCE while in the data transfer state are contained in section 4.3 below.

4.3 Procedures for data and interrupt transfer

The data transfer and interrupt procedures described in the following paragraphs apply independantly to each logical channel assigned for virtual calls existing at the DTE/DCE interface.

Normal network operation dictates that user data in data and interrupt packets are all passed transparently, unaltered through the network in the case of packet DTE to packet DTE communications. The order of bits in data packets is preserved. Packet sequences are delivered as complete packet sequences. Diagnostic codes are treated as described in sections 6.2.3, 6.5.3, and 6.6.1.

4.3.1 States for data transfer

A virtual call logical channel is in the data transfer state (p4) after completion of call establishment and prior to a clearing or restart procedure. Data, interrupt!, flow control, and reset packets may be transmitted and received by a DTE in the data transfer state of a logical channel at the DTE/DCE interface. In this state, the flow control and reset procedures described in section 4.4 apply to data transmission on that logical channel to and from the DTE.

When a virtual call is cleared, data and interrupt packets may be discarded by the network (see 4.5). In addition, data, interrupt, flow control, and reset packets transmitted by a DTE will be ignored by the DCE when the logical channel is in the DCE clear indication state (p7). It is left to the DTE to define DTE to DTE protocols able to cope with various possible situations that may occur.

4.3.2 User data field length of data packets

The standard maximum user data field length is 128 octets.

The user data field of data packets transmitted by a DTE or DCE may contain any number of octets up to the agreed upon maximum. The user data field shall contain an integral number of octets.

If the user data field in a data packet exceeds the maximum user data field length, the DCE will reset the virtual call with the resetting cause "Local procedure error".

4.3.3 Deliverv confirmation bit

The setting of the Delivery Confirmation bit (D bit) is used to indicate whether or not the DTE wishes to receive an end-to-end acknowledgement of delivery of the packet with the D bit set. This acknowledgement is for data it has transmitted, and the acknowledgement is made using the packet receive sequence number P(R) (see 4.4 below).

The use of the D bit does not obviate the need for a higher level protocol between communicating DTEs which may be used independantly of the D bit procedure to recover from user or network generated resets and clearings.

4.3.4 More data mark

If a DTE or DCE wishes to indicate a sequence of more than one packet, it uses the More Data Mark bit (M bit) as defined below.

The M bit can be set to one in any data packet. When it is set to one in a full data packet, or in a partially full data packet also carrying the D bit set to one, it indiactes that more data is to follow. Networks supporting AX.25 will not perform data packet segmentation or recombination.

A sequence of data packets with every M bit set to one except the last one will be delivered as a sequence of data packets with the M bit set to one except for the last one when the original packets having the M bit set to one are either full (irrespective of the setting of the D bit) or partially full but have the D bit set to one.

Two catgories of packets, A and B have been defined as shown in Table 6/AX.25. Table 6/AX.25 also illustrates the networks treatment of the M and D bits at both ends of a virtual call.

Data packet sent by source DTE				Data packet rcvd by the destination DTE	
Category	M	D	Full	M	D
B	0 or 1	0	No	0	0
B	0	1	No	0	1
B	1	1	No	1	1
B	0	0	Yes	0	0
B	0	1	Yes	0	1
A	1	0	Yes	1	0
B	1	1	Yes	1	1

Table 6/AX.25
Definition of two categories of data packets and network treatment of the M and D bits

4.3.5 Complete packet sequence

A complete packet sequence is defined as being composed of a single category B packet and all contiguous preceeding category A packets having the exact maximum user data field length with the M bit set to one and the D bit set to zero. All other data packets are category B packets.

When transmitted by a DTE source, a complete packet sequence is always delivered to the destination DTE as a single complete packet sequence.

The user data field of the last packet of the sequence may have less than the maximum length and the M and D bits are set as described in Table 6/AX.25.

Since the maximum user data field length is the same at both ends, the user data fields of data packets are delivered to the receiving DTE exactly as they have been received by the network. If the last packet of a complete packet sequence transmitted by the source DTE has a data field less than the maximum length with the M bit set to one and the D bit set to zero, then the last packet of the complete packet sequence delivered to the receiving DTE will have the M bit set to zero.

4.3.6 Qualifier bit

A complete packet sequence may be on one of two levels. If a DTE wishes to transmit on more than level, it uses the Qualifier bit (Q bit).

When only one level of data is being sent on a logical channel, the Q bit is always set to zero. If two levels of data are being sent, the transmitting DTE should set the Q bit in all data packets of a complete packet sequence to the same value, either zero or one. A complete packet sequence, which is sent with the Q bit set to the same value in all packets, is delivered by the network as a complete packet sequence with the Q bit set in all packets to the value assigned by the transmitting DTE.

When the Q bit is not set to the same value by the transmitting DTE within a complete packet sequence? a network supporting AX.25 will reset the logical channel with the cause "Local procedure error" and a diagnostic code of "Inconsistant Q bit setting".

Recommendation AX.29 gives an example of the procedures to be used when the Q bit is set to one.

Packets are numbered consecutively (see 4.4.1.1) regardless of their data level (Q bit setting).

4.3.7 Interrupt procedure

The interrupt procedure is used to allow a DTE to transmit data to the remote DTE without following the flow control procedure applying to data packets (see 4.4). The interrupt procedure applies only in the flow control ready state (d1) within the data transfer state (p4).

The interrupt procedure will have no effect on the transfer and flow control procedures applying to the data packets on a virtual call logical channel.

To transmit an interrupt, the DTE sends a DTE interrupt packet across the DTE/DCE interface. The DTE should not send a second DTE interrupt packet until the first one is confirmed by the reception of a DCE interrupt confirmation packet (see Note 2 to Table C-4/AX.25). After the interrupt procedure is completed at the remote end, the DCE will confirm the receipt of the interrupt by sending a DCE interrupt confirmation packet. The reception of a DCE interrupt confirmation packet indicates that the interrupt has been confirmed by the remote DTE by means of a DTE interrupt confirmation packet.

The DCE indicates an interrupt from the remote DTE by sending a DCE interrupt packet across the DTE/DCE interface which contains the same data field as that in the DTE interrupt packet transmitted by the remote DTE. A DCE interrupt packet is delivered at or before the point in the data packets stream at which the DTE interrupt packet was generated. The DTE will confirm reception of the DCE interrupt packet by sending a DTE interrupt confirmation packet.

4.4 Procedures for flow control

Section 4.4 only applies to the data transfer state (p4) and specifies the procedures covering flow control of data packets and reset on each logical channel used for a virtual call.

4.4.1 Flow Control

The transmission of data packets across a DTE/DCE interface of a logical channel in a virtual call is controlled separately for each direction, and is based on authorization from the receiver.

Flow control also allows a DTE to limit the rate at which it accepts packets across the DTE/DCE interface, noting that there is also a network-dependant limit on the number of packets which may be within the network for the virtual call.

4.4.1.1 Numbering of data packets

Each data packet transferred across the DTE/DCE interface for each direction of transmission in a virtual call is numbered sequentially.

The sequence numbering scheme of the packets is in module 8. The packet sequence numbers cycle through the entire range from zero to seven. The packet sequence numbering scheme is the same for both directions of transmission and is common for all logical channels at the DTE/DCE interface.

Only data packets contain this sequence number, which is called the packet send sequence number P(S).

The first data packet sent across the DTE/DCE interface for each direction of data transmission when the logical channel has just entered the flow control ready state (dl), will have a packet send sequence number equal to zero.

4.4.1.2 Window description

For each direction of a data transmission over a virtual call logical channel, a window is defined as the ordered set of W consecutive packet send sequence numbers of the data packets authorized to cross the interface.

The lowest sequence number in the window is referred to as the lower edge. When a virtual call at the DTE/DCE interface has just entered the flow control ready state (dl), the window related to each direction of data transmission has a lower window edge equal to zero.

The packet send sequence number of the first data packet not authorized to cross the interface is the value of the lower window edge plus W (module 8).

The standard window size W is 2 for each direction of data transmission at the DTE/DCE interface.

4.4.1.3 Flow control principles

When the sequence number P(S) of the next packet to be sent by the DCE is within the window, the DCE is authorized to transmit this data packet to the DTE. When the sequence number P(S) of the next data packet to be transmitted by the DCE is outside of the window, the DCE shall not transmit a data packet to the DTE. The DTE should follow this same procedure.

When the sequence number P(S) of the data packet received by the DCE is the next in sequence and is within the window, the DCE will accept the data packet. A received data packet containing a P(S) that is out of sequence (such as when there is a gap in the received P(S) numbering, or a duplicate P(S) number), out of window, or not equal to zero for the first data packet after entering the flow control ready state (dl) is considered by the DCE as a local procedure error. The DCE will reset the virtual call (see 4.4.3). The DTE should follow the same procedure.

A number (modulo S), referred to as a packet receive sequence number P(R), conveys across the DTE/DCE interface information from the receiver for the transmission of data packets. When transmitted across the DTE/DCE interface, a P(R) becomes the lower window edge. In this way, additional data packets may be authorized by the receiver to cross the DTE/DCE interface.

The packet receive sequence number, P(R), is conveyed in data, receive ready (RR), and receive not ready (RNR) packets.

The value of a P(R) received by the DCE must be within the range from the last P(R) received by the DCE up to and including the packet send sequence number of the next data packet to be transmitted by the DCE. Otherwise, the DCE will consider the reception of this P(R) as a procedure error and will reset the virtual call. The DTE should follow the same procedure.

The receive sequence number P(R) is less than or equal to the next data packet sequence number expected, and implies that the DTE or DCE transmitting P(R) has accepted at least all data packets numbered up to and including P(R)-1.

4.4.1.4 Delivery confirmation

When the D bit is set to zero in a data packet having P(S) equal to p, the significance of the returned P(R) corresponding to the data packet (ex. P(R)=p+1) is a local updating of the window across the packet level interface so that the achievable throughput is not constrained by the DTE-to-DTE round trip delay across the network(s).

When the D bit is set to one in a data packet having P(S)=p, the significance of the returned P(R) corresponding to that data packet (ex. P(R)=p+1) is an indication that a P(R) has been received from the remote DTE for all data bits in the data packet in which the D bit had originally been set to one.

When a DTE receives a data packet with the D bit set to one, it should transmit the corresponding P(R) as soon as possible in order to avoid the possibility of deadlocks (without waiting for further data packets). A data, RR, or RNR packet may be used to convey the P(R) (see Note to 4.4.1.6). Likewise, the DCE is required to send P(R) to the DTE as soon as possible after it is received from the remote DTE.

In the case where a P(R) for a data packet with the D bit set to one is outstanding, the local updating of the window will be deferred for subsequent data packets with the D bit set to zero.

4.4.1.5 DTE and DCE receive ready (RR) packets

RR packets are used by the DTE or DCE to indicate that it is ready to receive W data packets within the window starting with P(R), where P(R) is indicated in the RR packet.

4.4.1.6 DTE and DCE receive not ready (RNR) pack-

RNR packets are used by the DTE or DCE to indicate a temporary inability to accept additional data packets for a given virtual cal.. A DTE or DCE receiving an RNR packet shall stop transmitting data packets on the indicated logical channel, but the window is updated by the P(R) value of the RNR packet. The receive not ready condition is cleared by the transmission in the same direction of a RR packet or by a reset procedure being initiated.

The transmission of a RR packet after a RNR packet at the packet level is not to be taken as a demand for retransmission of packets which have already been transmitted.

The RNR packet may be used to convey across the DTE/DCE interface the P(R) value corresponding to a data packet which had the D bit set to one in the case that additional data packets cannot be accepted.

4.4.2 Throughput characteristics and throughput classes

The attainable throughput on virtual calls carried at the DTE/DCE interface may vary due to the stastical sharing of transmission and switch resources and is constrained by:

1) the access line characteristics, local window size and traffic characteristics of other logical channels at the local DTE/DCE interface;

2) the access line characteristics, local window size and traffic characteristics of other logical channels at the remote DTE/DCE interface, and;

3) the throughput achievable on the virtual call through the network(s) independant of interface characteristics including number of active logical channels. This throughput may be dependant on network service characteristics such as window rotation mechanisms and/or optional user facilities requested on national,international calls.

The attainable throughput will also be affected by:

1) the receiving DTE flow controlling the DCE;

2) the transmitting DTE not sending data packets which have the maximum data field length;

3) the local DTE/DCE window and/or packet sizes, and ;

4) the use of the D bit.

A throughput class for one direction of transmission is an inherent characteristic of the virtual call related to the amount of resources allocated to this virtual call. This characteristic is meaningful when the D bit is set to zero in data packets. It is a measure of the throughput that is not normally exceeded on the virtual call. However, due to the statistical sharing of transmission and switching resources, it is not guaranteed that the throughput class can be reached 100% of the time.

Depending on the network and the applicable conditions at the considered moment, the effective throughput may exceed the throughput class.

The definition of throughput class as a grade of service parameter is for further study. The grade of service might be specified when the D bit is set to zero or over a time period between the completion and initiation of successive D bit procedures.

The throughput class can only be reached if the following conditions are met:

a) the access data links of both ends of a virtual call are engineered for the throughput class;

b) the receiving DTE is not flow controlling the DCE such that the throughput class is not attainable;

c) the transmitting DTE is sending data packets which have the maximum data field length, and;

d) all data packets transmitted on the virtual call have the D bit set to zero.

The throughput class is expressed in bits per second. At the DTE/DCE interface, the maximum data field length is specified for a virtual call, and thus the throughput class can be interpreted by the DTE as the number of full data packets per second that the DTE does not have a need to exceed.

The default throughput classes for both directions of transmission correspond to the user class of service of the DTE (see 7.4.2.6) but do not exceed the maximum throughput class supported by the network.

The summation of throughput classes of all virtual calls supported at a DTE/DCE interface may be greater than the data transmission rate of the access line.

4.4.3 Procedure for reset

The reset procedure is used to re-initialize the virtual call, and in so doing removes in each direction all data and interrupt packets which may be in the network (see 4.5). When a virtual call at the DTE/DCE interface has just been reset, the window related to each direction of data transmission has a lower window edge equal to zero, and the numbering of subsequent data packets to cross the DTE/DCE interface for each direction of data transmission shall start from zero.

The reset procedure can only apply in the data transfer state (p4) of the DTE/DCE interface. In any other state, the reset procedure is abandoned. As an example, when a clearing or restarting procedure is initiated, reset requested and reset indication packets can be left unconfirmed.

For flow control, there are three states (d1, d2, and d3) within the data transfer state (p4). They are flow control ready (d1), DTE reset request (d2), and DCE reset indication (d3) as shown in the state diagram in Figure B-3/AX.25. When entering state p4, the logical channel is placed in state d1. Table B-4/AX.25 specifies actions taken by the DCE on the reception of packets from the DTE.

4.4.3.1 Reset request packet

The DTE shall indicate a request for reset by transmitting a reset request packet specifying the logical channel. This places the logical channel in the DTE reset request state (d2).

4.4.3.2 Reset indication packet

The DCE shall indicate a reset sending to the DTE a reset indication packet specifying the logical channel and the reason for the resetting. This places the logical channel in the DCE reset indication state (d3). In this state, the DCE will ignore all data, interrupt, RR, and RNR packets.

4.4.3.3 Reset Collision

Reset collision occurs when a DTE and a DCE simultaneously transmit a reset request packet and a reset indication packet specifying the same logical channel. Under these circumstances the DCE will consider the reset completed. The DCE will not expect a DTE reset confirmation packet and will not transfer a DCE reset confirmation packet. This places the logical channel in the flow control ready state (d1).

4.4.3.4 Reset confirmation packets

When the logical channel is in the DTE reset request state (d2), the DCE will confirm reset by sending to the DTE a DCE reset confirmation packet. This places the logical channel in the flow control ready state (d1).

The reset confirmation packet has only local significance. The time spent in the DTE reset request state (d2) will not exceed time limit T22 (see Annex D).

When the logical cahnnel is in the DCE reset indication state (d3), the DTE will confirm reset by transmitting to the DCE a DTE reset confirmation packet. This places the logical channel in the flow control ready state (d1). The action taken by the DCE when the DTE does not confirm the reset within time-out T12 is given in Annex D.

4.5 Effects of clear, reset and restart procedures on the transfer of packets

All data and interrupt packets generated by a DTE (or the network) before initiation by the DTE or the DCE of a clear, reset, or restart procedure at the logical interface will either be delivered to the remote DTE before the DCE transmits the corresponding indication on the remote interface, or be discarded by the network.

No data or interrupt packets generated by a DTE (or the network) after the completion of a reset procedure at the local interface will be delivered to the remote DTE before the completion of the corresponding reset procedure at the remote interface.

When a DTE initiates a clear, reset, or restart procedure on its local interface, all data and interrupt packets which were generated by the remote DTE (or the network) before the corresponding indication is transmitted to the remote DTE will be either delivered to the initiating DTE before DCE confirmation of the initial clear, reset, or restart request, or be discarded by the network.

The maximum number of packets which may be discarded is a function of network end-to-end delay and throughput characteristics and, in general, has no relation to the local window size. For virtual calls on which all data packets are transferred with the D bit set to one, the maximum number of packets which may be discarded in one direction of transmission is not larger than the window size of the direction of transmission.

4.6 Effect of physical and link level failures

When a failure on the physical and/or link level is detected, the DCE will transmit to the remote end a clear with the cause "Out of order" for each existing virtual call.

During the failure, the DCE will clear any incoming virtual calls with the cause "Out of order" and a diagnostic code of "Call setup or clearing problem".

When the failure is recovered on the physical and link levels, the restart procedure will be auctioned (see 3.5).

5 Datagram service

At this time, datagram service is not available in AX.25.