

ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

PACKETIZED DATA TRANSFER IN PRIVATE SWITCHING NETWORKS

ECMA TR/43

December 1987

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BRIEF HISTORY

This Technical Report describes packetized data transfer in Private Switching Networks (PSNs), including access to other networks via PSNs. This Technical Report is complementary to Technical Report ECMA TR/24, "Interfaces between Data Processing Equipment and Private Automatic Branch Exchange - Circuit Switching Application". Since in a circuit-switched environment the PSN provides a physical bearer only, ECMA TR/24 concentrates on the interfaces of Data Processing Equipment to a PSN. This Technical Report is more comprehensive and reflects the larger involvement of a PSN in packetized data transfer.

This Technical Report has the following objectives:

- To state ECMA policy with regard to the application of the CCITT ISDN Recommendations in the field of packetized data communication.
- To serve as a reference document and to fulfill a tutorial role for ECMA to guide the development of a set of standards for interfaces between Data Processing Equipment and PSNs.

The purpose of this Technical Report is not to define completely new approaches or solutions in the packet mode data transfer field but rather to complement existing international standards and support standardization trends. ECMA's major concern is that its standards be compatible with CCITT Recommendations describing packet mode data transfer services of the ISDN. Where possible and appropriate, compatibility with standards, recommendations and approaches of other bodies such as ISO, CEPT and IEC is maintained.

Adopted as an ECMA Technical Report by the General Assembly of 10th December 1987.

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1. SCOPE

This Technical Report describes packetized data transfer in Private Switching Networks (PSNs), including access to other networks (e.g. X.25) via PSNs. Packetized voice, video and other non-data packet mode bearer services are beyond the scope of this Technical Report.

This Technical Report also provides guidelines for the standardization of protocols supporting a new Bearer Service for packetized data transfer over PSNs. The architecture for these protocols fully aligns with ISDN out-of-band control principles. Furthermore, ISDN concepts compatible with high performance objectives are adopted, notably:

- the use of link layer addressing for routing and relaying purposes, and
- the partial termination of the bearer channel protocol in nodes of the network.

This Technical Report also describes functions required from terminals and PSNs to provide an overall end-to-end network service.

2. FIELD OF APPLICATION

This Technical Report applies to the operation of DPEs connected to a PSN at an S reference point; see Figure 1.

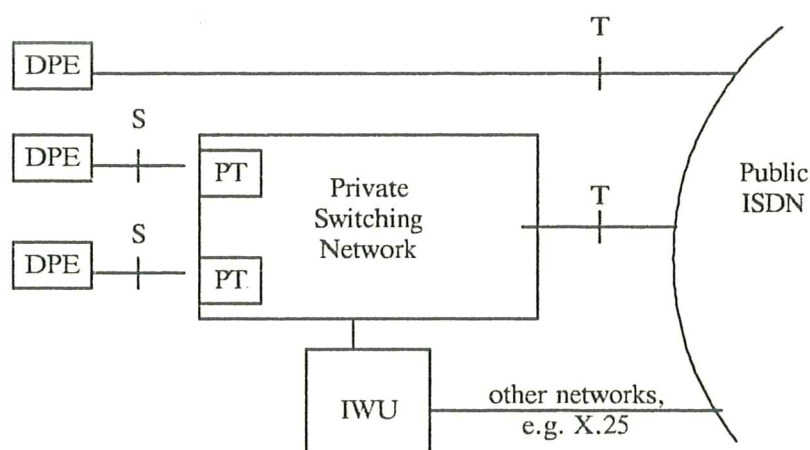


Figure 1 - Field of Application

A DPE can communicate with another DPE connected to the same PSN or it can communicate with a DPE connected to another network via an interworking unit. Although this Technical Report focuses on the first case, possible impact from interworking situations is taken into consideration.

Terminal portability is guaranteed between PSN and ISDN accesses (S and T reference points) in the sense that when a given bearer service is offered by both types of networks, it is accessed in the same manner by a DPE.

3. REFERENCES

ECMA Standards and Technical Reports

ECMA-102	Rate Adaptation for the Support of Synchronous and Asynchronous Equipment Using the V.-Series Type Interface on a Private Circuit Switching Network
ECMA-103	Physical Layer at the Basic Access Interface between Data Processing Equipment and Private Switching Networks
ECMA-104	Physical Layer at the Primary Rate Access Interface between Data Processing Equipment and Private Circuit Switching Networks
ECMA-105	Data Link Layer Protocol for the D-Channel of the S-Interfaces between Data Processing Equipment and Private Switching Networks
ECMA-106	Layer 3 Protocol for Signalling over the D-Channel of the S-Interfaces between Data Processing Equipment and Private Circuit Switching Networks
ECMA TR/13	Network Layer Principles
ECMA TR/14	Local Area Networks: Layers 1 to 4 Architecture and Protocols
ECMA TR/24	Interfaces between Data Processing Equipment and Private Automatic Branch Exchange - Circuit Switching Application
ECMA TR/34	Maintenance at the Interface between Data Processing Equipment and Private Switching Network
ECMA TR/44	An Architectural Framework for Private Networks

This Technical Report refers to proposed enhancements to Standards ECMA-105 and ECMA-106. In addition, these standards are based on CCITT Recommendations which are also undergoing development. The following conventions are adopted to refer to these documents:

- References to the ECMA Standards as they exist are referred to as: ECMA-105 and ECMA-106;
- References to future versions of these ECMA Standards updated to maintain alignment with applicable CCITT Recommendations are referred to as: ECMA105* and ECMA-106*;
- References to future versions of these ECMA Standards enhanced according to this Technical Report are referred to as: ECMA-105+ and ECMA-106+.

ISO Standards

ISO 3309	Information processing - Data communication - High-level data link control procedures - Frame structure
ISO 7498	Information processing - Open systems interconnection - Basic reference model
ISO DP 8524	Addendum to ISO 7498 covering connectionless-mode of transmission
ISO 8027	Information processing systems - Open systems interconnection - Transport service definition
ISO 8073	Information processing systems - Open systems interconnection - Transport protocol specification

ISO 8208	X.25 Packet level protocol for data terminal equipment
ISO 8348	Information processing systems - Data communications - Network service definition
ISO 8348 ADD. 1	Information processing systems - Data communications - Network service definition; Addendum 1 (covers connectionless-mode network service)
ISO 8473	Information processing systems - Data communications - Protocol for providing the connectionless-mode network service
ISO 8473 ADD. 1	Addendum 1; Provision of underlying service assumed by ISO 8473
ISO 8648	Information processing systems - Data-communications - Internal organization of the network layer
ISO DP 8880	Provision of network service in the general OSI environment
ISO 8802.X	Local area networks

CCITT Recommendations:

E.163	Numbering plan for the international telephone service
F.69	Plan for Telex Destination Codes
I.112	Vocabulary of terms for ISDNs
I.130	Method for the characterisation of telecommunication services supported by an ISDN and network capabilities of an ISDN
I.1YY	Framework for providing additional packet mode bearer services. CCITT SG XVIII working document
I.210	Principles of telecommunication services supported by an ISDN
I.211	Bearer services supported by an ISDN
I.310	ISDN network functional principles
I.320	ISDN protocol reference model
I.330	ISDN numbering and addressing principles
I.331/E.164	ISDN numbering plan
I.411	ISDN user-network interfaces reference configurations
I.412	ISDN user-network interface structures and access capabilities
I.430	Basic user-network interface - Layer 1 specification
I.431	Primary rate user-network interface - Layer 1 specification
I.440/Q.920	General aspects of the ISDN user-network interface Data Link layer protocol
I.441/Q.921	Specification of the ISDN user-network interface Data Link layer protocol
I.450/Q.930	General aspects of ISDN user-network interface layer 3 functions and protocol
I.451/Q.931	Specification of the ISDN user-network interface layer 3 protocol
I.460	Multiplexing rate adaptation and support of existing interfaces

I.461/X.30	Support of X.21 and X.21bis based DTEs by an ISDN
I.462/X.31	Support of packet mode terminal equipment by an ISDN
T.50	International alphabet no. 5.
V.24	List of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE)
V.25	Automatic answering equipment and/or parallel automatic calling equipment on the general switched telephone network including procedures for disabling of echo control devices for both manually and automatically established calls
V.35	Data transmission at 48 kbit/s using 60-108 kHz group band circuits
X.1	International user classes of service in public data networks and integrated services digital networks (ISDNs)
X.2	International data transmission services and optional user facilities in public data networks
X.3	Packet assembly/disassembly facility (PAD) in a public data Network
X.21	Interchange between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) for synchronous operation on public data networks
X.21bis	Use on public data networks of data terminal equipment (DTE) which is designed for interfacing to synchronous V-series modems
X.25	Interface between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit.
X.28	DTE/DCE interface for a start-stop mode data terminal equipment accessing the packet assembly/disassembly facility (PAD) in a public data network situated in the same country
X.29	Procedure for the exchange of control information and user data between a packet assembly/disassembly facility (PAD) and a packet-mode DTE or another PAD
X.32	Interface between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) for terminals operating in the packet mode and accessing a packet switched public data network through a public switched telephone network or a circuit switched public data network
X.75	Terminal and transit call control procedures and data transfer system on international circuits between packet-switched data networks
X.96	Call progress signals for public data networks
X.121	International numbering plan for public data networks
X.200	Reference model of open systems interconnection for CCITT applications
X.213	Network service definition for open system interconnection for CCITT applications

X.214	Transport service definition for open systems interconnection for CCITT applications
X.224	Transport protocol specification for open systems interconnection for CCITT applications
X.300	General principles and arrangements for interworking between public data networks, and between public data networks and other public networks

4. DEFINITIONS

The following are definitions of terms and acronyms used widely in this Technical Report. Some of them reflect the special application covered by this Technical Report and not a technical difference from the CCITT definitions. The basic vocabulary of ISDN terms can be found in CCITT Rec. I.112. Appendix J contains a list of acronyms used within this Technical Report.

4.1 Bearer Service

A Telecommunication Service that provides the capability for the transmission of signals between user-network interfaces (CCITT Rec. I.210). See Appendix B for further description of telecommunication services and service concepts.

4.2 Bearer Channel Protocol Intervention Level

The highest protocol level at which a PSN provides protocol termination on a given bearer channel.

4.3 B-Channel

B-channels provide a 64 kbit/s duplex synchronous access. The information on a B-channel may be non-switched or either circuit- or packet-switched depending on user request and network capabilities.

4.4 Continuous Bit/Byte Stream-Oriented Service (CBO)

A connection is said to support a CBO (Transmission) Service if it transfers a bit- or byte-stream with a constant bit rate and transfer delay during its lifetime, while delimiting (if any) is restricted to synchronous delimiting only.

4.5 Convergence Protocol

A protocol used on top of the subnetwork service boundary, which creates a new service boundary to provide a service which is closer to (or equal to) the OSI network service.

4.6 Coordinating Entity

That part of the Network Layer within an end system or interworking unit responsible for the coordination and synchronization of functions belonging to the Data and Signalling sub-entities of the layer entity implementing a PSN Access Protocol.

4.7 D-Channel

D-channels provide a 16 or 64 kbit/s duplex synchronous access. The use of the D-channel may be restricted to conveying signalling information in some applications. All information on D-channels is packetized.

4.8 Data Circuit-Terminating Equipment (DCE)

That part of a data station that provides the signal conversion and coding between the data terminal equipment and the line. Note that in the context of an X.25 network, for example, the DCE performs functions at the network and of an access line to the network.

4.9 Data Processing Equipment (DPE)

A particular class of terminal equipment primarily used to process data (in contrast to voice-only terminal equipment).

4.10 Data Processing Equipment - 1 (DPE-1)

Data processing equipment that directly connects to an S_0 or S_2 interface.

4.11 Data Processing Equipment - 2 (DPE-2)

Data processing equipment that indirectly connects to an S_0 or S_2 interface; a Terminal Adaptor is required to convert its R reference point interface to an S reference point interface. For example, an X.25 DTE is a DPE-2 device.

4.12 Data Terminal Equipment (DTE)

That part of a data station that serves as a data source, a data sink, or both.

4.13 Dynamic Window Control

The dynamic window control method consists of modifying the transmitter's transmit window when congestion is first detected and then as it decreases.

4.14 H-Channel

Wideband channels (i.e., multiples of 64 kbit/s). See CCITT Rec. I.412.

4.15 In-Band Signalling

Signalling applications where the signalling information is transmitted in the same information flow as the data. See also Out-of-Band Signalling.

4.16 Interworking Unit (IWU)

An interworking unit provides the functions needed to allow interworking between a PSN and another network, e.g. interworking between a PSN and an X.25 PSPDN.

4.17 Layer Service

The term Layer Service is defined in the reference model for Open Systems Interconnection. In this layered model, it defines the service that a layer provides to the next higher layer. See ISO 7498 and CCITT Rec. X.200.

4.18 Out-of-Band Signalling

Signalling applications where the signalling information is transmitted in a different physical or logical channel from the associated user data, e.g. over different physical paths, in different time-slots in a time-division multiplex stream.

4.19 Packet Assembler/Disassembler (PAD)

A device that assembles and disassembles packets in accordance with CCITT Recs. X.3, X.28, and X.29.

4.20 Packet Handler (PH)

A device for switching packets or frames in a manner so as to be able to route individual frames or packets out of a data stream into multiple other data streams.

4.21 Packet Mode Protocol (or PSN Packet Mode Protocol)

The access protocol based on the use of out-of-band control and link layer multiplexing.

4.22 Packet Switched Public Data Network (PSPDN)

A public subnetwork which is accessed via the X.25 protocol and which provides virtual circuit service.

4.23 Packetized Data Transfer

Transfer of data through a network where data is conveyed in packets and/or frames in a statistical manner. Packets or frames are propagated through the network and delivered to destinations based on addressing information contained in therein.

4.24 Private Packet/Frame and Circuit Switching Network (PPCSN)

A PSN which provides both circuit and packet/frame switching functions (i.e. all the functions of both PCSNs and PPSNs).

4.25 Private Circuit Switching Network (PCSN)

A PSN which only provides circuit switching functions, except that it may be able to transport packetized "user-to-user" information passed over the signalling channel.

4.26 Private Packet/Frame Switching Network (PPSN)

A PSN which only provides packet/frame switching functions.

4.27 Private Switching Network (PSN)

A private ISDN which provides switching functions (circuit and/or packet/frame switching). It is operated by the user and located on his premises to cover the communications needs in his domain. Data processing equipment is connected to a PSN at its S reference points. The term Private Switching Network includes both the private circuit switching network and the private packet switching network. The relationship between the definition of a PSN and definitions 4.26, 4.25, and 4.24 above is as shown below:

PSN	==	PPSN	or	PCSN	or	PPCSN
Private Switching Network		Private Packet Switching Network		Private Circuit Switching Network		Private Packet and Circuit Switching Network

4.28 PSN Termination (PT)

The termination of a PSN at the S-reference point.

4.29 Packet Switched Data Network (PSDN)

A packet-switched subnetwork which can be a PPSN (private) or a PSPDN (public) packet switched network.

4.30 R Interface

The generic term for the interface provided at the R reference point to allow the connection of non-ISDN terminals using, e.g, V.-series or X.-series interfaces.

4.31 Relaying

A function performed at intermediate nodes on an interconnection between communicating end-systems. The relaying function is performed by connecting two independent layer entities. For

example, a relaying function at the data link layer connects two data link layer entities to make an interconnection.

4.32 S Interface

The generic term for the interface provided at the S reference point as defined by CCITT for ISDN user-to-network interface.

4.33 S_0 Interface

The basic access S interface providing two B-channels and one D-channel (2B + D) at a bit rate of 192 kbit/s is called the S_0 interface.

4.34 S_1 Interface

The primary rate access S interface providing 23 B-channels and one D-channel (23B + D) at a bit rate of 1544 kbit/s is called the S_1 interface. This interface also supports a combination of B- and H-channels where an H-channel replaces a number of B-channels.

4.35 S_2 Interface

The primary rate access interface providing 30 B-channels and one D-channel (30B + D) at a bit rate of 2048 kbit/s is called the S_2 interface. This interface also supports a combination of B- and H-channels where an H-channel replaces a number of B-channels.

4.36 Signalling

The exchange of information specifically concerned with the establishment and control of connections, the transfer of user-to-user and management information in a telecommunication network, e.g. in a PPSN.

4.37 Subnetwork

A set of one or more intermediate open systems which provide relaying and through which end open systems may communicate. It is a representation within the OSI model of a real network such as a carrier network, a provider network or a LAN. It can also be defined as a collection of equipment and physical media which form an autonomous whole and which can be used to interconnect real systems for the purpose of communication (ISO 8648).

4.38 Subnetwork Access Protocol (SNAP)

The protocol which has to be executed by a system that wishes to access a subnetwork, irrespective of the existence of that subnetwork within the OSI environment.

4.39 Subnetwork Service

The service supported by the subnetwork access protocol.

4.40 Terminal Adapter (TA)

The Terminal Adapter is required to adapt from an R interface (e.g. according to the V.-series or X.-series) to the S interface. The TA may be an integral functional entity as part of the terminal or may be a separate physical unit connected between an R interface and the S interface.

4.41 Virtual Circuit

The generic concept of a logical connection. A virtual circuit may be implemented by means of a frame switched service or by means of a packet switched service.

5. PSN FUNCTIONAL MODEL AND CONNECTIVITY SCENARIOS AND TERMINAL ADAPTATION

5.1 PSN Functional Model

Two different functional models can be distinguished for communication between S reference points on the same PSN:

- circuit switching, and
- frame handling

5.1.1 Circuit Switching

The functional model is shown in Figure 2.

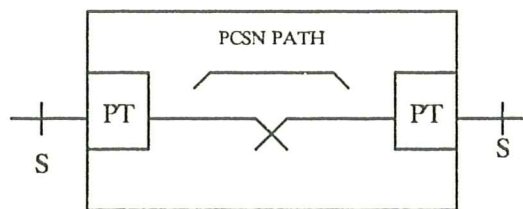
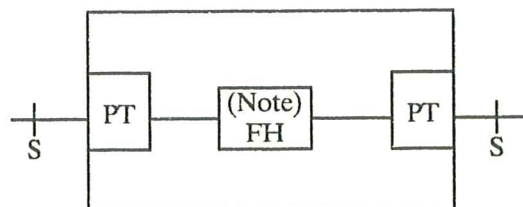


Figure 2 - Private Circuit Switching Network (PCSN)

User data is transferred through a circuit switched path (e.g., B channel) which is established between two DPEs by means of PSN call control functions and signalling.

5.1.2 Frame Handling

The functional model is shown in Figure 3.



The frame handler can contain frame relaying or frame switching functions, or both.

Figure 3 - Private Packet Switching Network (PPSN)

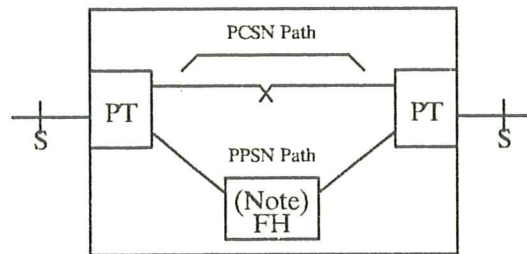
User data is transferred within the PSN via frame handling functions. These functions may include frame relaying or frame switching functions or both. For definitions of frame relaying and frame switching see 7.1.

NOTE 1

The provision of a PSN virtual circuit service according to CCITT Rec. X.31, case B, would require a packet handling function in the PSN. This case, however, is outside the scope of this functional model. See 7.1.

5.1.3 Circuit Switching and Frame Handling

Circuit switching and frame handling functions can be combined, as shown in Figure 4.



NOTE 2

The frame handler can contain frame relaying or frame switching functions, or both.

Figure 4 - Private Packet and Circuit Switching Network (PPCSN)

5.2 Connectivity Environments

Figures 5, 6, and 7 below show examples of connection types. Figures 5 and 6 show connections that are available within a circuit-switched network fabric; all three connections can be achieved within a private packet-switched network fabric. (Figures 5 and 6 are subcases of 8 for private packet switching networks.) All PCSNs provide B-channels. Some may also provide H-channels. The use of D-channels for the transfer of packet data is a PPSN option.

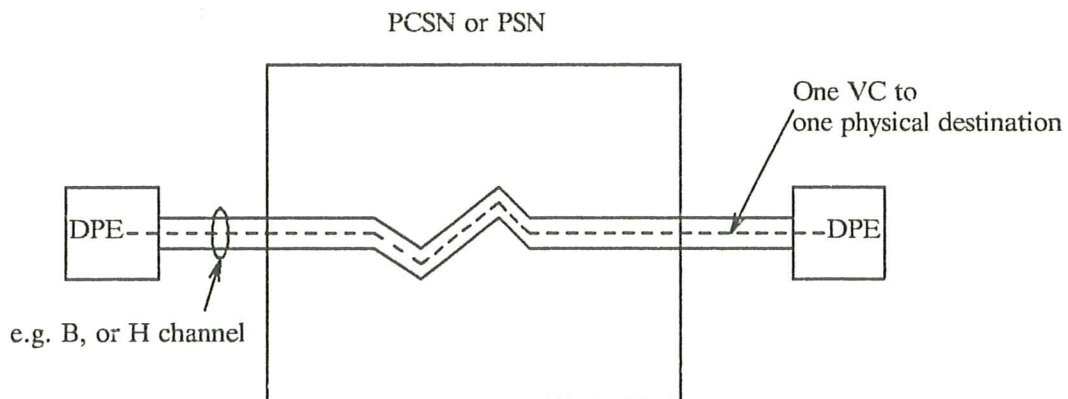


Figure 5 - Single Virtual Circuit (VC) between Two Endpoints

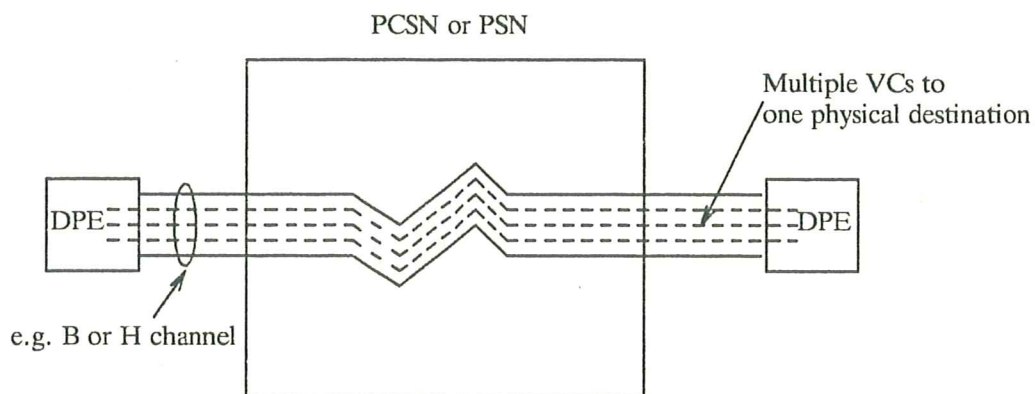
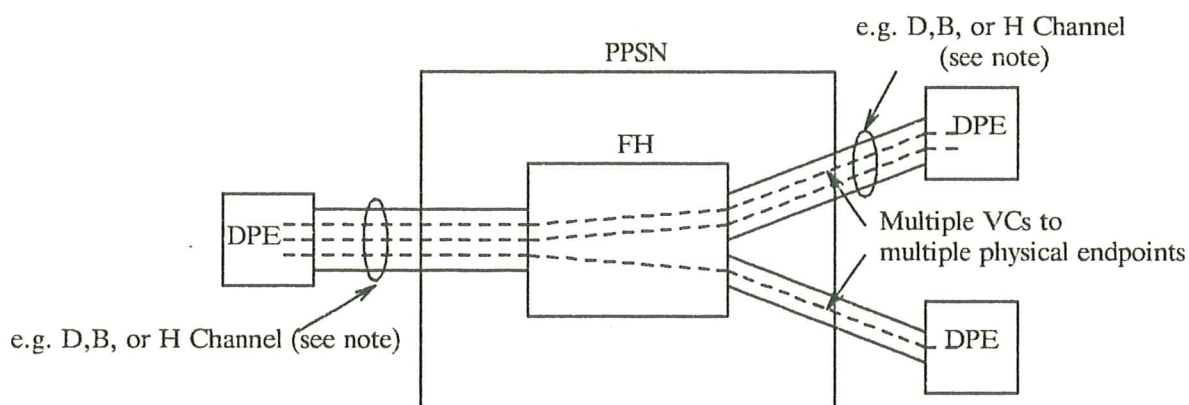


Figure 6 - Multiple Virtual Circuits (VCs) between Two Endpoints



NOTE 3

The use of D-channels for transfer of packet data is a PPSN option.

Figure 7 - Multiple Virtual Circuits (VCs) to Multiple Endpoints

5.3 Terminal Adaptation Functions

Terminal Adaptation functions (TA functions) are required to accommodate the connection of existing synchronous and/or asynchronous terminal equipment which supports non-ISDN interfaces to PSNs supporting ISDN interfaces.

Figure 8 indicates circumstances where some TA functions (e.g., physical layer, bit rate adaptation, D-channel handling etc.) may be required.

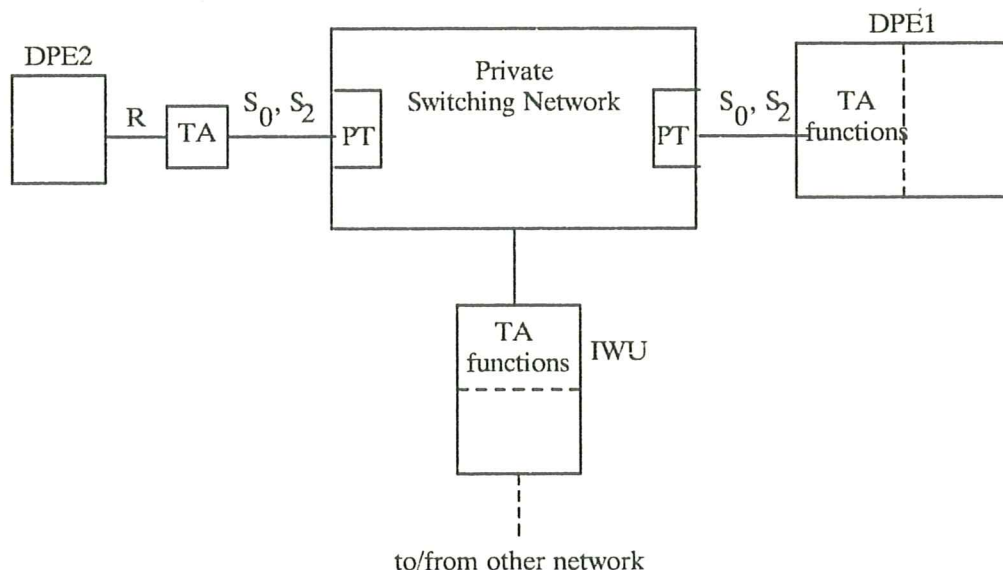


Figure 8 - TA Function Use

A TA function is required for adapting between the S and R reference points. The R reference point refers to non-ISDN interfaces such as those of the CCITT V.-series or X.-series Recommendations.

The functions of a TA between the R and S reference points are:

- to provide signalling information to the PSN,
- to provide rate adaptation from the terminal data rate to the bearer channel rate,
- to handle terminal status information,
- to provide end-to-end synchronization, and
- to provide maintenance capabilities (see ECMA TR/34).

To allow for interworking between DPEs connected at the R and S reference points, it is necessary to incorporate these TA functions within the DPE connected at the S reference point.

It is recognized that the PSN may also be connected to other networks and that some of these connections may require functions which can be provided by an Interworking Unit (IWU).

6. PACKETIZED DATA TRANSFER SERVICES

ISDNs and PSNs offer different features than those offered by dedicated packet data networks e.g., according to CCITT Rec. X.25.

The purpose of this Clause is to identify the features which should be included in new bearer services for packetized data transfer in order to fully exploit the ISDN/PSN capabilities such as out-of-band control, etc. 6.1 describes the support of DPE-2s according to CCITT Rec. X.25 by ISDN, as defined in CCITT Rec. X.31. 6.2 develops the requirements for new bearer services for packetized data transfer.

6.1 Support of X.25 DPEs by ISDN/PSN

DPEs conforming to X.25 connected to X.25 DCEs across a PSN require the assistance of TAs. Two main services are available to packet mode terminals connected to a PSN, namely:

- access to data transmission services provided by PSPDNs (PSPDN services), or
- use of a PSN virtual circuit bearer service.

In the first case a PSN transparent connection, either non-switched (permanent) or switched (on demand) is used.

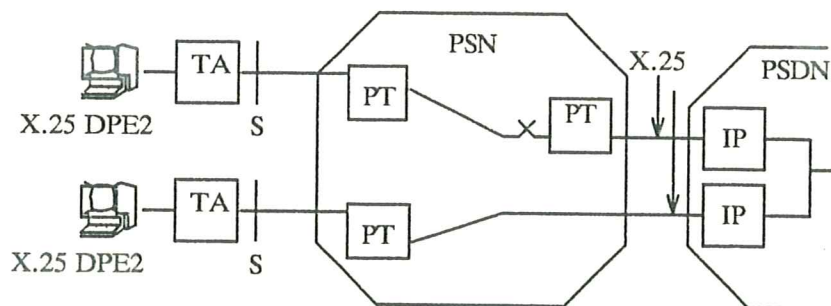
Both scenarios are described by CCITT Rec. X.31, a short description of which is given below. The subject of X.31 will not be dealt with in this Technical Report beyond what is presented here (6.1.1 to 6.1.5).

X.31 defines packet mode operation through an ISDN (i.e., through the B- and D-channels) using the X.25 protocol. PADs may be supported within the network or in the TA or DPE-1 in which case existing Recommendations shall apply for asynchronous access (e.g. X.3, X.28, X.29, etc).

X.31 only applies to Packet Mode operations carried out independently on a single connection type (i.e. involving either B- or D-channels).

6.1.1 Configuration when Accessing PSPDN Service (Case A)

This scenario (Figure 9) refers to a transparent handling of packet calls through a PSN. Access is possible only via the B-channel. In this context the only support that a PSN gives to packet calls is a physical 64 kbit/s circuit non-switched or switched transparent network connection between the appropriate Packet Switched Data Network (PSDN) interworking port and the X.25 user terminal adapter or DPE1 at the customer premises.



PT = PSN Termination

IP = Interworking Port providing X.25 DCE function

Figure 9 - Accessing PSPDN Service

In the case of permanent access, the X.25 DPE + TA or DPE-1 is connected to the corresponding PSDN port via the PSN. The TA performs only the necessary physical channel rate adaptation between the user rate at reference point R and the 64 kbit/s B-channel rate.

In the case of demand access to PSPDNs, the X.25 DPE + TA or DPE-1 is connected to a PSDN interworking port (IP) via the PSN. The interworking port is able to set up the physical B-channel through the PSN. In this type of connection, originating calls will be set up over the B-channel towards the PSDN port using the PSN signalling procedures on a D-channel prior to initiating X.25 level 2 and level 3 functions. This can be done by exploiting either hot-line (e.g. direct call) or complete selection methods. Moreover, the TA performs user rate adaptation at 64 kbit/s. Depending on the data rate adaptation technique employed, a complementary function may be needed at the interworking port of the PSPDN.

In the complete selection case, two separate numbers are used for addressing:

- the PSN (e.g. E.164 subset) number of the access port of the PSPDN indicated in the ECMA-106 SETUP message;
- the address of the called DPE indicated in the X.25 CALL REQUEST packet.

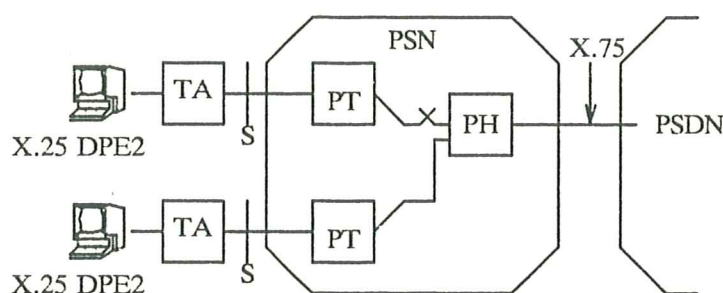
The corresponding service requested in the ECMA-106 SETUP message is circuit-mode bearer service.

For calls originated by the PSDN the same considerations as above apply. In fact with reference to Figure 9, the ISDN port of the PSDN includes both rate adaptation (if required) and path set-up functions.

When needed, DTE identification may be provided to the PSDN by using the call establishment signalling protocols in ECMA-106. Furthermore, DCE identification may be provided to the DTE, when needed, by using the same protocols.

6.1.2 Configuration for PSN Virtual Circuit Bearer Service (Case B)

In this scenario the packet handling (PH) function is provided within the PSN. The packet handler can be accessed either by B- or D-channels (see Figure 10).



PT = PSN Termination

Figure 10 - PSN Virtual Bearer Service

In Figure 10, X.75 is shown only as an example of an interworking protocol. It is beyond the scope of this document.

A first case is that of X.25 packet level procedures conveyed through the B- channel. In this case, the packet call is routed, within the PSN, to the packet handler function where the complete processing of the X.25 procedures can be carried out.

Multiple X.25 DPE + TA or DPE-Is (or a combination) can be supported at the customer's premises, any one of the terminals being able to use the B-channel on a per call basis at different times. Simultaneous multiple terminal operation of packet mode DPEs in the B-channel is possible using Layer 3 multiplexing. The use of layer 2 multiplexing is foreseen for X.31.

The packet handling function may be accessed in various ways depending on the related PSN implementation alternatives. A B-channel connection is set up towards a packet handling port supporting the necessary processing for B-channel packet calls, standard X.25 functions for level 2 and level 3 as well as path establishment functions for level 1 and possible rate adaptation.

A second case is that of X.25 packet level procedures conveyed through the D- channel. In this case, a number of X.25 DPE-2s can be operated simultaneously through the D-channel by using

connection identifier discrimination at layer 2. The accessed port is still able to support X.25 packet layer procedures.

It is important to note that the procedure for accessing packet switched data transfer service through a PSN user interface is independent of where the packet handling function is provided. However, the procedures for packet access through the B-channel or D-channel are different.

In both cases of B- and D-channel accesses, the address of the called DPE is contained in the X.25 CALL REQUEST packet. The establishment of the connection from the TA/DPE-1 to the PH function is done on the basis of the requested bearer capability (virtual circuit bearer service), therefore the user does not need to provide an access port number.

6.1.3 Service Characteristics when Accessing PSPDN Services (Case A)

In this case, the PSN offers a 64 kbit/s circuit-switched or non-switched transparent connection between the X.25 DPE + TA or DPE-1 and the PSPDN port. In a circuit-switched access the interworking port must be selected by the ISDN E.164 destination address in the D-channel signalling protocol when the TA/DPE-1 sets up the circuit-switched connection to the interworking port.

Since the packet switching service provider is a PSDN, some TA/X.25 DTEs are PSDN terminals; they are operated and administered by the PSDN. Other DTEs may access the PSDN without being subscribed to the PSDN permanently.

In the first case, the same capabilities as those provided by PSPDN services are maintained, including facilities, Quality of Service (QoS) characteristics and X.25 DTE/DCE interfaces. In the case where a DTE is not subscribed to the PSPDN, it would be provided with a limited set of PSPDN facilities.

A number from X.121 (PSPDN numbering plan) or possibly a number from E.164 (ISDN numbering plan) may be attributed to the X.25 DTE. The method for X.25 packets to convey numbers from the ISDN numbering plan and the relationship with X.121 requires further study.

6.1.4 Service Characteristics of the PSN Virtual Circuit Bearer Service (Case B)

In principle the virtual circuit bearer service provided within the ISDN or PSN shall not diverge from what is defined in the X.-Series Recommendations (e.g. in terms of facilities, QoS, etc.).

X.25 DPEs are PSN terminals. They are operated and administered by the PSN. The services and facilities provided as well as the QoS characteristics are those provided by the PSN. Existing features of the X.-Series Recommendations would be enhanced and additional features would also be developed taking into account the new ISDN customer capabilities (e.g. multiterminal arrangements, user rate at 64 kbit/s, as well as the possible evolution of compatibility checking). A number from the E.164 numbering plan will be attributed to the PSN interface.

6.1.5 Access Capabilities

Procedures for packet access through B- or D-channels may differ. In addition the access protocol is asymmetrical with respect to origination and termination of virtual calls.

When using a switched B-channel, communications will be established by clearly separating the establishment phase of the B-channel and the control phase of the virtual circuits using the X.25 protocol (link and packet layers). An incoming call will be accepted by a termination only after successful ISDN compatibility checking. Rate adaptation techniques will have to be used.

In general, a PSN has no knowledge of the access configuration. The incoming B-channel connection establishment will have to employ the D-channel point-to-point or point-to-multipoint signalling procedures (depending on whether a call is already established or not).

When using the D-channel, the logical channels supported by an X.25 DTE will be multiplexed onto one LAPD logical link (using the specific SAPI "p") supported by the TA at reference point S.

All X.25 packets, including call request and incoming call packets must be transported to and from the DTE in numbered information (I) frames on the LAPD link (with SAPI=p).

It has to be noted that the use of a D-channel access imposes some limitations such as maximum user data field length, maximum number of DPEs supported, throughput class, and so forth.

6.2 New Bearer Services for Packetized Data Transfer

CCITT Rec. X.31 provides support of the existing X.25 service but does not employ out-of-band signalling for virtual circuit control. An additional feature which is not utilized by X.31 is the concept of using link layer addressing for routing.

Because control of virtual circuit calls is shared between ISDN and X.25 call control mechanisms, X.31 has the following characteristics:

- call establishment is based on a two-stage procedure: the in-band establishment of a virtual circuit is preceded by a preparation phase using out-of-band control;
- in some scenarios two different numbering plans are used concurrently (E.164 and X.121);
- there is a possibility of overlap of facility control between ISDN D-channel and X.25 in-band procedures; and
- future compatibility problems with new supplementary services due to the difficulty of integrating and coordinating the two call control mechanisms may arise.

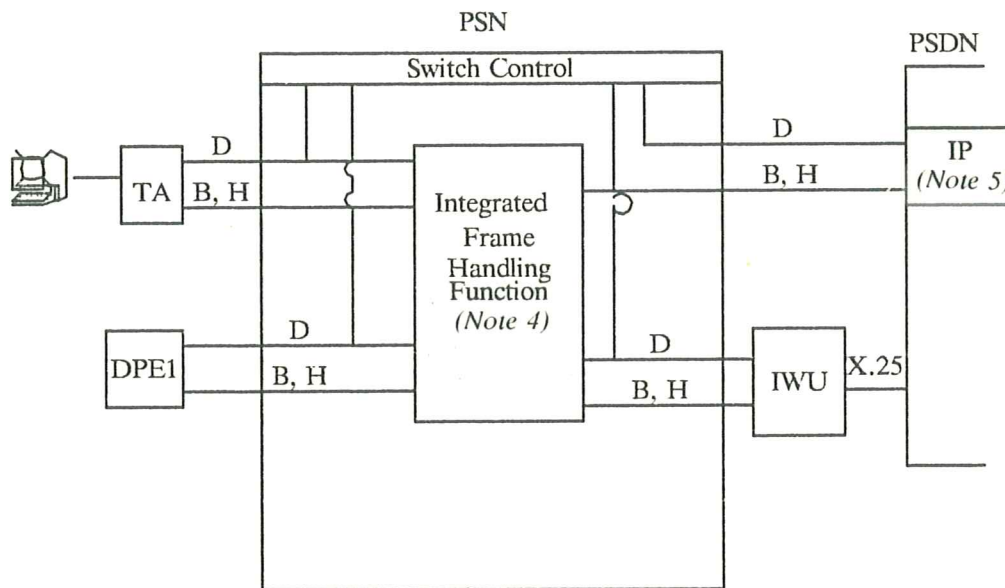
As multiplexing is currently restricted to Layer 3 in X.31, non D-channels do not provide for sharing of services on the same channel.

These characteristics can be improved by a new bearer service with the following features:

- in accordance with the ISDN protocol reference model, out-of-band control is used for the control of virtual circuit switching functions; and
- link level multiplexing of user data flows is employed to increase the flexibility for provisioning of services in the PSN.

In the remainder of this Technical Report, this new bearer service will be referred to as frame mode service.

Figure 11 illustrates a bearer service that makes use of frame switching or frame relaying. As shown in this Figure, the D-channel provides for control of virtual circuit switching. User data is carried on a bearer channel.



NOTE 4

Circuit switched paths permitted also.

NOTE 5

The IP is an interworking port.

NOTE 6

The DPE-I, IWU and IP may contain some TA functions towards the PSN.

Figure 11 - Frame Mode Bearer Services in PSN

6.2.1 General Considerations for Frame Mode Services

A key principle of ISDN is service integration at the user/network interface. One requirement of this integration is a user network signalling relation, supported by D-channel messages, for the control of all bearer services and their facilities. The 1984 I-Series Recommendations exploit this principle of service integration only for circuit mode bearer services. The next step is to extend service integration to all bearer services.

6.2.2 Architectural Design Considerations

The out-of-band signalling component of the Frame Mode Service architecture provides:

- i) The potential sharing across all bearer services of functional units providing, for example, call control and supplementary services. As additional basic services are defined, a common method of control for all services minimizes proliferation of signalling types and procedures. In addition, as supplementary services are added in the future, they could potentially apply to all bearer services.
- ii) A common method of control for all services enhances the ability to provide multi-services, i.e. services where a call may utilize more than one type of bearer service at different periods during the call. A common control method increases the feasibility of switching between bearer services while a call is in progress (in-call modification).

- iii) The characteristics of requested bearer services, such as QoS attributes, can be based solely on the information transfer needs and not on signalling needs because signalling and data transfer do not share the same logical path. Thus, for packetized bearer services, it is possible to define a range of bearer services that are controlled by a separate signalling channel.

6.2.3 Information Transfer Considerations for Frame Mode Services

An information transfer protocol stack can be defined for providing PSN services for packetized data transfer.

To provide for a spectrum of concurrent information flows with greatly different service requirements on a common physical channel (on, for example, an H-channel), differentiation (e.g. identification) should be done at the lowest possible level in the data transfer protocols. The logical link identification of the LAPD link layer protocol provides the required functionality. The use of LAPD based protocol for data transfer does not require the creation of a totally new protocol.

An X.25-like service is defined only if the X.25 packet layer protocol (data phase) is carried on top of frame mode service. An X.25-like service is defined here as a service meeting the OSI connection-mode network service definition (CCITT Rec. X.213 or ISO 8348) and which also provides procedures similar to X.25 such as, for example, the Q-bit procedures. Other protocols may be carried on top of frame mode services. For example, connectionless-mode network service could be provided by carrying the appropriate network layer protocol on top of frame mode services.

6.2.4 Packet Mode Bearer Services Identified by CCITT as Additional

Three distinct bearer services additional to X.31 are under study in CCITT.

These services are: frame relaying, frame switching, and packet switching. Frame relaying is provided when no protocol functions above the core functions of LAPD are terminated in the network. These core functions are:

- frame delimiting, alignment, and transparency,
- frame multiplexing/demultiplexing using the address field,
- frame syntax validation,
- detection of transmission errors.

Frame Switching is provided when the full LAPD protocol is terminated in the network. Packet switching is provided when the full LAPD protocol is terminated and the data transfer part of the X.25 packet layer protocol is terminated in the network (denoted as X.25-based service).

7. PSN FRAME MODE BEARER SERVICES

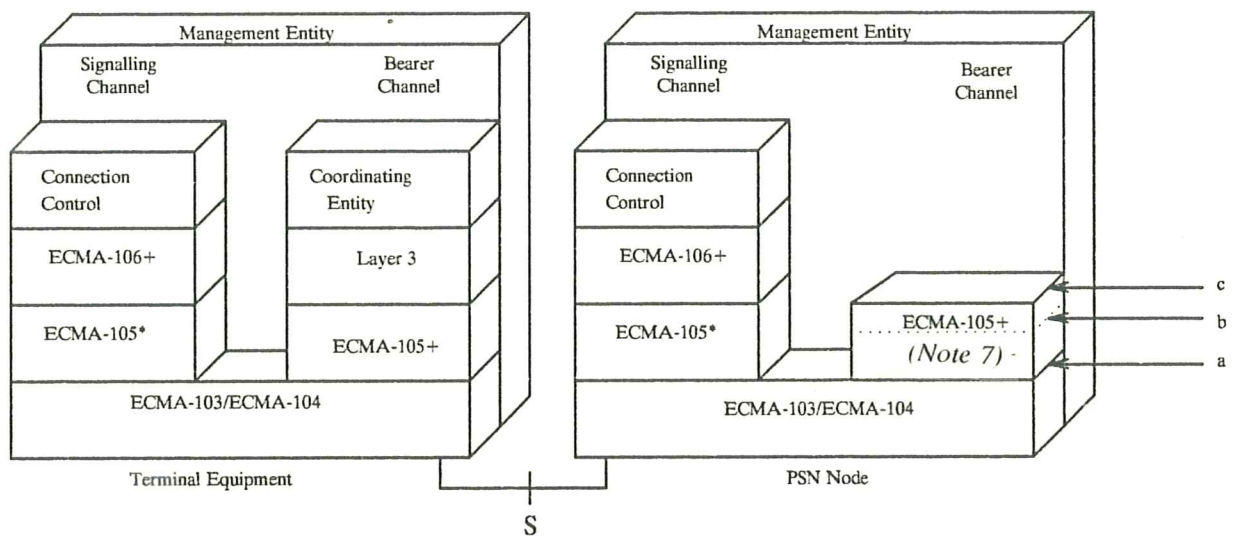
Of the Packet Mode Bearer Services identified by CCITT as additional to X.31, the first two bearer services - frame relaying and frame switching are the subject of this Technical Report. These services are referred to as frame mode services or frame mode bearer services. For both of these services it is understood that the link layer protocol is always fully terminated in end systems (an interworking unit is also considered as an end system). This Technical Report considers the support of an X.25-like service which is provided by means of convergence functions over frame mode service (packet switching is not done in the PSN). The OSI Connection-Mode Network Service (CO-NS) is provided in the end systems. The support of Connectionless-Mode Network Service (CL-NS) is also provided by means of the appropriate convergence functions over frame mode bearer services. In this chapter the provision of frame mode services in a PSN is described including:

- a definition of the services,
- network intervention,

- QoS considerations,
- service and parameter negotiation, and
- frame mode service selection criteria.

7.1 PSN Protocol Processing Options

Figure 12 illustrates the relationship between protocols which pass across the S reference point and a network node. The figure also shows the possible protocol break points (i.e. points at which the network could terminate the protocol(s) as required in order to provide a requested grade of service).



NOTE 7

Lower layer 2 bit level functions, e.g. flag generation, bit stuffing, CRC calculation, and address translation.

Figure 12 - PSN Protocol Termination Break Points

As shown in Figure 12 the network may terminate the bearer channel protocol(s) in one of three ways:

- Case a: Only the physical layer for circuit switching service functionality.
- Case b: Only the physical layer and the lowest sub-layer of the Data Link layer are terminated. The main function of the network is to provide for logical link address mapping (see Note 7); "Frame Relaying".
- Case c: Full termination of the Physical and Data Link layers. "Frame Switching".

Support of logical link address mapping requires flag generation/detection and bit stuffing. The FCS of the receiving frame is checked in the receiving control process while the FCS of the transmitted frame is calculated and appended in the transmitting control process. For transmitted frames in the frame relaying node the FCS relates to the translated address; as a result, the FCS is always recalculated.

In this Technical Report, case (a) is referred to as "circuit switching", case (b) is referred to as "frame relay", and case (c) is referred to as "frame switching". Note that the Layer 3 protocol is transparent to the PSN and operates between End Systems or between an End System and an IWU.

In this Technical Report a Layer 3 protocol is used to provide necessary convergence to meet OSI CO-NS requirements. The data phase aspects of the X.25 PLP are used to provide the convergence. The service is referred to as X.25-like service.

7.1.1 Protocol Processing Options as a Function of Requested Bearer Capability

If an End System requires a certain bearer capability from a PSN and if the PSN accepts the request, then it must provide the Protocol Processing Option (intervention level) corresponding to the requested bearer service in at least one node in the path provided. In the other nodes in the path, a lower Protocol Processing Option can be used, provided the requested Quality of Service can be met.

Table 1 shows the different Protocol Processing Options that can be used for other nodes in a path, as a function of the requested bearer capability. An example of a frame bearer service provided by a PSN using a frame relay and a frame switched node is shown in Figure 13.

If the PSN cannot, temporarily or permanently, provide the requested bearer capability, then it can try to negotiate/indicate a lower bearer capability (lower Protocol Processing Option) with the End System.

PSN Protocol Processing Options Bearer Service Requested by End System	a	b	c
Frame Mode End System Processes (c)	*	*	*
Circuit End System Processes (a)	*		

Table 1 - Bearer Channel Protocol Processing Options as a Function of Requested Bearer Capability

Break points a , b , and c are those indicated in Figure 12.

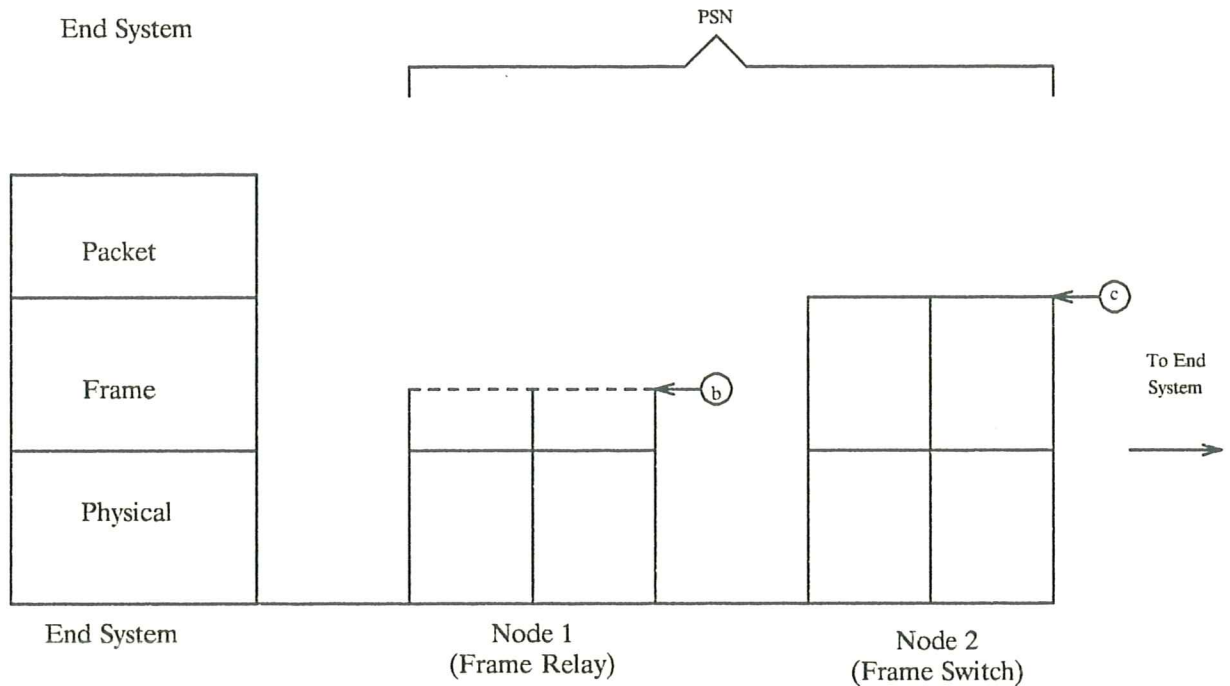


Figure 13 - Example of Different PSN Protocol Interventions. Based on a User Requested Packet Bearer Capability

7.1.2 Quality of Service and Design Considerations with respect to Protocol Processing Options

The relationships between throughput, transit delay, and data integrity with respect to the degree of protocol processing performed by a PSN (which may consist of one or more nodes) at a node are important considerations in selecting a flexible access protocol suite which allows protocol processing options. Quality of Service (QoS) is expressed in terms of throughput, transit delay, and data integrity.

7.1.2.1 Quality of Service as Applicable for a PSN

Starting from Rec. X.213, QoS parameters are devised as applicable for a PSN. The discussion is based on the following model (see Figure 14), which shows the relationship of PSN QoS with the QoS as defined in Rec. X.213.

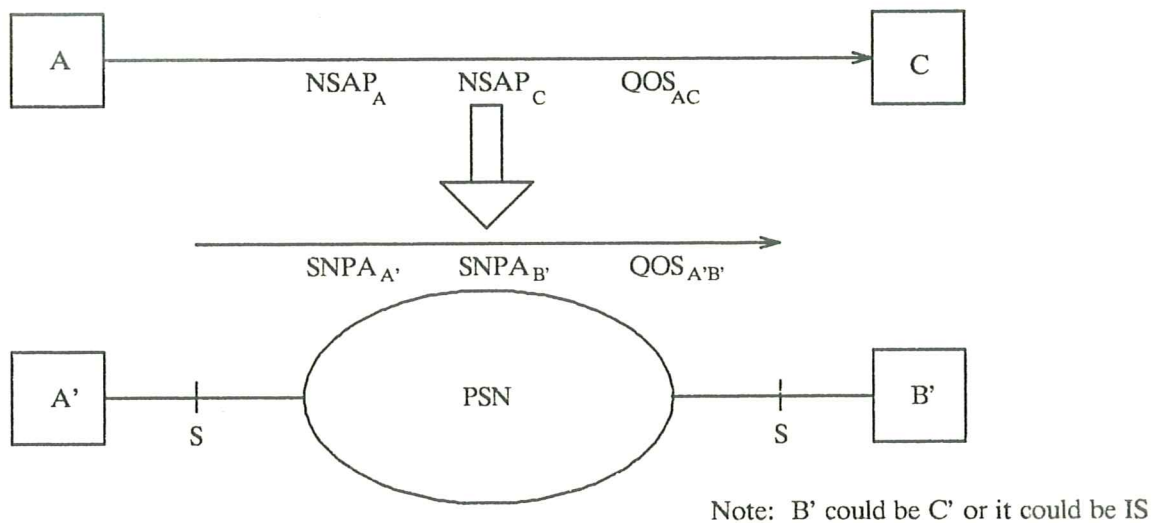


Figure 14 - Relation of X.213 QoS for PSN QoS (B' could be C' or it could be IS)

7.1.2.1.1 Quality of Service Allocation

It is assumed that an End System A initiates a connection to an End System C. A is attached directly to a PSN, C may be connected to the same PSN, or may be reachable only via an Intermediate System (IS) B. The routing function in End System A now is responsible for translating the global address pair $NSAP_A$, $NSAP_C$ into an address pair applicable to the PSN, that is $SNPA_A$, $SNPA_B$. At the same time, the routing function of A has to define the QoS it requires for the connection A'-B', in order to obtain the QoS it wants for the connection A-C. It should be noted here, that B' may need access to QoS_{AC} , and that therefore the PSN should transfer transparently QoS_{AC} in addition to SAP_A , $NSAP_C$.

7.1.2.1.2 New Quality of Service Definitions

New definitions used in QoS are proposed for a PSN. For relationships, see Figure 15. The following new definitions are introduced:

Frame Bearer Error Rate

The ratio of total incorrect, lost, and duplicate frames transferred across the S boundary during a measurement period for a given connection. See Figure 15.

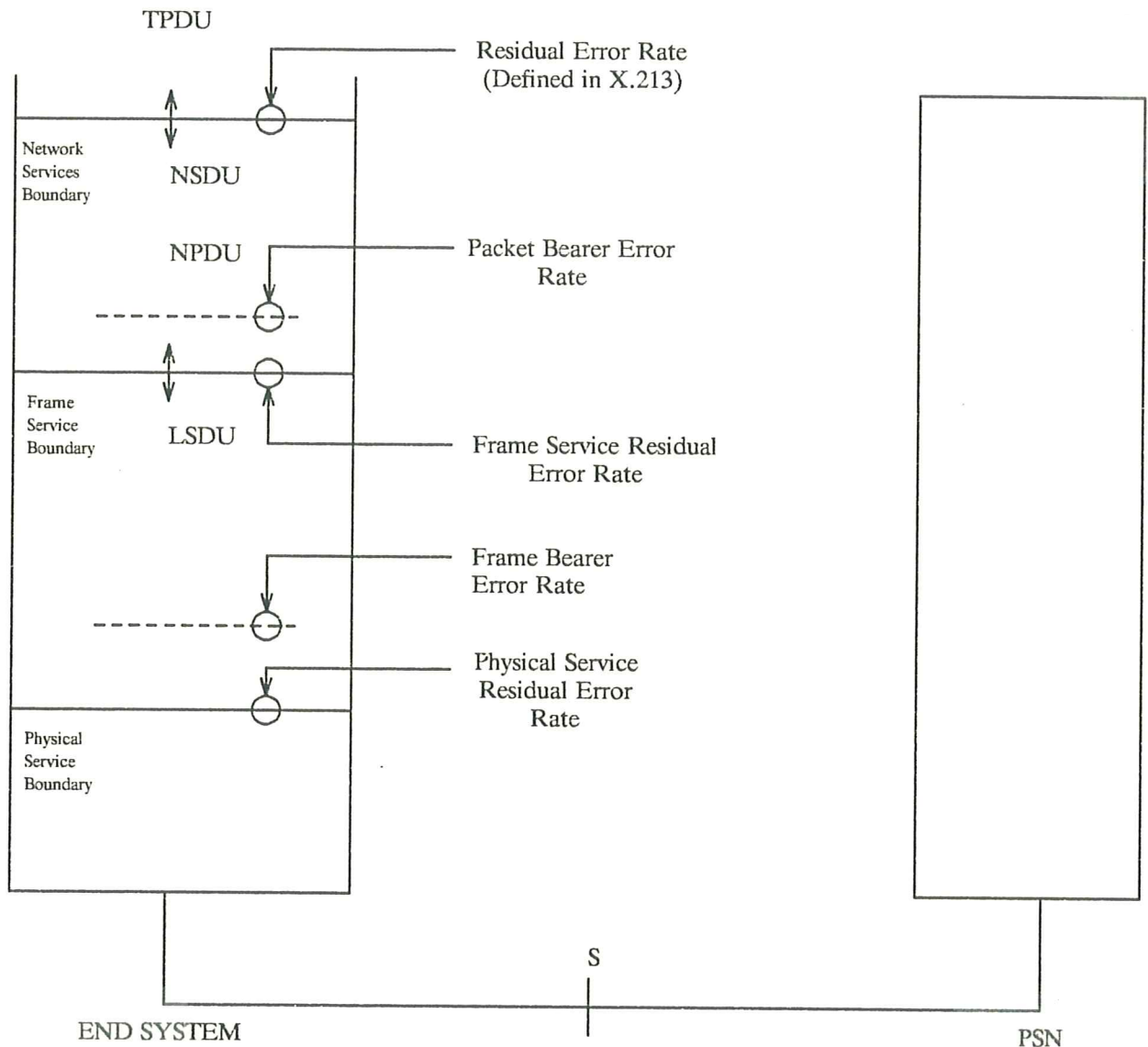


Figure 15 - Relationship with Existing Error Rate Definitions

Frame Service Residual Error Rate

Frame Service Residual Error Rate is the ratio of total incorrect, lost, and duplicate Frame SDUs transferred across the Frame Service to higher layer boundary during a measurement period for a given connection.

Packet Bearer Error Rate

The ratio of total incorrect, lost, and duplicate packets transferred across the S boundary during a measurement period for a given connection.

This QoS parameter is partially influenced by the Frame Service Residual Error Rate. It also depends on the end system protocol used at Layer 3 for data transfer.

7.1.2.1.3 QoS Parameters Applicable to Frame Mode Services

The QoS parameters are shown in Table 2. Nomenclature applied is:

- $QoS_{A'B'}$ = $F(QoS_{AC}, \text{etc.})$; how $QoS_{A'B'}$ is derived from QoS_{AC} is outside the scope of this document.
- A PSN needs to provide for transparent transfer of QoS_{AC} (in addition to $NSAP_A$, $NSAP_C$).
- All parameters defined as "Fixed by A" or "Negotiated" should be included in Bearer Capability Request.
- There is a need for specifying minimum/maximum values for QoS parameters in ECMA Standards related to the PSN.

$QoS_{A'B'}$, here means the Quality of Service on the path between A' and B', QoS_{AC} on the path between A and C, etc.

Connection Establishment	Delay Failure Probability	Fixed by PSN Fixed by PSN
Connection Release	Delay Failure Probability	Fixed by PSN Fixed by PSN
Data Transfer	Throughput Target Throughput minimum Transit delay target Transit delay maximum Frame Bearer Error Rate Transfer failure probability Connection Resilience	Negotiated A'/PSN/B' Fixed by A', -> B', PSN Negotiated A'/PSN/B' Fixed by A', -> B', PSN Fixed by A', -> B', PSN Fixed by A', -> B', PSN Fixed by A', -> B', PSN
Other	Connection Protection Connection Priority Maximum Acceptable Cost	Fixed by A', -> B', PSN Fixed by A', -> B', PSN Fixed by A', -> B', PSN

Table 2. Quality of Service applicable to Frame Mode Service

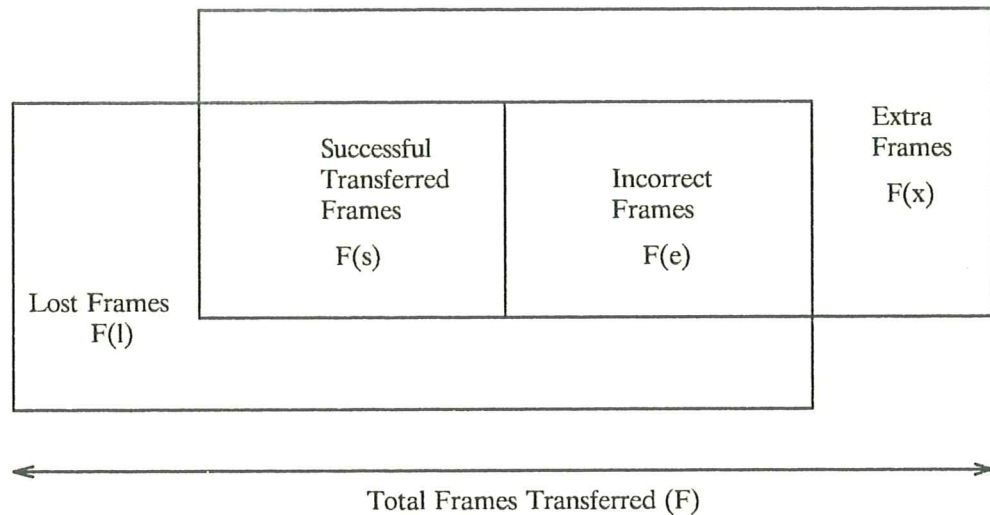
The DPE may consider the use of QoS parameters optional, except for the target throughput which must be indicated in both directions.

Fixed by X here means: X determines the lifetime value; the other 2 parties involved can accept or reject the call. Example: "Throughput minimum Fixed by A', -> B', PSN" means that A' can indicate a minimum throughput class value in the negotiation process; the call will be rejected by the PSN or by B' if either of them cannot satisfy this request.

Negotiated A'/PSN/B' here means: the parameter value is determined in a 3-party negotiation process between A', the PSN and B'.

Some QoS parameters described for data transfer (e.g., transit delay and throughput) are related to the bearer service. How these QoS parameters are carried by the signalling mechanism is outside the scope of this document and shall be considered during the standardization of ECMA 106+. Here throughput for a logical connection is defined as the number of

data bits contained between the address field and the CRC of frames successfully transferred in one direction across the connection per unit time. Successful transfer means that the CRC check of each frame is satisfied. Transit delay is defined between two S reference points. Transit delay of a frame starts at time t1 at which the first bit of the address field of the frame crosses the first reference point and ends at time t2 at which time the last bit of the closing flag of the frame crosses the second reference pt. Transit delay is t2 - t1.



$$FBER = \frac{F(e) + F(l) + F(x)}{F}$$

Figure 16 - Frame Bearer Error Rate

7.1.3 Frame Mode Bearer Service Negotiation

Two frame mode bearer services were identified above: Frame Switching and Frame Relaying. It is assumed that End Systems requesting Frame Mode Bearer Services access always implement procedures to access both Frame Switching Bearer Services and Frame Relaying Bearer Services.

The selection of Frame Switching or Frame Relaying is negotiated between the End System initiating a Frame Mode call and the PSN, and the result is indicated to both calling and called End System.

Figure 17 shows the three cases that need to be identified in the selection process, the three cases are:

- Case A: in the path between the two End Systems only Frame Relays (in addition to circuit switching) can be found.
- Case B: the path between the two End Systems includes full termination of the Link Layer Protocol at both edges by Frame Switches (this is sometimes referred to as edge termination).
- Case C: in the path between the two End Systems one or more Frame Switches can be found, but at least on one edge a Frame Relay can be found (or, in other words, at least one of the End-Systems has visibility of a Frame Relay).

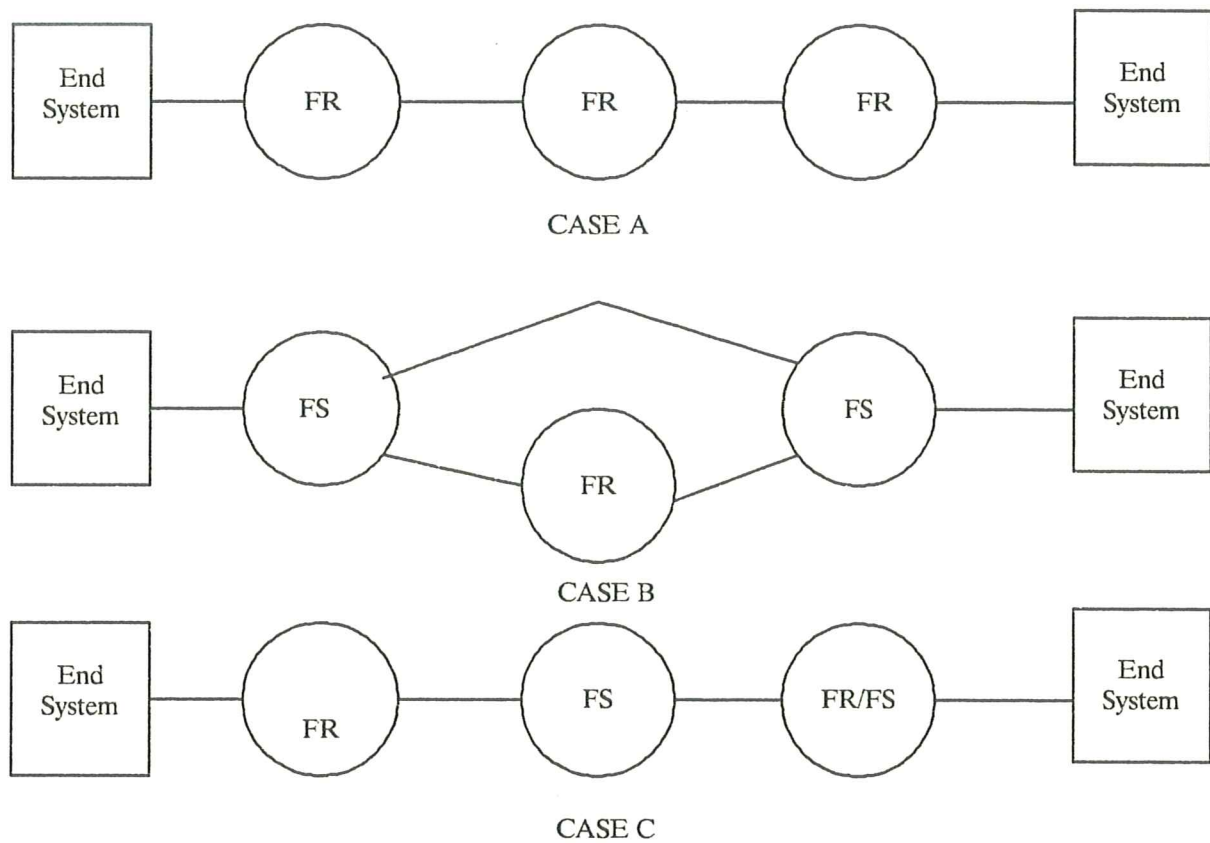


Figure 17 - Frame Mode Service Scenarios

Table 3 shows the options available to the PSN as a function of the option requested by the calling End System. PSN options which may be offered are a function of PSN capabilities as well as topology.

End System Request	Pure Frame Relay (case A)	Pure Frame Switch (case B)	Frame Switch w/Frame Relay (case C)
ANY	x	x	x
Preferred Relay	X	x	x
Preferred Switch	x	X	x
Exclusive Relay	X		
Exclusive Switch		X	

Table 3 - PSN Options

X means that the network should select this option, and only if it is not possible, should it try another option (another alternative is not possible if an exclusive request was indicated).

x means that the network is allowed to select this option.

Different indications may be given to the two End Systems, as one may have visibility of a Frame Relay, the other one may not. Table 4 shows the possible indications to the two End Systems as a function of calling End System selected options and PSN response.

PSN Option						
	A (pure relay)		B (pure switching)		C (mixed)	
Calling ES	Indication called	Indication calling	Indication called	Indication calling	Indication called	Indication calling
ANY	R	R	S	S	S/Sr	S/Sr
Pref. Sw	R	R	S	S	S/Sr	S/Sr
Excl. Relay	R	R				
Excl. Sw.			S	S		
Pref. Relay	R	R	S	S	S/Sr	S/Sr

Table 4 - Indications to the End Systems

R = pure Frame Relay
S = Frame Switch, no Relay visible
Sr = Frame Switch, Relay visible

7.1.4 Signalling Mechanisms

The following signalling mechanisms are given as an example and shall be further clarified during the standardization of ECMA-106+.

The bearer service will be indicated by the DPE as frame switching or frame relaying in the Bearer Capability Element. When the DPE is prepared to accept an alternative proposal it will indicate this by use of an additional indicator (e.g. preferred/exclusive bit). The default value of the indicator will be exclusive. The parameters defining the QoS and the constraint parameters for the layer 2 protocol will normally have the default values such as is indicated in Table 5, for the window size k. The precise definition of the layer 2 default parameter values are to be determined as part of ECMA-105+ standardization.

Channel	k	Throughput
16 kbps	4	16 kbps
64 kbps	7	64 kbps
384 kbps	16	384 kbps
1,92 Mbps	36	1,92 Mbps

Table 5 - Layer 2 Default Parameters

When any of these parameters needs to be changed by one of the parties involved (initiator DPE, network, or terminating DPE) that party will provide for the new parameter values(s) in relevant call control messages.

These parameters will be carried in existing or new Information Elements. See Table 2 and point three in 7.1.2.1.3.

The initiating DPE and the PSN may change one of the parameters by modifying the value in the SETUP message. The destination DPE will change one of the parameters by modifying the value in the CONNECT message. The scenarios depicted in Figures 18 and 19 are summarized in Table 6.

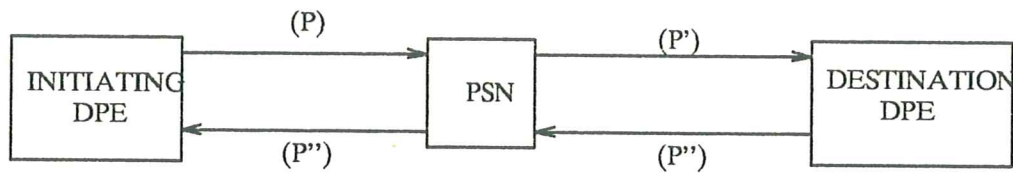


Figure 18 - Parameter Negotiation - Initial Parameters Proposed

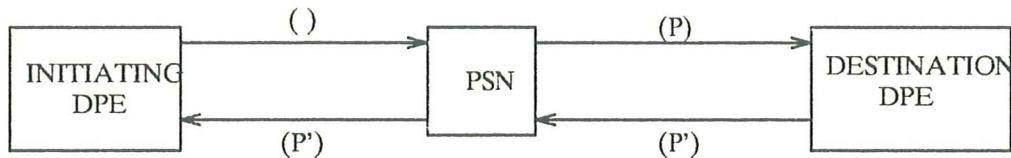


Figure 19 - Parameter Negotiation - No initial Parameter Proposal

MESSAGE	INITIATOR	PSN	DESTINATION
SETUP	*	*	
CONNECT			*

Table 6 - Messages Affected by Negotiation

Where (P) indicates the presence of a (modified) parameter value and () indicates the use of default values. (P') indicates the presence of a value potentially different from (P'). (P'') indicates a value potentially different from (P). The parameter information element is optional.

7.1.5 Procedures for Service and Parameter Negotiation

The following procedures are given as an example and shall be further clarified during the standardization of ECMA-106+. The initiating DPE will specify the required bearer service and any optional additional information (exclusive indicator, QoS parameters, layer 2 parameters, etc.) in the SETUP message.

The PSN may transmit this information unchanged or modified as part of the SETUP message sent to the destination DPE. The PSN may also provide new parameter values when it does not want to accept the default values. New proposed parameter values must be either smaller or less strict than the values initially proposed (including default parameters). The PSN also has the option of rejecting the call using the appropriate release procedure.

On receipt of the SETUP message the terminating DPE may either:

- accept the call with a CONNECT message, or
- reject the call with the appropriate procedure.

In the first case, it will always return in the CONNECT message, all defined parameters provided in the parameter information element of the SETUP message. This information may be either unchanged or modified if not acceptable. Additionally it may also provide new parameter values when it does not want to accept the proposed or default values. In this case a smaller or less strict value may be proposed.

The parameter information element will be delivered unchanged to the initiator DPE via the CONNECT message.

When either the PSN or destination DPE receives a SETUP message it will examine the information in the parameter information element. The information comprises a number of parameter values, a default value will be assumed for any parameter which is missing. One or more parameters in this element, or parameter defaults, may specify a level of resource which is unavailable to the connection. Such parameters may be altered, or added in the case of defaulted parameters, to a level which can be supported. This level will always be less in terms of resource usage than was asked for. The viability of supplying a reduced level is dependent upon the criteria defined for the parameter. If not viable, the call would be rejected.

7.1.5.1 Quality of Service Considerations For Frame Mode Bearer Service

The negotiable parameters which bear on the Quality of Service are: throughput, transit delay, window size (k), acknowledgment timer (T200), and the information field length (N201). Of these parameters only the window size (k) and the information field length (N201) have a bearing on the selection between the two frame mode bearer services. It is assumed that T200 has a relatively large value relative to end-to-end transit delay. The effects of the other parameters are essentially constant with regard to the bearer service type. If k and N201 are improperly selected there may be a negative effect on throughput.

The frame relay bearer services are implemented using the ECMA-105 protocol using multi-frame procedures. ECMA-105 provides a windowed protocol and as such requires that the amount of data transmitted is limited to a maximum amount called a window until the other side provides an acknowledgement for this data. This procedure places a maximum limit on the throughput of a connection when the window size is insufficient to maintain constant data transmission. This can occur when the time required to receive an acknowledgement is longer than the time required to transmit a window's worth of data. When this occurs, the transmitter is idled until the acknowledgement is received, thus decreasing the possible throughput of the connection.

The maximum throughput depends on the product of k and N201. To obtain maximum throughput these values must be large enough to sustain transmission and acknowledgement cycle. Thus for frame relay bearer service, the k and N201 values proposed for a call must be checked against the topology of the connection. If the values are insufficient to meet the required throughput, the call cannot be offered using frame relay bearer service. For frame switching bearer service, the topological considerations concern only the connections between the DPE and the PSN node providing the frame switching function.

7.1.5.2 Quality of Service and System Parameter Negotiation

When an End System establishes a call, it requires a certain Quality of Service from the network and at the same time expresses its constraints in terms of layer 2 system parameters (see Table 7). Parameters which are fixed are not changed within the negotiation process, but if the values can not be achieved, the call attempt should be dropped.

Parameter	Defined by
k maximum acceptable value	negotiated by A'/PSN/B'
N201 target value	negotiated by A'/PSN/B'
N201 minimum acceptable value	Fixed by A',->B',PSN
T200	Fixed by A',->B',PSN

Table 7 - ECMA-105 System Parameter as Constraints

During the negotiation phase the network should look at the constraints expressed by the End System and calculate if the QoS requirements are achievable taking into account the system parameters and the connection topology. After performing those calculations, the network can make the following decisions:

- drop the call when user requirements and network constraints cannot be reconciled,
- forward the call with original system parameters when user expressed constraints are sufficient to continue the call,
- forward the call with reduced values of system parameters when user expressed constraints are greater than necessary for continuing the call, or
- forward the call with reduced values of system parameters when network resources are limited but allow the quality of service minimums to be met.

If the call is forwarded, the destination DPE receives the proposed system parameters. The DPE can then make one of the following decisions:

- drop the call because the system parameter and/or the QoS requirements cannot be accepted by the DPE,
- accept the call as offered, or
- accept the call with reduced values of system parameters and QoS values because the DPE resources are limited, but as far as can be determined by the DPE, the QoS minimums can be met.

If the call is accepted, the PSN will adjust its resources to match any reductions in system parameters and convey those parameters to the originating DPE unless the new parameters are insufficient to support the quality of service minimums. In such cases (which should rarely occur), the call will be dropped and an indication as to the reason for the dropping of the call will be sent to both DPEs.

Default values of system parameters are established for each parameter. Default values of k are set according to the physical channel rate since this supports the highest throughput possible. When system parameters are not explicitly indicated in the SETUP message, this signifies that these values are proposed. The default target and minimum values of N201 are specific protocol matters.

7.1.5.3 Quality of Service Considerations

If an End System requires a certain bearer capability from a PSN, makes an exclusive request for that bearer capability, and the PSN accepts the request, then the PSN must provide the Protocol Processing Option corresponding to the requested bearer capability in at least one node in the path provided. In the other nodes in the path, lower protocol processing options can be used, provided the requested Quality of Service can be met.

In choosing to operate with a given protocol processing option, a request for a bearer service will require that a layer set of options be fully agreed between connected End Systems. The result for a PSN supporting a packet bearer service, for example, can be summarized as follows:

- a PSN may use protocol processing options b, and/or c,
- for restricted cases (i.e. when a PSN is also able to provide circuit switching), the PSN may use protocol processing option a, or
- a PSN might also be able to support X.31 scenarios.

In all cases the PSN will negotiate with / indicate to the End Systems the protocol processing option used.

7.1.5.4 Design Considerations for a PSN

There is a fundamental design trade-off that can be made at a network node between processing time and throughput and transit delay. A given amount of processing will eventually limit throughput and increase transit delay as the traffic in and out of the node is increased. As the traffic at the interfaces is increased, the interval between transmissions at the full rate of the interface becomes less than the interval required to do the processing. Thus, given no other constraints, the less processing required at a node, the greater the throughput which can be handled within that node.

7.1.6 Frame Relay Service Selection Criteria

Frame relay bearer service offers lower transit delay and potentially higher throughput compared to a frame switching service (where all link layer functions are processed). There are two factors that may impair the performance of frame relay however. These two factors are acknowledgment delay which increases as switching nodes and distance are added to a connection, and loss of frames due to buffer overflow. Frame relay service may be offered when two conditions are met: First, the round-trip delay effects on the window size required to meet a given throughput are minimal, and second, the round trip delay effects on network resources due to increased buffer requirements from larger window sizes results in a minimal frame loss rate. The purpose of setting these conditions is to put a constraint on the maximum value for parameters that a packet mode DPE needs to support. This ceiling on parameters also simplifies the negotiation procedures of the signalling process. Figure 20 shows how a given node may support either a frame relay or frame switching bearer service depending on the parameters of a call. When the conditions that are detailed below are met, a frame relay is performed in the node. If some parameters are exceeded, however, a protocol handling resource may be added to the connection in that node to provide frame switching.

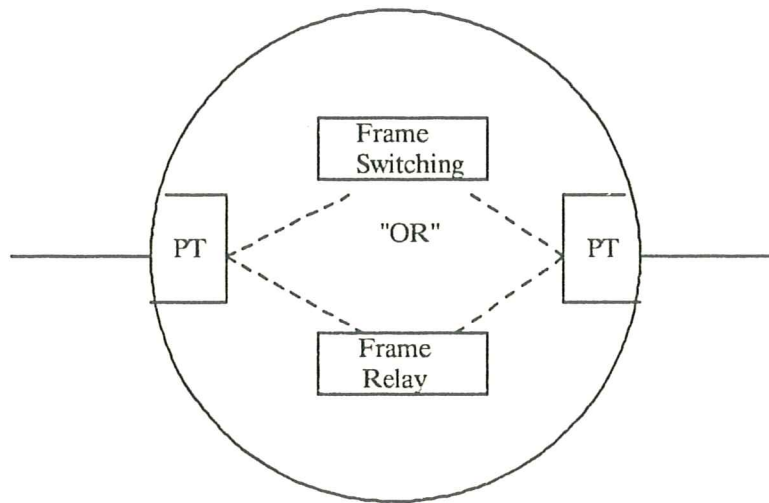


Figure 20 - Frame Relay and Frame Switching Provided in a Single Switching Node

The selection of appropriate parameters and their values to insure the above conditions are met are described in the following clauses.

7.1.6.1 Minimizing the Effects of Round-Trip Delay on Performance

Frame relay techniques provide lower transit delay compared to frame switching because of the lower protocol processing requirements of frame relay. However, because no processing is performed at frame relay nodes, window rotation will occur over physically long connections which could involve a large number of tandem connections (hops) and thus will require larger windows to maintain full throughput. Since the effects of the longer delay are seen in terms of window size, the criterion for measuring the effects is based on the window size. The window size at layer 2 required to maintain full throughput for a connection involving a single data stream is determined as follows:

$$\text{Window Size} = \frac{\text{Round-Trip Delay}}{\text{Frame Transmit Time at Required Throughput}}$$

This is equivalent to

$$k = \frac{\text{Roundtrip Delay}}{\left[\frac{\text{Frame Length}}{\text{Throughput}} \right]}$$

The round-trip (RT) delay is the sum of propagation delays, transmission delays, and processing delays. A model connection showing the delay processes is shown in Figure 21.

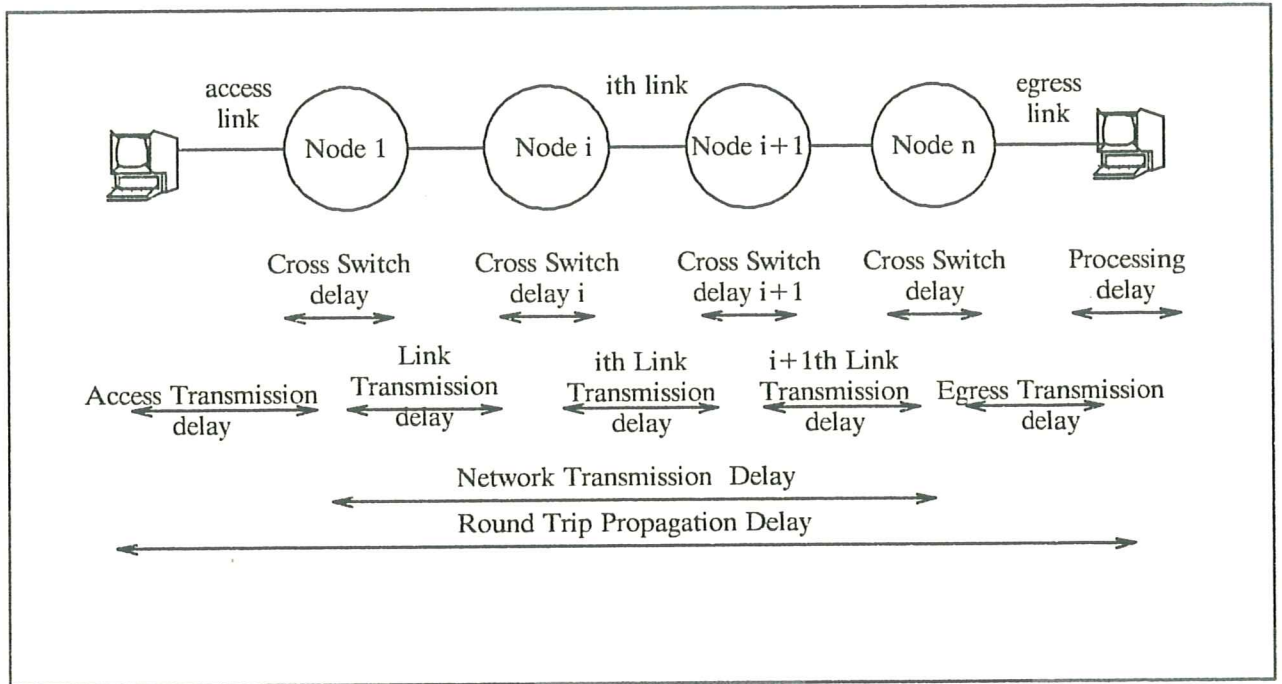


Figure 21 - Model of Connection for Round-Trip Delay Analysis

The equation may now be expressed as:

$$k = \frac{\text{Access Trans} + \text{Propagation delay} + \text{Endpoint processing} + \sum_{i=1}^n (\text{Link Trans Time}_i + \text{Cross Switch Delay}_i)}{\text{Frame Transmit Time}}$$

Where n is the number of network nodes and the nth link is the egress link; thus, the nth link transmission time is the egress link transmission time.

Next we examine each factor in the equation separately. First, the contribution to window size based on propagation delay is expressed as follows:

$$k_{prop} = \frac{RT \text{ propagation delay}}{\left[\frac{\text{Frame length}}{\text{Throughput}} \right]}$$

It is of interest to determine the distance required to drive this value to one. For 128 octet frames at 64 kbps, propagation delays of less than 17 ms fill this condition. With propagation delays of 5 μ s per km and a frame size of 128 octets, the contribution to the window required for 64 kbps throughput is one or less at distances of up to 1600 km (3200 round trip). For 384 kbps throughput, the corresponding distance is 267 km (533 km round trip). For 1,92 Mbps throughput, the corresponding distance is 53 km (106 km round trip). Thus for every multiple of these distances, the window size must be increased by one to insure no loss of throughput. Doubling the frame size will also double the distance transited without adding further to the

window size requirement. Thus for 512 octet frames, the distance at 64 kbps is 6400 km, at 384 kbps it is 1066 km, and at 1,92 Mbps it is 212 km.

Next the amount of increase in window size due to the time it takes to transmit frames across the access line is as follows:

$$k_{Transmission} = \frac{Information\ Transmission\ Time + Acknowledgement\ Transmission\ Time}{\left[\frac{Frame\ Length}{Throughput} \right]}$$

Frame transmission time is calculated by dividing the frame length by the transmission speed. Thus the previous equation applied to the access line is expressed as:

$$k_{access} = \left(1 + \frac{Frame\ Length_{ack}}{Frame\ Length_I} \right) \left[\frac{Throughput}{Access\ Line\ Speed} \right]$$

Note that for more than one virtual connection the throughput speed must be less than the line speed. Thus for many virtual connections sharing a line, the contribution to window size is a fraction of one.

The amount of increase in window size due to delay on the egress line is determined similarly to the access line and is expressed as follows:

$$k_{egress} = \left(1 + \frac{Frame\ Length_{ack}}{Frame\ Length_I} \right) \left[\frac{Throughput}{Egress\ Line\ Speed} \right]$$

In the same manner, the amount of increase in window size due to delay on the *i*th network link is expressed as follows:

$$k_{ith\ link} = \left(1 + \frac{Frame\ Length_{ack}}{Frame\ Length_I} \right) \left[\frac{Throughput}{Network\ Link_i\ Speed} \right]$$

From this can be seen that when the length of an acknowledgement frame is much less than an information frame the additional window requirement for transmission is equal to the throughput to line speed ratio. As this ratio can never be more than 1, the maximum increase per node is 1. If contrary to the normal case, acknowledgement frames are of the same order of length as information frames, the maximum increase due to transmission time per hop is 2.

It is worthwhile at this point to note that the speeds of the access, egress and network links will not always be the same. For 64 kbps throughput requirements, if the network link speeds are 384 kbps, the additional window requirements are 1 / 6 per hop and for 1,92 Mbps network links, the requirements are 1 / 30 per hop.

It can now be seen that with access speeds of 64 kbps and network trunk speeds of 384 kbps and higher, the window size requirements remain very small, and are relatively unaffected by

the number of relay nodes in the connection. Thus these situations are prime candidates for the frame relay bearer service.

The next factor to consider is the contribution due to cross switch delay. Cross switch delay is defined here to mean the time interval between receipt of an entire frame at the switch and the transmission of the first bit of the frame on the next link. In terms of the window increase, the cross switch delay effect is as follows:

$$k_{cross} = \frac{Cross\ Switch\ Delay_l + Cross\ Switch\ Delay_{ack}}{\left[\frac{Frame\ Length}{Throughput} \right]}$$

Thus to keep the cross switch delay factor from significantly affecting the window size requirement, the cross switch delay at 64 kbps should be in the order of 1 ms, at 384 kbps 300 μ s, and at 1,92 Mbps: 70 μ s when 128 octet frames are used. These values would increase the window size by one for every eight switches that are transited. Even if these cross switch delays are doubled, the window size only needs to be increased by one for every four hops.

The final factor to consider in the window size requirement is component due to delay incurred in processing the frames at the endpoint. The increase in window size due to endpoint processing time is expressed as follows:

$$k_{endpoint} = \frac{Endpoint\ Processing\ Time}{\left[\frac{Frame\ Length}{Throughput} \right]}$$

The endpoint processing time will add one to the window size if it is equal to 16 ms for 64 kbps throughput, or 2,7 ms for 384 kbps throughput, or 0,53 ms for 1,92 Mbps throughput.

7.1.6.2 Recommendation for Maximum Round-Trip Delay Criteria (Maximum Window)

The results of the window size analysis are summarized in Table 8. The value F is defined as follows:

$$F = \left(1 + \frac{Frame\ Length_{ack}}{Frame\ Length_l} \right) \left[\frac{Throughput}{MIN(Access\ Line\ speed, Network\ Link\ speed, Egress\ Line\ speed)} \right]$$

The only component of the window size requirement that is sensitive to the frame length is that due to propagation delay. In the table the values of this component for 128, 256, and 512 octets are shown. The results are expressed as the number of kilometers that can be added to the distance between the connection endpoints before the window size requirement increases by one. The table does not include effects due to cross-switch delay or endpoint processing which are assumed to be negligible.

Throughput Requirement	Trunk Speed bps	Access	Transmission	Network Propagation			Egress
				128 oct	256 oct	512 oct	
16 K	64 k	F	F/4 per Hop	6400 km	12800 km	25600 km	F
	384 k	F	F/4 per Hop	6400 km	12800 km	25600 km	F
	64 k	F	F/4 per Hop	6400 km	12800 km	25600 km	F
64 K	64 k	F	F per Hop	1600 km	3200 km	6400 km	F
	384 k	F	F/6 per Hop	1600 km	3200 km	6400 km	F
	1,92 M	F	F/30 per Hop	1600 km	3200 km	6400 km	F
384 k	384 K	F	F per Hop	267 km	533 km	1066 km	F
	1,92 M	F	F/5 per Hop	267 km	533 km	1066 km	F
1,92 M	1,92 M	F	F per Hop	53 km	106 km	212 km	F

Table 8 - Summary of Window Size Requirements For Full Throughput

If a value of 7 is set for the maximum allowable window for frame relay service, the scenarios presented in Table 9 are possible. The value 7 is a reasonable value because it is the default value for X.25 LAPB and provides good performance for LAPD frame relay. The table is based on the use of 128 octet frames; for longer frames, the distance figures are multiplied by the ratio of the longer frame to 128. For example for 512 octet frames, the distances in the table are multiplied by 512 / 128, i.e. by 4.

Through-put	Trunk Speed	Max k	Hops			
			1	2	3	4
16 k	64 k	4	11200	9600	8000	6400
	≥384 k	4	12800	12800	12800	12800
64 k	64 k	7	6400	4800	3200	1600
	≥384 k	7	6400	6400	6400	6400
384 k	384 k	16	2403	2136	1869	1602
	1,92 M	16	2403	2403	2403	2403
1,92 M	1,92 M	36	1749	1696	1643	1590
Speed in bps			Distance in Kilometers (km)			

Table 9 - Maximum Window Size Frame Relay Scenarios

7.1.6.3 Minimum Frame Loss Rate Requirements

The allowable frame loss rate allocated to network buffer overflow should be on the order of the loss rate due to transmission impairments. This value is typically on the order of 1 frame lost in 10^{-6} .

7.1.7 Congestion Control

PSNs should be designed in such a way that congestion has a very low probability of occurrence. Nevertheless, congestion may occur, due to, for example,

- failures of resources like trunklines or switching nodes, or

- severe peaks in the total traffic offered to some parts of the PSN.

In order for PSNs to operate in a manner to insure the efficient use of resources under congestion conditions, control mechanisms should be provided.

The objectives of congestion control are:

- protection of the network against congestion,
- optimization of user throughput,
- fairness among DPEs of the same priority class,
- protection of the network against abuse by individual DPEs.

Fairness dictates that all DPEs on a PSN implement the same procedures. Methods of congestion control are:

Network initiated congestion control

i) Passive congestion control.

This does not affect existing calls.

- Congestion control confined within the PSN. The effects of this are apparent within the PSN only.

Alternative routeing - using alternative routeing, congested areas of the network are by-passed.

- Congestion control not confined within the PSN. The effects of this are apparent at the terminal/DPE.

Resource allocation (e.g. bandwidth management)

- Adjusted allocation : new calls are allocated with smaller window size or reduced packet length requirements.
- Call blocking : no resources are available for new calls.

ii) Active congestion control.

This affects existing calls and is always apparent outside the PSN.

- Congestion control not confined within the PSN

Throttle message

A throttle message is sent by the network to the terminal to affect the effective throughput of the DPE. The message will have varying levels of significance:

- . stop till start message is received
- . stop for a period of time
- . reduce window
- . reduce window for a period of time.

Whether the throttle message is implemented using in-band or out-of-band mechanisms is for further study.

Flow control between the DPE and the PSN provides a means to reduce the throughput of the DPE into the network (as well as end to end). It can therefore be used as a replacement for the throttle message and accompanying mechanism. This mechanism only applies between entities which fully terminate the link layer protocol, e.g., between an end system and a PSN node which provides frame switching.

- Congestion control actioned within the PPSN
 - . the network drops frames,
 - . the network drops calls.

The network initiated congestion control mechanisms are listed in ascending severity. The network should first try to reduce congestion by passive means and if unsuccessful should then try active means. The network should only drop calls as a last resort.

Terminal initiated Congestion Control.

In this method the terminal detects congestion and reacts to it. The terminal reduces its window size to a "safe" value and increases it according to an algorithm until either the congested throughput limit, or the maximum terminal throughput is achieved. This is called the dynamic window control mechanism. See Appendix C.

7.1.7.1 Congestion control in a Frame Switching Network

In a frame switching network all the network initiated congestion control mechanisms except the throttle message are used. Terminal initiated congestion control is not necessary. See Table 10.

7.1.7.2 Congestion Control in Frame Relaying Networks

In a frame relaying network all the network initiated congestion control mechanisms, except flow control are used to overcome the lack of flow control within the PSN. It is proposed to use an end-to-end dynamic windowing mechanism with a throttle message. In this context the throttle message significance becomes: reduce window to an indicated value and increase according to the dynamic window algorithm. See Appendix C and see Table 10.

Congestion Control Method	Frame Switching	Frame Relaying
Alternative routeing	x	x
Resource allocation		
adjusted	x	x
call block	x	x
Throttle message		
stop until start	NN	NR
stop for duration	NN	NR
reduce window	NN	x
reduce window for duration	NR	NR
Flow control	x	-
Drop frames	x	x
Drop calls	x	x
Dynamic windowing	-	x

NN-not needed; - not applicable; x-applicable; NR-not recommended

NOTE 8

The window will increase according to the dynamic window algorithm used.

Table 10 - Congestion Control in Frame Switching/Relaying PSNs

8. CONSIDERATIONS FOR SELECTING A PROTOCOL SUITE

When considering and comparing potential access protocol suites for satisfying the needs of a data transport protocol on PSNs, the following items need to be considered:

- The selected protocol suite shall allow for the provision of the OSI Network Service, i.e. provide the flexibility to support both connection-mode network service (CO-NS) and connectionless-mode network service (CL-NS).
- The selected protocol suite shall be symmetric. This is a critical requirement for the information transfer protocol and highly desirable for the signalling protocol.
- The selected protocol suite shall be backward compatible with Standards ECMA-105 and ECMA-106.
- The selected protocol suite shall follow the CCITT Rec. I.320 Protocol Reference Model.
- The selected protocol suite, which applies at the S interface, should be independent of whether the connection is provided by circuit switched or virtual circuit switched network paths.
- The selected protocol suite should be developed such that the network is free to support the degree of protocol processing suitable to its configuration and the quality of service requirements of the user.
- The selected protocol suite shall aim to allow for minimum complexity in interworking with existing networks using other protocol suites to support the OSI Network Service (e.g., interworking with an X.25 network). See Appendix B.
- The selected protocol suite shall provide for default operating parameters in order to allow operation in the absence of the negotiation of such information end-to-end (e.g. when an end-to-end connection includes non-ISDN circuit switched paths).
- The selected protocol suite shall, at the minimum, be able to support some of the facilities similar to those listed by X.2 for public data networks or as defined by ISDN supplementary services.
- The selected protocol suite should attempt to avoid duplication of functions across protocol layers.
- The selected protocol suite shall provide for all call control signalling (both circuit and virtual circuit call control) in the common signalling channel.
- The selected protocol suite preferably should be able to do call establishment as a one stage procedure, i.e. the establishment of a call reference, addressing, the negotiation of parameters such as the physical and logical channel identification, should be accomplished in a single call set-up procedure.
- The access protocol architecture should provide the flexibility to support both connection-mode network service (CO-NS) and connectionless-mode network service (CL-NS).

8.1 OSI Connection Mode Network Service

When a connection-mode protocol suite is selected, it should be able to support the OSI connection-mode network service (CO-NS) as defined in CCITT Rec. X.213 and ISO 8348. See also Appendix B. CO-NS is obtained by means of convergence functions in the end systems.

8.2 OSI Connectionless-Mode Network Service

The PSN will be considered as an independent subnetwork and is typically, connection-oriented.

When a CL mode is considered, the protocol suite will be selected based on the principles mentioned in ISO DP 8524 and 8348 Addendum 1. See Appendix B.

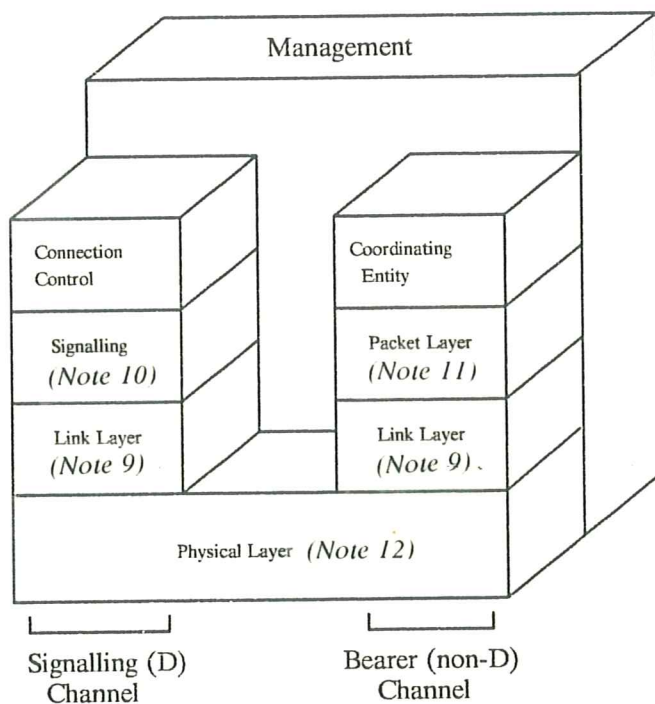
The CL-NS will be obtained by means of connectionless enhancement according to ISO 8473 Addendum 1 that will make use of Subnetwork Independent convergence functions (SNICF) and subnetwork dependent convergence functions (SND CF). The protocol suite defined for the PSN will be considered as the subnetwork access protocols.

9. PROTOCOL REFERENCE MODEL

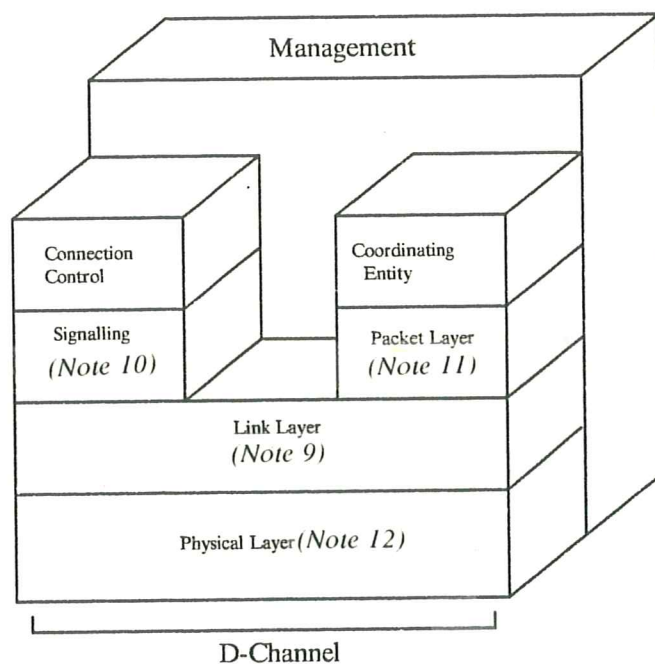
This Clause consists of two parts, 9.1 discusses the reference model itself, and 9.2 shows the mapping of a specific protocol suite to the reference model.

9.1 Protocol Reference Model Definition

The protocol reference model for the packet mode application consists of a dual-stack of protocols. In accordance with the ISDN concepts of out-of-band signalling, a signalling suite is used on the signalling channel, while another suite is used for user data transfer. Figure 22 shows how the two stacks appear when data is transmitted on a non-D-channel (left side), and how they are merged for D-channel operation (right side). A coordinating entity provides the necessary synchronization between the signalling (D-channel) and data network entities (Bearer channel). For merging of the two suites, it is necessary that as few differences as possible exist between them. The protocol model (i.e. the set of protocols) in Figure 22 illustrates the goal of providing nearly identical protocols at layers 1 and 2 of the signalling and data transfer suites, while the differences at Layer 3 are necessary to support the two specialized functions of signalling and user-data transfer.



-OR-



NOTE 9

Refers to an HDLC protocol similar to ECMA-105

NOTE 10

Refers to a functional signalling protocol similar to ECMA-106

NOTE 11

Refers to an empty layer, or a packet layer protocol similar to X.25 PLP data phase used as a convergence protocol

NOTE 12

Refers to a physical layer protocol similar to ECMA-103 / ECMA-104

Figure 22 - Protocol Reference Model, Protocol Suites

CCITT Rec. 1.320 demonstrates how the network relays data at layers below the network layer boundary. The OSI reference model defines this process as a sub-networking data transfer function.

For this protocol reference model, provision of Connection-Mode Network Service (CO-NS) is made by using a CO-NS network layer data protocol. The (CO-NS) protocol is transported by a PSN frame mode bearer service. Connectionless-Mode Network Service is provided by the DPE by using a Connectionless-Mode Network Protocol (CL-NP). The CL-NP is transported by a PSN frame bearer service.

9.1.1 Interactions between NS Provider and Higher Layers for CO-NS Operation

In the case where the End System is supporting the CO-NS, a convergence protocol is required over the Frame Mode Bearer Service provided by the PSN. In the following example, the X.25 PLP data phase is assumed to provide the needed convergence functionality. The use of X.25 PLP provides for the support of OSI and non-OSI higher layer applications (e.g. a PAD environment). The parallel stacks of protocols that supply the signalling and data transfer capabilities within packet mode applications provide the OSI Network Service to the higher layers. Figure 23 shows how the coordinating entity and management entity co-ordinate the functionality requested by a higher layer into the functions provided by each of the two protocol stacks - signalling functions by the signalling protocol stack and data transfer functions by the data transfer stack. The coordinating functionality is also responsible for the synchronization of the events which occur over the two separate information flows. This synchronization extends to areas such as user data flow initiation and termination.

The management plane is defined by the protocol reference model of 9.3 which is based on the CCITT ISDN protocol reference model. The management entity residing there has two roles:

- The first role is to insure communications between the different planes: the control plane (or signalling plane), and the user plane (or data phase plane).
- The second role is to perform resource management. For connection-oriented services, this includes:
 - . Converting network layer user requirements into parameters for layers 3, 2, and 1 based on equipment capabilities.
 - . Controlling the assignment of resources (as negotiated) in the different layers of the user plane.
 - . Controlling the release of resources when the connection service is terminated.

The coordinating entity provides a convergence function needed to coordinate the primitive actions at the layer 4 / 3 boundary with the protocol entities involved in an instance of communication.

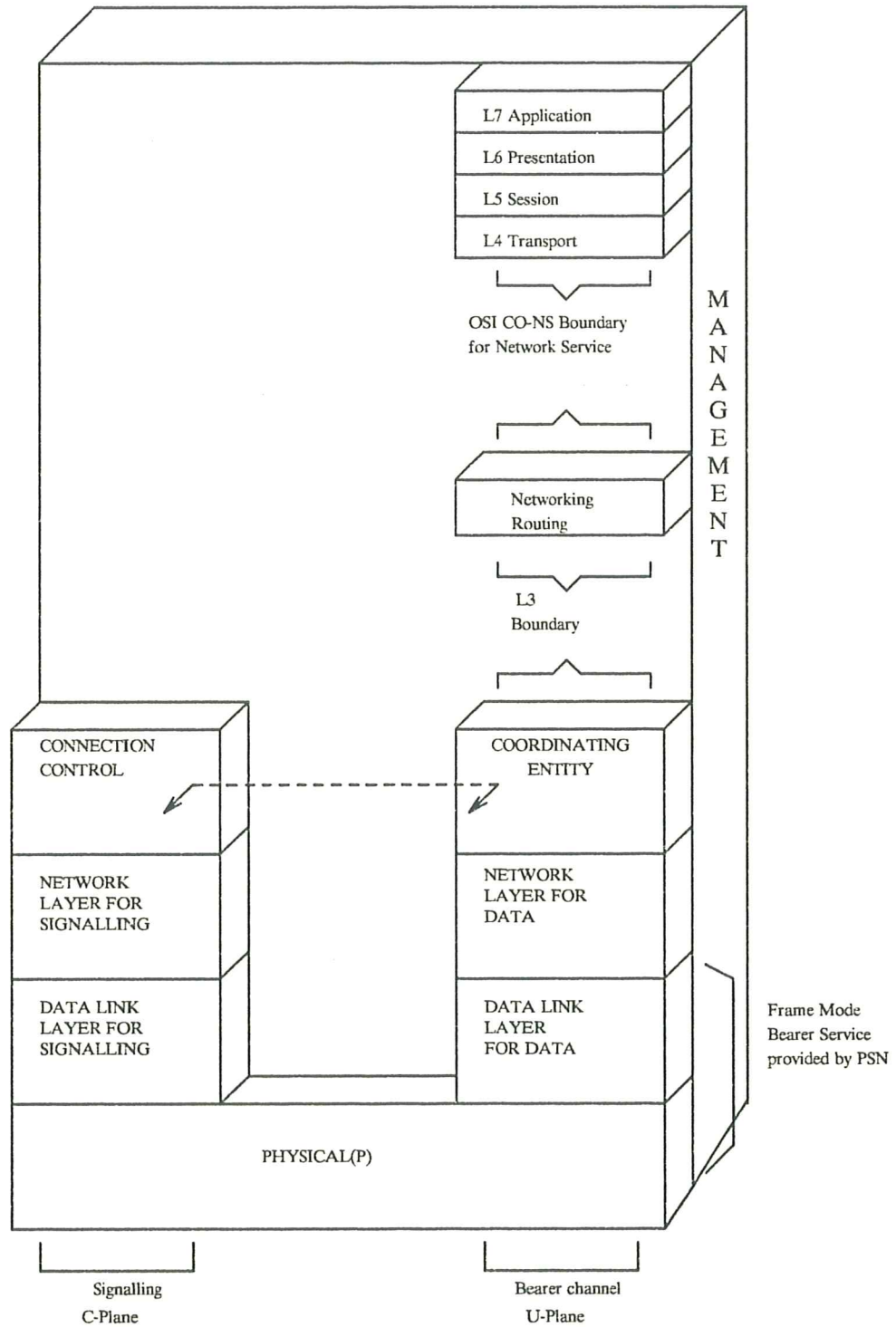


Figure 23 - Interactions of NS Provider with Layer 4 and above

Figure 24 shows that PAD functions for packet mode applications appear as another higher layer protocol application.

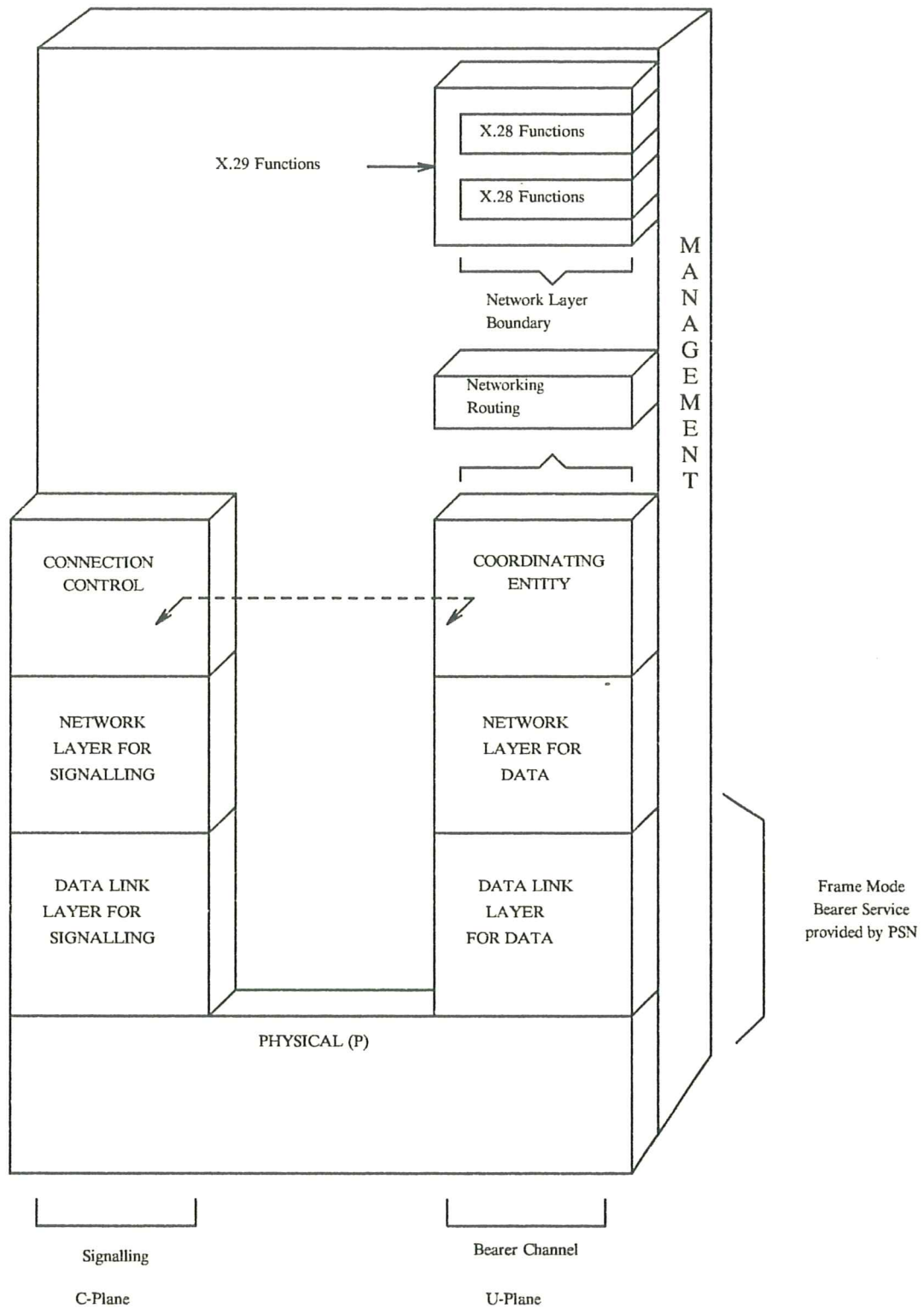


Figure 24 - Interactions with PAD Application

9.1.2 Interaction between Subnetwork Service Provider and Higher Layers for CL-NS Operation

In the case where the End System is working in a connectionless-mode at OSI Layer 3, Figure 25 shows the interaction and layer boundaries.

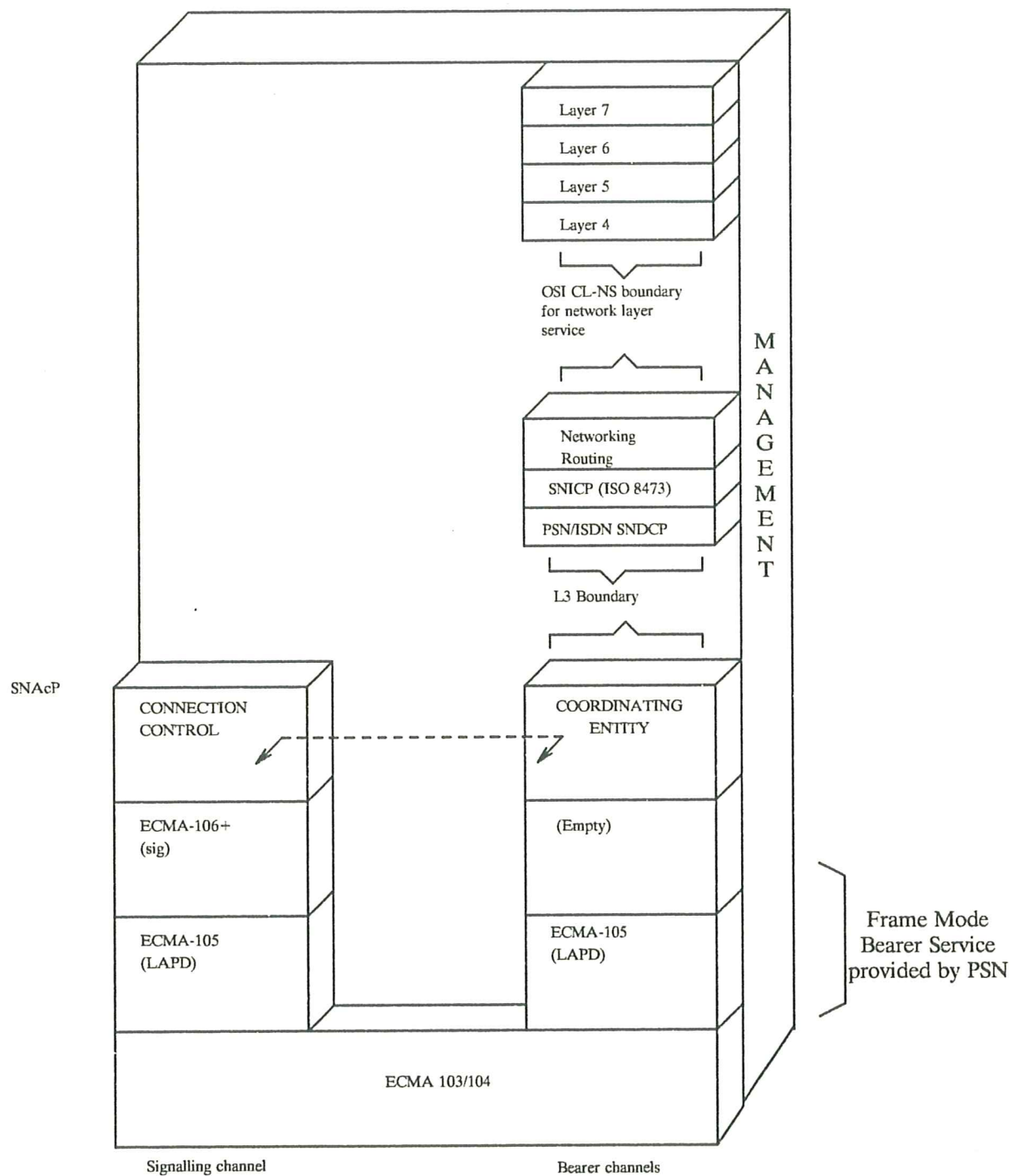


Figure 25 - Interactions and Layer Boundaries in a CL-mode context

9.2 Mapping of Specific Protocol Suite to Reference Model

The specific protocol suite that can provide the functions required for packet mode data transfer within the protocol reference model described above is discussed in this section. This protocol suite accommodates the considerations for selecting a protocol suite discussed in 10.

The protocols used for provisioning the signalling channel are ECMA-106 at Layer 3 (further

described in 11) and ECMA-105 at Layer 2 (further described in 10).

The protocol used in the bearer channels is ECMA-105 at Data link layer (see 8). ISO 8208 (X.25 PLP) data phase only (further described in 11) is used in the case of CO-NS provided in the End System.

9.3 Application of the Protocol Model to PSNs

The generic ISDN protocol model is shown in Figure 26. There are three functional groupings which are named the user plane, management plane, and the control plane. The control plane includes both signalling (ECMA-106) and call control functions. The user plane includes OSI protocol layers and a coordinating entity whose function is to map the OSI network service onto the PSN. The management plane provides a means for communication between n and c plane entities.

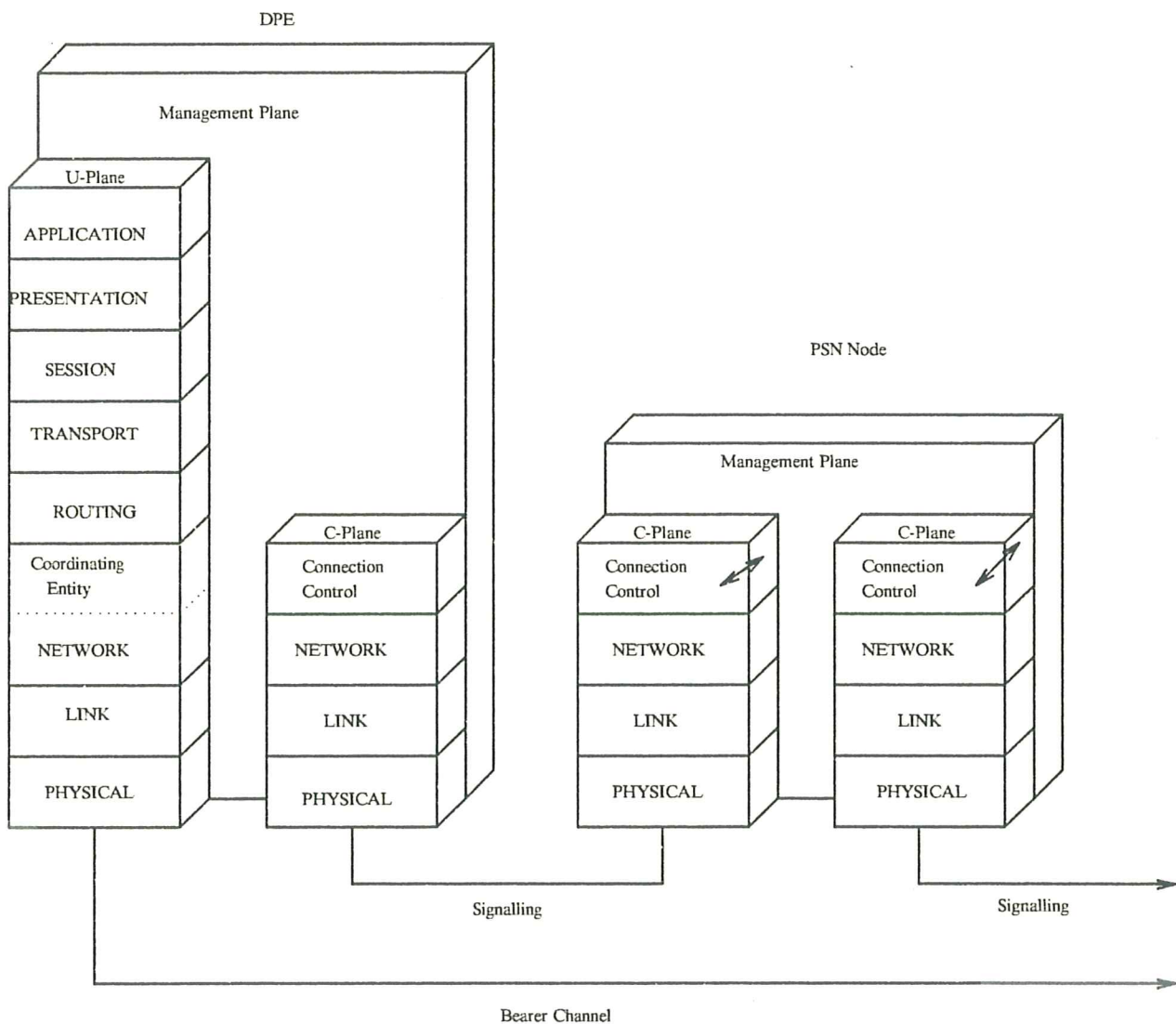


Figure 26 - ISDN Protocol Model for Circuit Switching in the PSN

Establishment of a connection requires the association of the different layer resources in both the DPE and the PSN. These associations are negotiated between the two call control entities via the signalling mechanism. An example of the resources required are: physical links, logical links, and logical channels. This combination of resources is associated with a NSAP at each DPE. These

resources are maintained during the life time of the connection. The types of resources required depend on the bearer capability requested for the connection as shown in the following examples. To simplify the diagrams, the examples do not distinguish between the control, user, and management planes.

The use of out-of-band signalling creates a requirement for synchronization between the U plane and the C plane. An example is to use an exchange of SABME/UA frames to synchronize the layer two protocol on the bearer channel.

The PCSN case is handled first followed by PPSN examples.

Figure 27 illustrates the functions provided by a PCSN. The D-channel is connected to the control and signalling entities within the PCSN. The data is transferred over the B-channel via the PCSN to another terminal device. This scenario provides compatibility with existing PCSN implementations while providing for growth into full ISDN implementations.

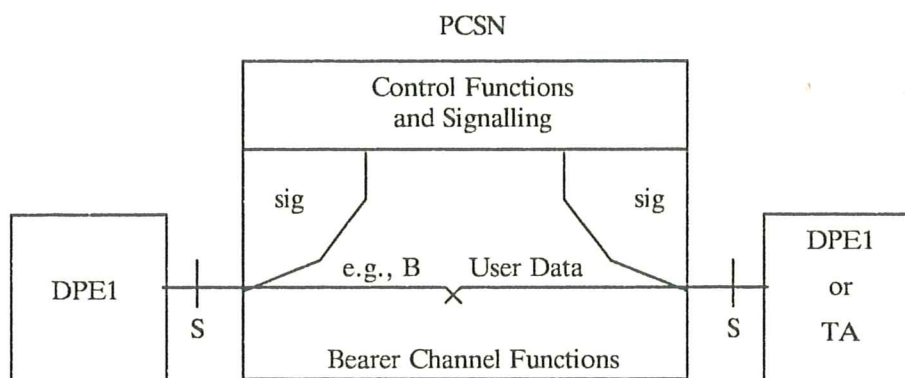


Figure 27 - PCSN - User Data on B-channel

Figure 28 illustrates the physical layer relay function provided within a PCSN. Only data transfer functions are shown. Connectionless-mode network service may also be provided for this configuration by replacing the X.25 PLP data phase protocol with ISO 8473.

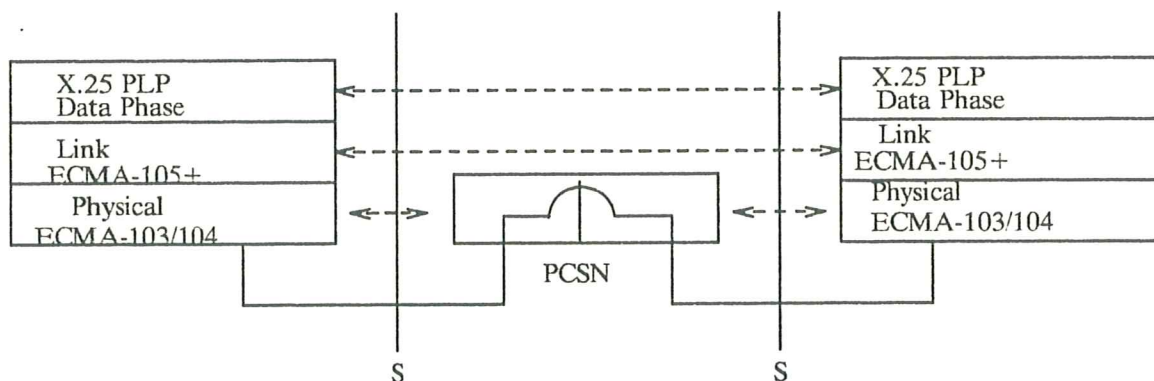


Figure 28 - Physical layer relaying within a PCSN (Data Transfer Only)

Figure 31 shows an example of full link layer termination provided by the FH. This full link layer termination may be required in order to provide an adequate quality of service on end-to-end connections which involve more than one PSN switch (see Appendix G). When link level termination is provided, congestion control is provided by the Network via Layer 2.

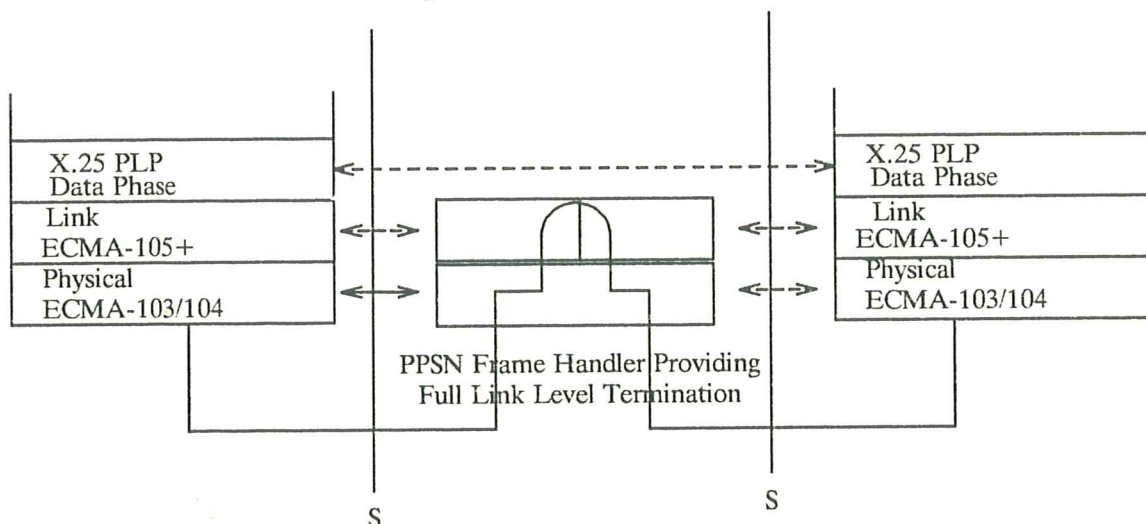


Figure 31 - Full link layer termination by a PPSN

Note that Figures 28, 29, 30, and 31 apply as well when the PSN is used in support of CL-NS with the exception that X.25 PLP Data Phase is not used.

10. LINK LAYER PROTOCOL FOR SUPPORT OF SIGNALLING AND DATA TRANSFER

The Data Link Layer protocol is based on Standard ECMA-105. The protocol is variously referred to as Link Access Procedure "D" (LAPD) when the protocol procedures are referred to, or as ECMA-105 when the protocol and associated management procedures are referred to.

The PPSN environment can be characterized as consisting of a network of transmission links of varying capacities, each of which is error-prone. Because of this environment, the link layer protocol must provide protection against errors and congestion.

10.1 General

The purpose of LAPD is to convey information between higher layer entities or between management entities across the S_0 and S_2 interfaces.

LAPD is independent of the transmission bit rate. It requires a duplex, bit transparent channel. It can be used in support of signalling or in support of packetized data transfer.

ECMA-105 provides functions for:

- The provision of one or more Data Link connections. Discrimination between the Data Link connections is by means of a Data Link Connection Identifier (DLCI) contained in each frame.
- Frame delimiting, alignment and transparency, allowing recognition of a sequence of bits transmitted as a frame.
- Sequence integrity of frames across a Data Link connection.

- Detection and recovery of transmission, format and operational errors on a Data Link connection.
- Notification to management entity or to Layer 3 entity or both of unrecoverable errors.

Data Link Layer functions provide the means for information transfer via point-to-point data links.

10.2 Primitives Required between Layer 3, Layer 2, and Management

Layer 3/2 primitives are described in ECMA-105. Management to Layer 2 primitives are defined in 11. The following information is conveyed via such primitives:

- DLCI to use for communication, or request to obtain DLCI through Layer 2 procedures,
- Parameters to use (k, N201, etc.) for a specific DLCI connection,
- Report of error conditions.

10.3 Types of operation

Two types of operation of the Data Link Layer are defined for information transfer: unacknowledged and acknowledged. They may coexist on the same Data Link.

- Unacknowledged operation

With this type of operation higher layer information is transmitted in Un-numbered Information (UI) frames. UI frames are not acknowledged. Transmission and format errors may be detected but no error recovery mechanism is defined. No flow control mechanism is defined. This type of operation is applicable for signalling on point to multipoint configurations. Other uses are for further study.

- Acknowledged operation

With this type of operation, higher layer information is sent in frames that are acknowledged at the Data Link Layer. Error recovery procedures are specified. In the case of errors which cannot be corrected by the Data Link Layer, a report is made to the Network Layer. Flow control procedures are also defined.

Acknowledged operation is applicable for point-to-point information transfer only. This type of operation is applicable for carrying user data in an ISDN environment (i.e. in an environment in which data is carried over error-prone media).

A multiple frame mode of operation is used. This means that higher layer information is sent in numbered Information frames (I frames). A number of I frames may be outstanding at the same time (Data Link Layer window mechanism). Multiple frame operation is initiated by a multiple frame establishment procedure. Note that this type of operation is used for transfer of signalling information and will be implemented in all endpoints as well as in the PSN. This type of operation provides a better grade of service than that provided by unacknowledged operation and is preferred for data transfer on a bearer channel (because of the error recovery provided) in addition to its use for transfer of signalling information.

The services provided by the acknowledged mode of operation are:

- . acknowledged transfer of higher layer information,
- . identification of Data Link connection endpoints to permit a higher layer or management entity to identify its peer entity,
- . sequence integrity of Data Link Layer frames,
- . detection and recovery of transmission, format and operational errors,

- . notification to the management entity or to the Layer 3 entity (or both) of unrecoverable errors, and
- . flow control.

10.4 Types of frames

All Data Link Layer messages are transmitted in HDLC frames (see ISO 3309).

The following types of frames are used:

- Numbered information frames: information (I) frames are used to perform information transfer between Layer 3 entities.
- Supervisory frames: the supervisory frames (RR, RNR, REJ) are used to perform link supervision control functions (e.g. acknowledge I frames, request retransmission of I frames, or request temporary suspension of transmission).
- Un-numbered information frames: un-numbered information (UI) frames are used in support of some management activities (e.g., TEI allocations). Their use for data transfer is for further study.
- Un-numbered frames: the un-numbered frames (SABME, DM, DISC, UA, FRMR,) are used to provide additional link control functions, such as establishment and dis-establishment.

10.5 Data Link connection identification

A Data Link connection is identified at Layer 2 by a Data Link Connection Identifier (DLCI). The DLCI is meaningful only to the two Layer 2 entities between which the DLCI identifies a link.

The DLCI is associated with a (Layer 3) Connection Endpoint Identifier (CEI) at each end of the link. The CEI is used to identify message units passed between the Data Link Layer and Layer 3.

10.5.1 D-channel use of DLCI

The DLCI, as used on the D-channel, consists of two elements:

- The Service Access Point Identifier (SAPI) is used to identify the higher layer protocol, and thereby service, carried over an instance of the link procedure.
- The Terminal Endpoint Identifier (TEI) is used to identify a specific endpoint within a service access point. The TEI is assigned by means of a separate TEI assignment procedure.

The SAPI is determined on the basis of the service requested. The currently defined SAPIs for use on the D-channel are:

SAPI	Definition
0	Signalling
1	Virtual Circuit (Packet Mode)
16	X.25 (X.31 Scenarios)
63	Management
all others	Undefined or Reserved

Table 11 - Service Access Point Identifiers

TEIs are assigned through a TEI Assignment Procedure described in ECMA-105. The TEI has meaning with reference to SAPIs 0, 16, and 63. TEI addresses associated with SAPI 1 may be negotiated via the signalling channel (ECMA-106+).

10.5.2 Use of the DLCI on channels other than the D-channel

On channels other than the D-channel, the LAPD identifier applicable on that channel consists of two parts:

- SAPI, which is coded according to the service to be provided on the given channel similar to its use on the D-channel; and
- A flexibly assigned part (assignment to a given instance of communication is negotiated via signalling procedures on the D-channel. This part of the address is similar to the TEI on a D-channel. This field can be extended when needed by means of the existing LAPD extension mechanism.

The DLCI on non D-channels has local significance only for frame relaying and frame switching. It is used for "book-keeping" purposes only on an access line or on an inter-PSN trunk. For frame relaying and frame switching the LAPD address must be mapped from one value to the same or different value across a LAPD relaying or switching point.

A proposed encoding of the two LAPD address fields is shown in Table 12.

SAPI Values	
SAPI	Definition
0	Reserved for Signalling Virtual Circuit (CO-NS with Out of Band Control)
1	
16	X.25 (X.25 carried on LAPD)
62	Virtual Circuit (CL-NS)
63	Reserved for Management
all others	Undefined or reserved
TEI Values on non D-channels	
TEI	Definition
0	Reserved for Signalling
1-126	Negotiated via Out-of-Band Control Channel
127	Reserved for Management

Note the following:

- i) The SAPI values 0, 1, 16, and 63 are as per CCITT and ECMA encodings for D-channel usage.
- ii) The SAPI encoding of 62 for CL-NS is an example of a possible encoding.
- iii) The TEI field could be extended by one octet maximum only if 126 TEI values are not sufficient for a given SAPI on a given interface.
- iv) The assignment of more than one SAPI value to a given service is outside the scope of this technical report. This option could be considered during the standardization of ECMA-105+.

Table 12 - DLCI Values on non D-channels

NOTE 13

There are applications where there is a need to transport properly identified signalling and management information via B- or H-channels between PSNs. Preservation of the DLCI structure allows the transport of signalling and management information over non-D bearer channels. See 10.5.2.

11. NETWORK LAYER PROTOCOLS FOR SUPPORT OF CONNECTION-MODE NETWORK SERVICE (CO-NS)

This Clause defines details of a Layer 3 data transfer protocol which can be carried on top of a frame mode bearer service to provide CO-NS. It is recognized that other possibilities exist, however, the protocol defined, is considered to be the most appropriate candidate. Details of signalling protocol functions are also given.

11.1 Provision of Connection-Mode Network Service (CO-NS)

It is illustrated at a high level how the requirements of the CO-NS are met by the Packet Mode protocol, e.g. where data transfer functions are provided on a bearer channel and virtual call control functions are handled on the associated D-channel. Coordination and synchronization of functions between the Bearer and Signalling channels are also discussed.

When the X.25 PLP is used to support CO-NS then it requires that the underlying Data Link Layer service provides the following:

- a negligible residual-bit-error rate,
- a negligible out-of-sequence rate, and
- a negligible frame-loss and duplication rate.

This service is provided by the multiple-frame mode of operation of LAPD.

11.1.1 Protocol Entities involved in providing Network Services

Figure 32 illustrates the entities involved in providing the OSI Network Service within an PSN endpoint. As shown, the Network Service is provided by the combination of services provided by the protocol suites on both the D-channel and the Bearer channel.

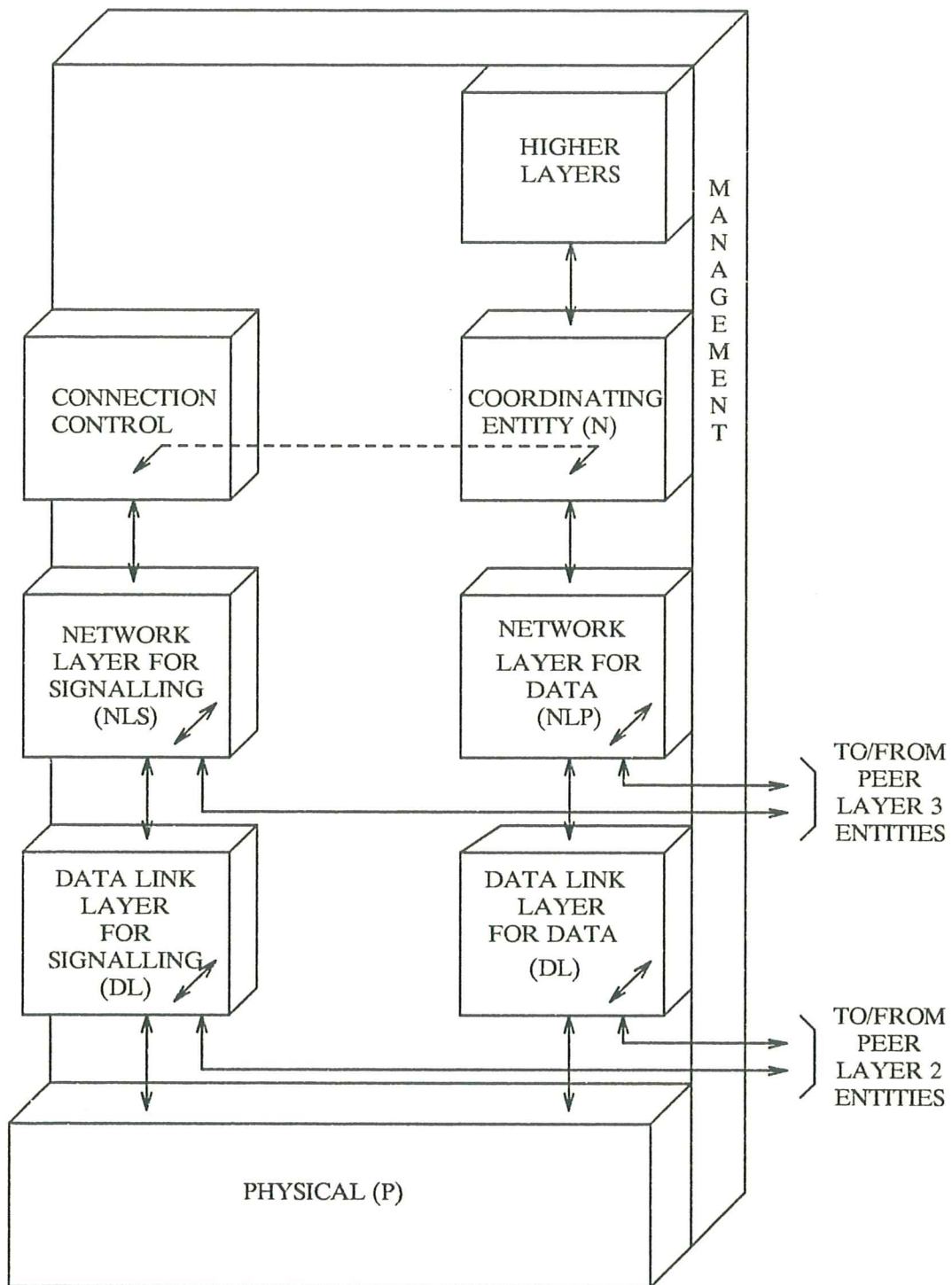


Figure 32 - Entities involved in Network Service Provision

Figure 32 shows all the entities involved in providing the network service. As shown in the figure, there are two different sets of protocols, one providing a signalling service and the other providing a data transfer service. All protocol entities have an interface into the management layer. There is one physical layer entity which supports both sets of protocols. At the link layer, there are two identical protocol entities, one providing service for signalling, the other for data transfer.

Management functions are provided to coordinate and synchronize the activities of the signalling network layer and the data transport network layer. There are two different network layer protocols, one providing signalling functions, the other providing data transfer functions. The interface to the transport layer is via the coordinating entity.

11.1.2 Primitives between Network and Transport Layer Entities

Tables 13, 14, and 15 summarize how the packet mode protocol meets the requirements of the OSI Network Service by supplying each of the primitive actions.

Table 13 summarizes primitives used at the layer 4 / 3 boundary for the Network Connection (NC) establishment phase. As shown, OSI Network Service parameters are paired with ECMA-106+ messages and elements. NSDUs are conveyed end-to-end over the Network Connection via ECMA-106 User-User elements. The OSI Network Service permits up to 128 bytes of NS User Data to be conveyed as part of the N-CONNECT primitive parameters. The global Quality of Service parameter set is the set of the various QoS parameters required for the entire connection from end system to end system. The PSN QoS parameter set is the set of QOS parameters for the portion of the connection that involves the PSN.

NSAPs must be mapped to PSN addresses. Appendix C of ISO 8878 gives two methods for accomplishing this mapping: directory or algorithmic procedures. Out of this process are obtained the PSN (E.164 conforming) addresses. In addition to performing the mapping function, the NSAPs must be transferred end-to-end.

PRIMITIVE	OSI CO-NS PARAMETERS	ECMA-106+ MESSAGES AND PARAMETERS
N-CONNECT request	Called NSAP Address Calling NSAP Address Receipt Confirmation Selection Expedited Data Selection Global Quality of Service Parameter Set NS User-Data	SETUP Destination PSN Address Origination PSN Address D-bit Capability Selection (Note 16) Expedited Service Request (Note 15) PSN QOS parameter set User-to-User (Note 14) Intervention Level Selection Called NSAP Address Calling NSAP Address Global QOS param. set
N-CONNECT indication	Called NSAP Address Calling NSAP Address Receipt Confirmation Selection Expedited Data Selection Global Quality of Service Parameter Set NS User-Data	SETUP Destination PSN Address Origination PSN Address D-bit Capability Selection (Note 16) Expedited Service Request (Note 15) PSN QOS parameter set Throughput and Transit Delay User-to-User (Note 14) Intervention Level Selection Called NSAP Address Calling NSAP Address Global QOS param. set
N-CONNECT response	Responding NSAP Address Receipt Confirmation Selection Expedited Data Selection Global Throughput and Transit Delay NS User-Data	CONNECT Connected PSN Address D-bit Capability Selection (Note 16) Expedited Service Request (Note 15) Throughput and Transit Delay User-to-User (Note 14) Intervention Level Selection Responding NSAP Address Global QOS param. set
N-CONNECT confirm	Responding NSAP Address Receipt Confirmation Selection Expedited Data Selection Global Throughput and Transit Delay NS User-Data	CONNECT Connected PSN Address D-bit Capability Selection (Note 16) Expedited Service Request (Note 15) Throughput and Transit Delay User-to-User (Note 14) Intervention Level Selection Responding NSAP Address Global QOS param. set

NOTE 14 - User-to-User is less than or equal to 128 bytes.

NOTE 15 - Selection of the use of INTERRUPT packets for data transfer.

NOTE 16 - Selection of the use of the D-bit in DATA packets for data transfer.

Table 13 - Network Connection Establishment Primitives

Table 14 summarizes release primitives used at the layer 4/ 3 boundary for the Network Connection (NC) release phase.

PRIMITIVE	OSI CO-NS PARAMETERS	ECMA-106+ MESSAGES AND PARAMETERS
N-DISCONNECT Request	Reason Responding Address NS User-Data	DISCONNECT Cause (Note 17) User-to-User
N-DISCONNECT Indication	Originator Reason Responding Address NS User-Data	DISCONNECT Cause Cause (Note 17) User-to-User

Table 14 - Network Connection Release Primitives

NOTE 17

The equivalent to a responding address is not presently provided for in ECMA-106 for the DISCONNECT Message.

Table 15 summarizes primitives used at the layer 4 / 3 boundary for Network Connection (NC) data transfer phase. During normal data transfer, the D bit may be set to ZERO if no confirmation is requested or to ONE if a receipt confirmation is requested. If no receipt confirmation is requested, the N-DATA-ACKNOWLEDGE primitives are not used. If a receipt confirmation was requested, the actual acknowledgement is conveyed via window rotation (advance in P(R) in DATA, RR or RNR packets).

PRIMITIVE	OSI CO-NS PARAMETERS	X.25 PLP PACKETS AND PARAMETERS
N-DATA request	Confirmation Request NS User-Data	DATA D-bit User Data
N-DATA indication	Confirmation Request NS User-Data	DATA D-bit User Data
N-DATA ACKNOWLEDGE request	<none>	DATA, RR, RNR P(R)
N-DATA ACKNOWLEDGE indication	<none>	DATA, RR, RNR P(R)
N-EXPEDITED DATA request	NS User-Data	INTERRUPT Interrupt User Data (<i>Note 18</i>)
N-EXPEDITED DATA indication	NS User-Data	INTERRUPT Interrupt User Data (<i>Note 18</i>)
N-RESET request	Reason	RESET REQUEST Diagnostic code
N-RESET indication	Originator Reason	RESET INDICATION Resetting Cause Diagnostic cause
N-RESET response	<none>	RESET CONFIRMATION
N-RESET confirm	<none>	RESET CONFIRMATION

Table 15 - Network Connection Data Transfer Primitives

NOTE 18

User data is less than or equal to 32 bytes.

The applicability of Expedited Data Transfer and Receipt Confirmation is dependent on agreement as to its use during the Network Connection Establishment phase.

The Data Transfer Phase primitives can be grouped into three categories:

- N-DATA and N-DATA-ACKNOWLEDGE primitives used for Windowed, Sequenced User Data Transfers;
- N-EXPEDITED-DATA primitives used for expedited User Data Transfers; and
- N-RESET primitives used for reset of the virtual circuit.

The queuing and flow control requirements of OSI CO-NS are also met by the packet mode protocol. In addition, the requirements for a reassembly capability are met by the M bit in DATA packets.

11.1.3 Sequences of Primitives at the Network Connection Endpoint

Figure 33 describes the primitive naming conventions, and the primitive flow between protocol entities providing the packet mode CO-NS. The figure shows the naming conventions for the primitives, the generic term "activity" refers to the action as in, for example, N-CONNECT. The generic term "type" refers to one of the four types of action: Request, Indication, Response, or

Confirm. The first part of the primitive name indicates the flow of the primitive. For example MNLS primitives are exchanged between the Management (M) entity and the Network Layer Signalling (NLS) entity. The sequence of primitives can be directly related to the Network Service state transition diagram described in Appendix B.

11.1.3.1 Outgoing Call Establishment

Table 16 shows the sequence of primitives required to establish an outgoing call. For reasons of clarity, the Table shows only those primitive exchanges that are an integral part of the coordination function. Primitive exchanges required for ordinary data transfer between layers are not shown. Peer-to-peer communications are shown as breakpoints spanning the Tables (e.g. the exchange of ECMA-106 SETUP and CONNECT messages). The Tables also assume that the signalling path has been initialized, and is ready to provide service. Appendix H shows examples of ECMA-106 signalling sequences.

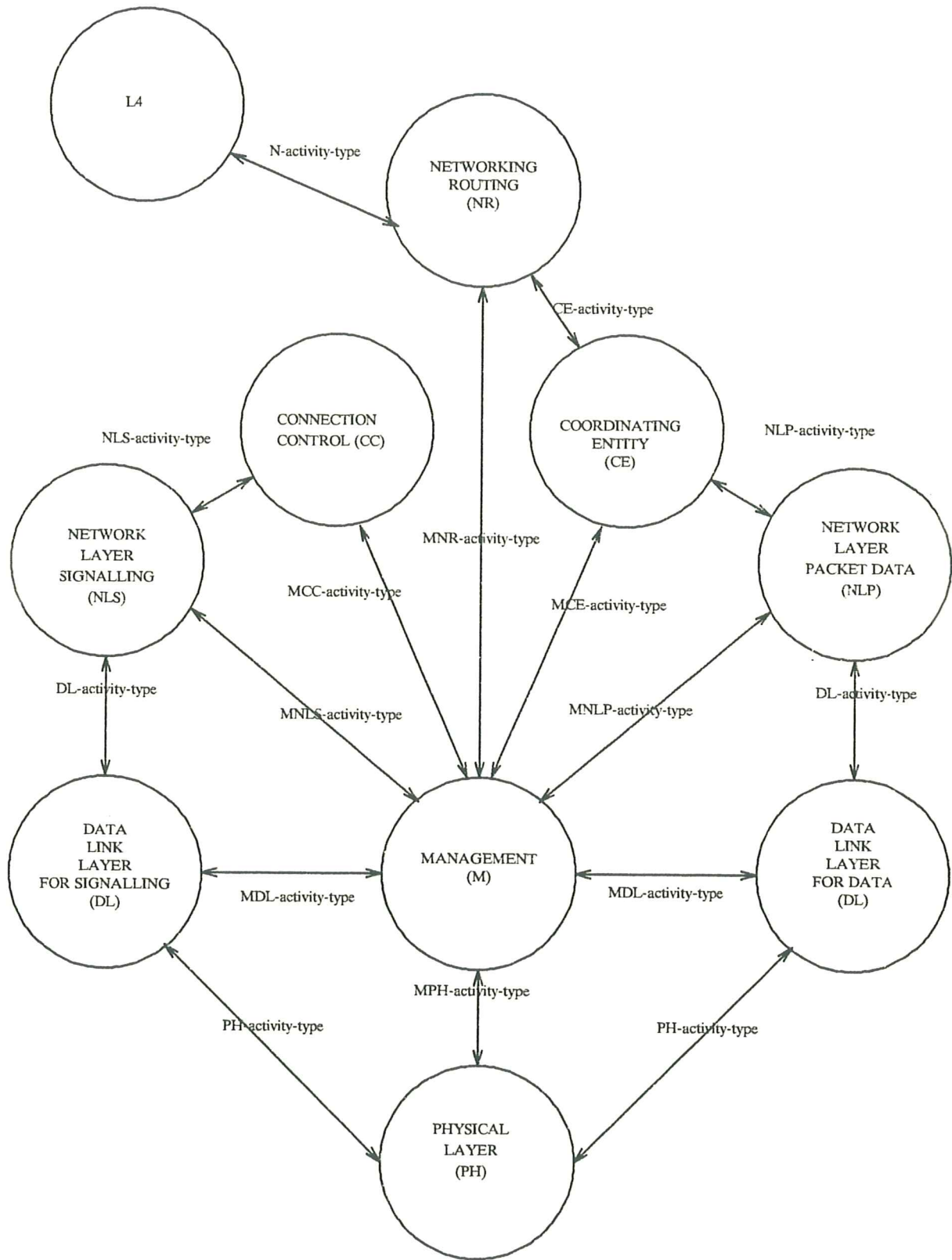


Figure 33 - Naming Conventions for Primitives at an NC Endpoint

Table 16 - Outgoing Call Establishment Primitive Sequences

Step	Primitive	Direction			Parameters
1	N-CONNECT-request	Layer 4 to Networking routing			Source NSAP, Destination NSAP, Receipt Confirmation Selection, Expedited Data Selection, Global Quality of Service Parameter set, NS User-Data
2	MNR-CONSULT-request/indication	Networking routing Management Entity	to		Source NSAP, Destination NSAP, Receipt Confirmation Selection, Global Quality of Service Parameter set, NS User-Data, Calling Address, Called Address, PSN Quality of Service parameter set
3	CE-CONNECT-request	Networking routing Coordinating Entity	to		Source NSAP, Destination NSAP, Receipt Confirmation Selection, Global Quality of Service Parameter set, NS User-Data, Calling Address, Called Address, PSN Quality of Service parameter set
4	MCE-CONNECT-request	Coordinating Entity Management Entity	to		Source NSAP, Destination NSAP, Calling Address, Called Address, NS User-Data, W, Modulus, Expedited Data Selection, Receipt Confirmation Selection, Global and PSN Quality Of Service Parameter Set, Intervention level selection
5	MCC-CONNECT-request	Management Entity Connection Control	to		Source NSAP, Destination NSAP, Calling Address, Called Address, Intervention level selection, Global Quality of Service NS User-Data, W, Modulus, LCI, Packet Size, Throughput class, Transit delay, DLCI, k, N201, T200, C/R bit, Physical Channel
6	NLS-CONNECT-request	Connection Control to Signaling Entity			Same as previous step
Send ECMA-106 SETUP Message Receive ECMA-106 CONNECT Message Send ECMA-106 CONNECT ACKnowledge					
7	NLS-CONNECT-confirmation	Signaling Entity to Connection Control			Responding NSAP, Connected Address Negotiated parameters: Intervention level selection, NS User-Data, LCI, Packet Size, W, Modulus, Expedited Data Selection, Receipt Confirmation Selection, Throughput class, Transit delay, DLCI,k,N201,T200, C/R bit, Physical Channel
8	MCC-CONNECT-confirmation	Connection Control Management Entity			Same as previous step

Step	Primitive	Direction	Parameters
9	MNLP-ASSIGN-request	Management Entity to Network Data Entity	Layer 3 parameters: LCI, Packet Size, W, Modulus, Expedited Data Selection, Receipt Confirmation Selection, Throughput class, Transit delay
10	MDL-ASSIGN-request	Management Entity to Data Link Entity	Layer 2 parameters: DLCI,k,N201,T200, C/R bit
11	MPH-ASSIGN-request	Management Entity to Physical Channel	
12	MCE-CONNECT-confirmation	Management Entity to Coordinating Entity	Connected Address, receipt confirmation selection, expedited data selection, NS user-data, responding NSAP, Global Quality of Service Parameter Set (for Layer 4)
13	NLP-CONNECT-request	Coordinating Entity to Network Data Entity	
14	DL-ESTABLISH-request	Network Data Entity to Link Entity	
15	DL-ESTABLISH-confirmation	Data Link Entity to Network Data Entity	
16	DL-DATA-request	Network Data Entity to Data Link Entity	Contains X.25 RESET REQUEST Message
RESET REQUEST X.25 Message Sent RESET CONFIRMATION X.25 Message Received			
17	DL-DATA-indication	Data Link Entity to Network Data Entity	Contains X.25 RESET CONFIRMATION Message
18	NLP-CONNECT-confirmation	Network Data Entity to Coordinating Entity	
19	CE-CONNECT-confirmation	Coordinating Entity to Networking Routing	Responding NSAP, Connected Address, Receipt Confirmation Selection, Expedited Data Selection, Global Quality of Service Parameter set, NS User-Data
20	N-CONNECT-confirmation	Networking routing to Layer 4	Responding NSAP Receipt Confirmation Selection, Expedited Data Selection, Global Quality of Service Parameter set, NS User-Data

Table 16 - Outgoing Call Establishment Primitive Sequences (continued)

11.1.3.2 Incoming Call Establishment

Table 17 shows the sequence of primitives required to establish an incoming call.

Table 17 - Incoming Call Establishment Primitive Sequences

Step	Primitive	Direction			Parameters
receive ECMA-106+ SETUP					
1	NLS-CONNECT-indication	Signalling Entity to Connection Control			Source NSAP, Destination NSAP, Calling Address, Called Address NS User-Data, Global QOS parameter set, Proposed Parameters: LCI, Packet Size, W, Modulus, Expedited Data Selection, Receipt Confirmation Selection, Throughput class, Transit delay, DLCI,k,N201,T200, C/R bit, Physical Channel
2	MCC-CONNECT-indication	Connection Management Entity	Control	to	Same as previous step
3	MCE-CONNECT-indication	Management Coordinating Entity	Entity	to	Same as previous step
4	CE-CONNECT-indication	Coordinating Networking Routing	Entity	to	Source NSAP, Destination NSAP, PSN Calling Address, PSN Called Address Expedited Data Selection, Receipt Confirmation Selection, Global Quality of Service Parameter Set, NS User-Data
5	N-CONNECT-indication	Networking Routing to Layer 4			Source NSAP, Destination NSAP, PSN Calling Address, PSN Called Address Expedited Data Selection, Receipt Confirmation Selection, Global Quality of Service Parameter Set, NS User-Data
6	N-CONNECT-response	Layer 4 to Networking Routing			Expedited Data Selection, NS User-DATA, Receipt Confirmation Selection, Responding NSAP, Global QOS parameter set
7	CE-CONNECT-response	Networking Coordinating Entity	Routing	to	Expedited Data Selection, NS User-DATA, Receipt Confirmation Selection, Responding NSAP, Global QOS parameter set plus responding address
Flow Control On					
8	MCE-CONNECT-response	Coordinating Management Entity	Entity	to	Responding address, Responding NSAP NS User-Data, Negotiated Parameters LCI, Packet Size, W, Modulus, Expedited Data Selection, Receipt Confirmation Selection, Throughput class, Transit delay, DLCI,k,N201,T200, C/R bit,
9	MCC-CONNECT-response	Management Connection Control	Entity	to	Same as previous step
10	NLS-CONNECT-response	Connection Control to Signalling Entity			Same as previous step

Step	Primitive	Direction	Parameters
send ECMA-106+ CONNECT message			
receive ECMA-106+ CONNECT ACKnowledge message			
11	NLS-AFFIRM-indication	Signalling Entity to Connection Control	
12	MCC-AFFIRM-indication	Connection Control to Management Entity	
13	MNLP-ASSIGN-request	Management Entity to Network Data Entity	Network Layer Negotiated Parameters: LCI, Packet Size, W, Modulus Delivery Confirmation, Throughput class, Transit delay,
14	MDL-ASSIGN-request	Management Entity to Data Link Entity	Negotiated Link Layer Parameters: DLCI, k, N201, T200, C/R
15	MPH-ASSIGN-request	Management Entity to Physical Layer	Physical Channel
16	MCE-AFFIRM-indication	Management Entity to Coordinating Entity	
SABME Frame Received UA Frame Sent			
17	DL-ESTABLISH-indication	Data Link Entity to Network Data Entity	
18	DL-DATA-indication	Data Link Entity to Network Data Entity	Contains an X.25 RESET INDICATION Message
RESET INDICATION X.25 Message Received RESET CONFIRMATION X.25 Message Sent			
19	DL-DATA-request	Network Data Entity to Data Link Entity	Contains an X.25 RESET CONFIRMATION Message
20	NLP-CONNECT-indication	Network Data Entity to Coordinating Entity	
Flow Control Off			

Table 17 - Incoming Call Establishment Primitive Sequences (continued)

11.1.3.3 Data Transfer Phase

In the Data Transfer Phase, the coordinating entity merely passes N- primitives to the NLP entity. Table 18 shows the correspondence between these primitives.

Layer 4/ Layer 3	Coordinating Entity/ Network Layer Packet Data
N-DATA-request	NLP-DATA-request
N-DATA-indication	NLP-DATA-indication
N-DATA-ACKNOWLEDGE request	NLP-DATA-ACKNOWLEDGE request
N-DATA-ACKNOWLEDGE indication	NLP-DATA-ACKNOWLEDGE indication
N-EXPEDITED-DATA request	NLP-EXPEDITED-DATA request
N-EXPEDITED-DATA indication	NLP-EXPEDITED-DATA indication
N-RESET request	NLP-RESET request
N-RESET indication	NLP-RESET indication
N-RESET response	NLP-RESET response
N-RESET confirmation	NLP-RESET confirmation

Table 18 - Data Transfer Primitive Correspondence

Synchronization of the actions on the signalling and bearer channels is the responsibility of the coordinating entity. Orderly clearing is the responsibility of the Session Layer in OSI applications, or other higher layer entities (such as X.29 in the PAD case) for non-OSI applications. The signalling entity may be requested to initiate a virtual channel release sequence via a DISCONNECT message received from its peer. The Network Layer assumes no responsibility for data integrity, it does, however, provide detection of error conditions.

11.1.3.4 Call Clearing

Table 19 shows the sequence of primitives required to clear a call. Call clearing can be initiated at either end, both cases are described.

Table 19 - Call Clearing Primitive Sequences

CASE 1 - Near end originated disconnect					
Step	Primitive	Direction			Parameters
1	N-DISCONNECT-request	Layer 4 to Networking Routing			Cause, User-Data Responding Address
2	CE-DISCONNECT-request	Networking Coordinating Entity	Routing	to	Cause
3	MCE-DISCONNECT-request	Coordinating Management Entity	Entity	to	Cause
4	MCC-DISCONNECT-request	Management Connection Control	Entity	to	Cause
5	NLS-DISCONNECT-request	Connection Control to Signalling Entity			Cause
		Send ECMA-106+ DISCONNECT Receive ECMA-106+ RELEASE Send ECMA-106+ RELEASE COMPLETE			
6	NLS-DISCONNECT-confirmation	Signalling Entity to Connection Control			None
7	MCC-DISCONNECT-confirmation	Connection Management	Control Entity	to	None
8	MNLP-REMOVE-request	Management Entity to Network Data Entity			None
9	MDL-REMOVE-request	Management Entity to Data Link Entity			None
10	MPH-REMOVE-request	Management Entity to Physical Layer			None
11	MCE-DISCONNECT-confirmation	Management Coordinating	Entity	to	None
12	CE-DISCONNECT-confirmation	Coordinating Networking	Entity Routing	to	None
13	N-DISCONNECT-confirmation *	Networking Routing to Layer 4			None

*OSI does not recognize the need for this primitive as Disconnect is not a confirmed service.

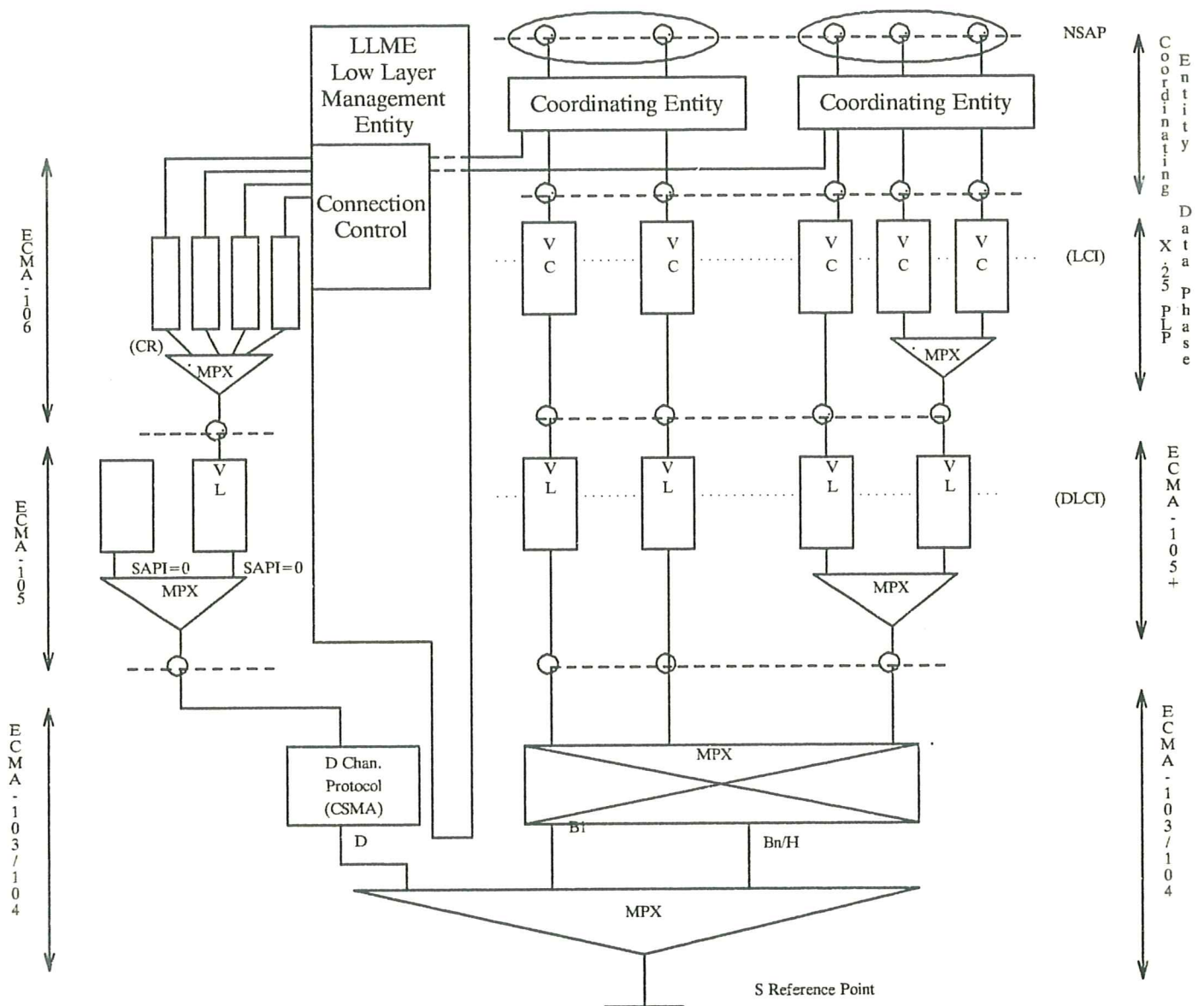
CASE 2 - Far end originated disconnect				
Step	Primitive	Direction		Parameters
		receive ECMA-106+ DISCONNECT		
		send ECMA-106+ RELEASE		
		receive ECMA-106+ RELEASE COMPLETE		
1	NLS-DISCONNECT-indication	Signalling Entity to Connection Control		Cause, User-Data
2	MCC-DISCONNECT-indication	Connection Management Entity to Control Entity		Cause, User-Data
3	MNLP-REMOVE-request	Management Entity to Network Data Entity		None
4	MDL-REMOVE-request	Management Entity to Data Link Entity		None
5	MPH-REMOVE-request	Management Entity to Physical Layer		None
6	MCE-DISCONNECT-indication	Management Entity to Coordinating Entity		Cause, Reason, Origin, User-Data
7	CE-DISCONNECT-indication	Coordinating Entity to Networking Routing		Cause, Reason, Origin, User-Data
8	N-DISCONNECT-indication	Networking Routing to Layer 4		Cause, Reason, Origin, User-Data

Table 19 - Call Clearing Primitive Sequences (continued)

11.2 Layer 3 for Signalling

11.2.1 Packet Mode Call Control Concepts

Figure 34 illustrates the addressing concepts applicable to the packet mode for the CO-NS case in an end system. As shown in the Figure, there are many addressing concepts in use at each layer of the protocol. The network address does not completely distinguish an instance of communication. A given instance of communication between a pair of NSAPs is associated with a layer three address (Logical Channel Number), a layer two address (CEI as it is known to Layer 3, DLCI as it is known to Layer 2), a physical layer address (channel number), and a means of distinguishing the end system. In order to perform the switching function, the PSN must establish similar associations and maintain them for the call duration. All connection management elements for a given call are associated in an end system by means of the ECMA-106 call reference value.



VL = Virtual Link
VC = Virtual Channel
MPX = Multiplexer

CR = Call Reference
LCI = Logical Channel identifier
CEI = Connection Endpoint Identifier

NOTE 18

Multiple End Systems may be provided on a point to multiple point passive bus configuration.

NOTE 19

LLC SAP, LL SAP and CBO SAP are modelling concepts discussed in ECMA TR/44.

Figure 34 - Packet Mode Connection Management Concepts

11.2.2 Signalling Considerations

The Layer 3 protocol used on the signalling link is ECMA-106. Elements and procedures need to

be added to the ECMA-106 protocol in order to provide for new Packet Mode Services. Note that the existing structure of ECMA-106 should readily accommodate the needed enhancements. Additional procedures are needed for:

- physical channel, logical link and virtual channel negotiation at originating and terminating end points,
- notification and possible negotiation of packet mode parameters such as quality of service,
- clearing of logical and physical channels, and
- negotiation of bearer capability and lower layer compatibility.

No new ECMA-106 messages are anticipated, however, several new elements and/or extensions to fields will be required.

The main function of the Layer 3 signalling is the control of circuit (e.g. B-channel) and virtual (e.g. D- or B-channel packet) circuits. This function is provided by the exchange of messages across the S interface.

Layer 3 procedures applying to the S interface use the services provided by the Data Link Layer. The Data Link Layer operations are described earlier in this document.

11.2.3 Considerations for providing X.25-like Network Facilities in the PSN

To meet requirements that X.25-like facilities be accessible at the DPE to PSN internally, several areas of X.25 functionality which affect signalling need to be addressed (See Appendix F). These are:

- indication of restricted response when using the Fast Select Facility,
- provision of a minimum throughput class negotiation capability between two terminals,
- indication of transit delay and provision of an end-to-end transit delay negotiation capability,
- A receipt confirmation negotiation capability.
- provision of an expedited data negotiation capability,
- provision of necessary cause and diagnostic codes,
- provision of closed user group capabilities, and
- provision of call redirection capabilities.

Study is needed to determine how to accommodate these requirements in ECMA-106. However, the PSN is not assumed to provide facilities other than those required to support CO-NS.

11.2.4 Invocation of X.25-like by the User Facilities

The DPE is not assumed to support any particular facility other than those required for the OSI CO-NS. If additional facilities are supported there are two procedures for their control:

- control of call related facilities, i.e. in connection with a call control procedure, and
- registration/cancellation of facilities, independent of call control procedures.

11.3 Extensions to ECMA-106 for Frame Mode Data Call Control

11.3.1 Frame Mode Call Initiation

The following statements are given as examples and shall be further clarified during the standardization of ECMA-106+. The basic call establishment procedures of ECMA-106 should be followed. Additions to the existing procedures are required to include the following capabilities:

- i) Identify call as frame mode within the SETUP message. The frame mode indication is required for three cases:
 - Network supports pure frame switching bearer service,
 - Network supports pure frame relay bearer service, or
 - Network supports a mixture of frame relay and frame switching bearer service.

The frame mode indications can be achieved through appropriate use of existing Bearer Capability and Low Layer Compatibility information elements.
- ii) The PPSN must recognize that it should process call initiation requests for packet mode calls on an access that already has active packet mode calls.
- iii) The PPSN must allow additional packet mode call requests to be specified by the end systems as being included on the same channel as other existing packet mode calls.
- iv) Use of the call reference should be expanded to identify a particular virtual call over a bearer channel.
- v) A logical link address information element should be established. The relevant information element should be incorporated in the call establishment message and in their response messages used in other applications. Negotiation procedures similar to those for B-channel negotiation should be adopted. The purpose for allowing negotiation of the logical link (DLCI) address is to enable networks to use patterns of addresses such as in assigning certain logical links to certain destinations for certain uses. The logical address is not a scarce resource, using an alternative logical address places no restrictions on the DPE.
- vi) New information elements and modifications to existing elements to identify Layer 2 data transfer parameters should be investigated. Examples of the information which will be carried in these elements include quality of service, throughput class, frame size, timer values, and window sizes. For initial implementation, these information elements should be supported via appropriate mechanisms to avoid potential incompatibilities with future CCITT definitions. When these information elements are formally assigned by CCITT, a migration to the CCITT defined information elements should be accommodated.
- vii) Procedures for negotiation of the data transfer parameters should be established. The general framework for negotiation is described in 7.1.3.
- viii) Data transfer necessarily depends on D-channel signalling to establish logical connections and negotiate the various data transmission parameters. However, once the logical connection is established, the data transport channels must be initialized. Initialization procedures should be based on the exchange of SABME/UA frames at Layer 2 and should be appropriately synchronized with ECMA-106 CONNECT and CONNECT ACKnowledge messages.

11.3.2 Additional Parameter Negotiation/Indication

When X.25 PLP data phase is used as a convergence protocol to support the CO-NS in the End systems, additional parameters need to be negotiated between the End-Systems. Parameters could include, for example, packet size and window size for Layer 3.

When X.25 PLP data phase is being used to support an X.25-like service in the End Systems, additional parameters such as expedited data selection, and delivery confirmation selection need to be negotiated/indicated.

11.3.3 Call Clearing

The message exchange for frame mode call clearing should be the same as existing circuit mode

call clearing procedures. However, it must be recognized that multiple logical connections may exist over the same physical channel. Therefore, frame mode call clearing should result in the release of the call reference but not in the disconnection of the physical channel. The physical channel should be cleared only when the last active logical link associated with that physical channel is cleared.

11.4 Level 3 for Data Transfer

The Layer 3 used for data transfer is based on ISO 8208 rather than CCITT Rec. X.25. The rationale for basing the Layer 3 on ISO 8208 is that the ISO document describes the protocol (X.25 PLP) from the DTE prospective and is symmetric (i.e. DTE to DTE connections are accommodated).

The primary function of the Layer 3 data transfer protocol is to carry user data reliably between two endpoints. This is done by exchanging packets across the network. Call establishment and release is done using the signalling channel protocols described in 9.3.

11.4.1 Packets Used for Data Transfer

Of the several packet types available in the full ISO 8208 X.25 PLP protocol, only those of the data transfer phase are used. Figure 35 shows the selection of packets.

X.25 PLP PACKETS	
Call Request Incoming Call Call Accepted Call Connected Clear Request Clear Indication Clear Confirmation	X.25 PLP (DATA TRANSFER) PACKETS
Data Interrupt Interrupt Confirmation	
Receive Ready Receive Not Ready Reject Reset Request/Indication Reset Confirmation	
Restart Request/Indication Restart Confirmation	
Diagnostic	
Registration Request Registration Confirmation	

Figure 35 - Packet Types

Each packet used for data transfer is described below:

- DATA - Used to carry sequenced user data with M, Q, and D bits. May also serve to acknowledge previously received DATA packets,
- RECEIVE READY (RR) - Used to indicate to the peer packet layer entity that the local entity is not in a busy condition. May also serve to acknowledge previously received DATA packets,

- RECEIVE NOT READY (RNR) - Used to indicate to the peer entity that the local entity is in a busy condition. May also serve to acknowledge previously received DATA packets,
- INTERRUPT - Used for expedited data transfers outside the DATA packet flow,
- INTERRUPT CONFIRMATION - Used to confirm the receipt of the INTERRUPT packet,
- RESET REQUEST/INDICATION - Used to request that the peer entity reset a logical channel, and
- RESET CONFIRMATION - Used to confirm to the peer that a logical channel has been reset.

The procedures for the use of these packets is identical to that described in ISO 8208. Appendix I gives an analysis of the other ISO 8208 packet types and why they are not needed for providing the required capabilities.

11.4.2 Data Transfer Information Flows

Figure 36 illustrates Layer 3 Data Transfer information flows, and how they are carried by the link level. The link level provides a reliable connection using multiple frame acknowledged information exchange of sequenced information frames. The link level protocol must be robust enough to recover from bit errors, frame loss, and duplication of information in all but extreme cases.

In addition, the link level provides the capability to carry several Layer 3 information flows, as shown in Figure 36.

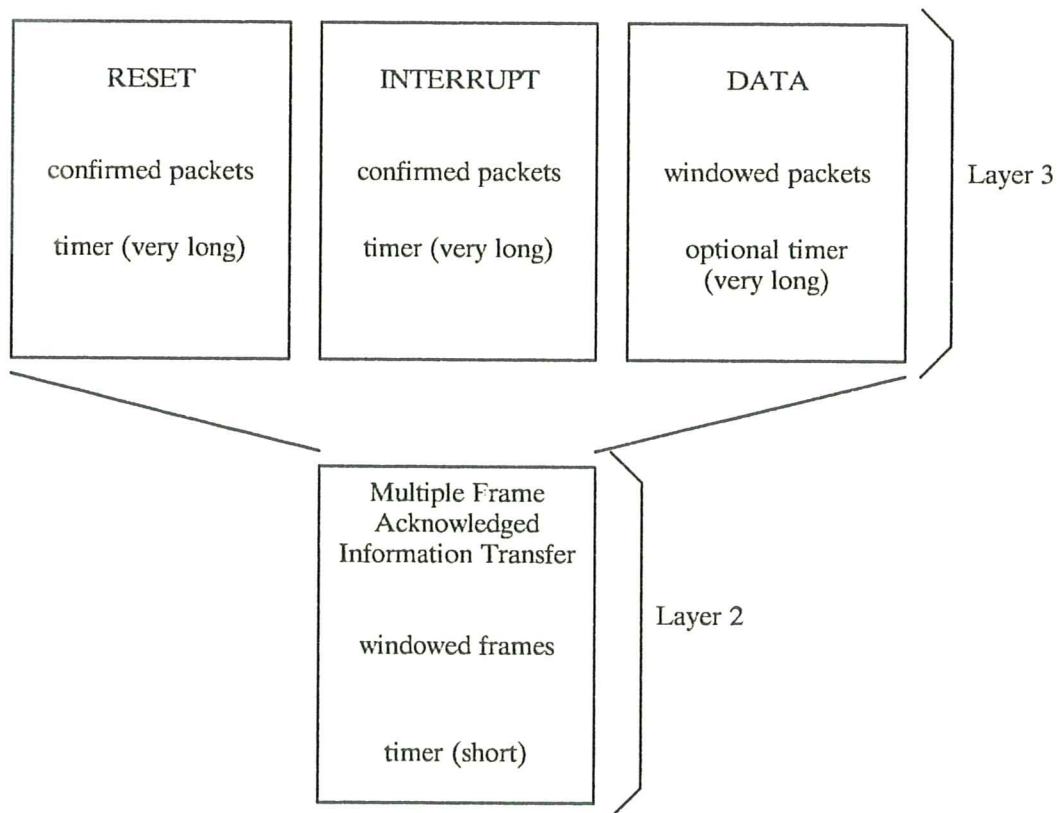


Figure 36 - Data Transfer Information Flows

Three distinct information flows occur at Layer 3:

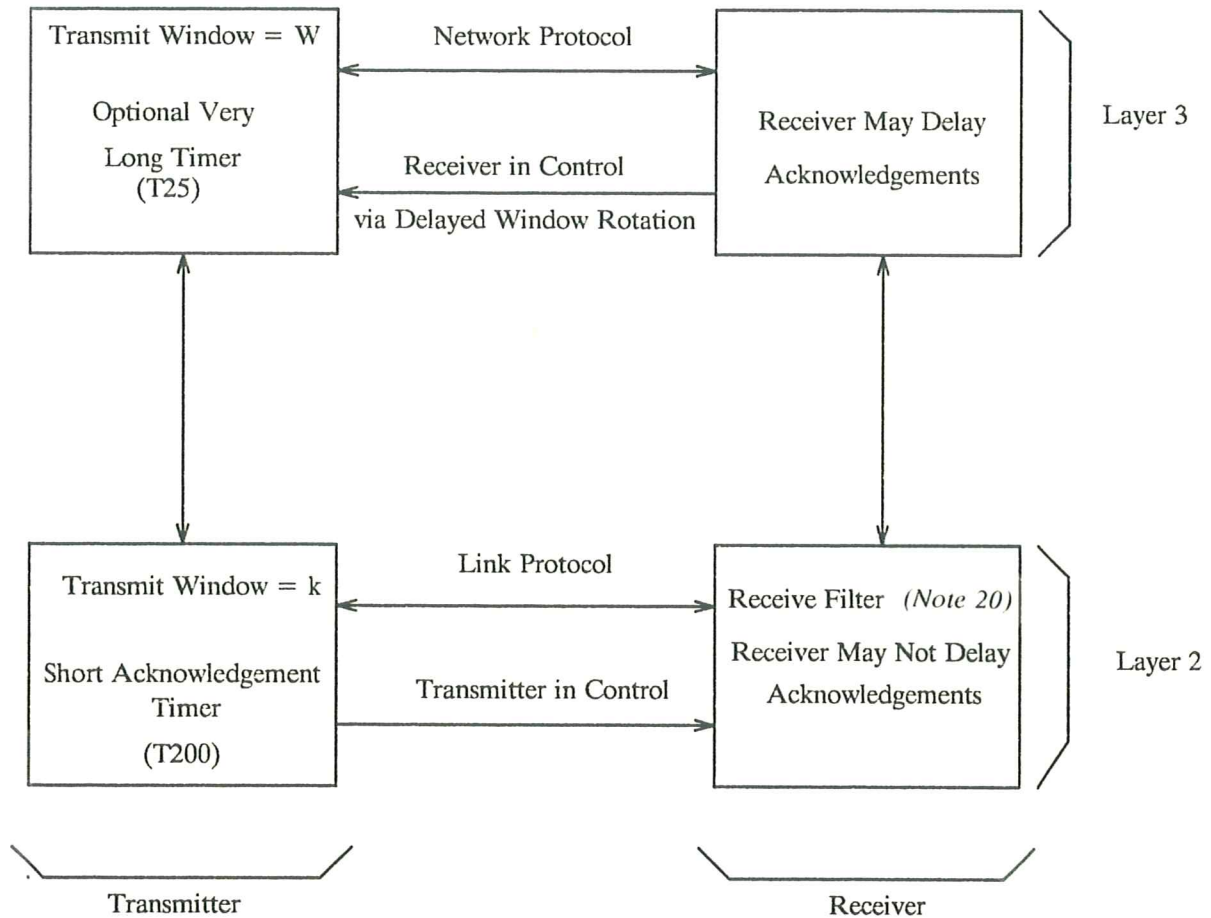
- A confirmed RESET flow is used to reset a logical channel at the beginning of a data transfer or upon detection of a fault condition at Layer 3. During a RESET packet exchange neither INTERRUPT nor DATA flows are valid.
- A confirmed INTERRUPT flow is used for transfer of expedited user data. The INTERRUPT user data flow is separate from the normal DATA flow. Only a single unconfirmed INTERRUPT packet may be outstanding at any given time.
- A windowed (sequenced) DATA flow is used to transfer non- expedited user data. The DATA packet flow provides for implicit flow control via a window rotation mechanism. It also allows explicit flow control using RR and RNR packets. The DATA packet flow also provides segmentation and reassembly capability (M-bit), delivery confirmation service (D-bit), and qualified data transfer (Q-bit).

11.4.2.1 Flow Control and Congestion Control

The store and forward nature of the transfer mechanism puts a general requirement on the protocol to control the amount of information delivered to network nodes and end systems for resource protection (e.g. buffers, processing power). Flow control is the name of this function applied to end systems (end to end pacing). Flow control may be used as a congestion context mechanism when applied to network nodes.

11.4.2.1.1 Flow Control and Congestion Control Mechanisms at Layer 2 and 3 in an X.25-like Environment (Full Protocol Termination)

Figure 37 illustrates the differences between the implicit window rotation flow control mechanisms available at layers 2 and 3. Functions which apply at both the transmitter and receiver are shown. As noted in the figure, Layer 2 uses a short acknowledgement timer, thus requiring the peer data link entity to not delay acknowledgements. Conversely, the Layer 3 transmitter has either no acknowledgement timer, or a long acknowledgement timer. This allows the peer Layer 3 entity to delay acknowledgements until it is ready to receive more data.



NOTE 20

Information frames are delivered to Layer 3 one at a time if correct and in sequence.

Figure 37 - Implicit Flow Control Mechanisms at Layers 2 and 3

Because the Layer 2 acknowledgement timer is short, the transmitter is in control of the data flow unless the receiver gives it the order to stop sending (choke effect). If the peer does not respond quickly, the transmitter retransmits the frame. This may eventually cause the link to be reset. On the other hand, since Layer 3 acknowledgements are not time-critical, the receiver is effectively in control. That is, the receiver may choose to not acknowledge packets already received until such time as additional packets are ready to be received. This mechanism allows intelligent buffer management by the receiver, and could be used, for example, by a terminal adaptor that must interwork the network with a slower speed device.

Another major difference between the flow control mechanisms at Layer 3 and Layer 2 is that Layer 3 flow control only controls the pace of Layer 3 DATA packets, whereas Layer 2 flow control controls the pace of all Layer 3 packet types (i.e. Layer 2 cannot distinguish among Layer 3 packet types per the OSI model).

The optional timer at Layer 3 (T25) may be implemented in order to detect lock-up conditions. If the timer is long enough, it has no substantial effect on the control the receiver has

over the connection, but does allow the transmitter to recognize that an inordinate amount of time has transpired without receipt of window rotation information and thus to deduce that an abnormal situation has arisen.

When Layer 2 and Layer 3 are terminated in network nodes, both flow control and congestion control may be provided with the same mechanism. The RR/RNR mechanism and window rotation mechanism is used directly for congestion control, and the back pressure effects as this is may be propagated through the networks supports flow control.

11.4.2.1.2 Congestion Control When Protocols are not Fully Terminated in the PSN

When the Layer 2 protocol is not fully terminated in the node, there is a need for a new mechanism for congestion control. This is because the node cannot access the Layer 2 protocol mechanisms. The congestion control mechanism can be triggered by the source (or by the network node). Its effect is to reduce the size of the transmit window of the source thus reducing the load on network resources. The amount of data that is injected into a network is influenced by the window size. Normally the window is sized to prevent blocking the source because of the round trip delay effect on acknowledgements. Thus it puts an upper limit on the amount of data injected over the link in the PSN at a given moment in time. See also Appendix C.

11.4.3 System Parameters for Data Transfer

A set of system parameters which are negotiable between DPE and DPE has been identified. In order to allow the data transfer protocol to operate smoothly over connections where parameter negotiation is not available, default value may need to be established. Such defaults shall be defined in the appropriate protocol standards.

The system parameters that need to be established are indicated in Table 20 below.

Parameter
Logical Link Identifier
Window Size k (Note 21)
Information field length (N201) (Note 22)
Acknowledgment Timer (T200)
Throughput Class
Transit Delay

Table 20 - Principle System Parameters

NOTE 21

The default window size selected for the link layer should reflect that it is used to carry a single logical channel in the default case and allowance be made for both DATA packet flows as well as INTERRUPT and/or RESET packet flows. Thus, it is the responsibility of the terminal to ensure that k should be at least one greater than W (the Layer 3 window).

NOTE 22

Buffering considerations in PPSN networks may place a practical limit on the User Data Field length. For LAPD on D-channels, the maximum value of N201 is 260 octets.

11.4.4 End System Parameters

A set of system parameters pertinent to the convergence protocol that are negotiable between the End Systems has also been identified. Guidelines for negotiating these parameters are required.

Also, in order to allow the data transfer protocol to operate smoothly over connections where End System parameter negotiation is not available, default values may need to be established. These defaults might be directly derived from the negotiated frame bearer parameters. Such defaults shall be defined in the appropriate protocol standards.

The End System parameters that need to be established are indicated in Table 21 below.

Parameter
Logical Channel (<i>Note 23</i>)
Sequencing (Modulo value)
Window Size (<i>Note 24</i>)
User Data Field Length (<i>Note 25</i>)

Table 21 - Principle End System Parameters

NOTE 23

Normal operation will employ a single logical channel over a logical link in which case the logical channel default should be logical channel 1.

NOTE 24

X.25 uses a default window size of 2 for DTE to X.25 DCE network access connections. However, since the packet mode protocol provides end-to-end connection capabilities, a larger default window size may be required which can be provided using a non-standard default window size (e.g., $W = 3$).

NOTE 25

Buffering considerations in PPSN networks may place a practical limit on the User Data Field length. For LAPD on D-channels, the maximum value of N201 is 260 octets.

12. SUBNETWORK DEPENDENT CONVERGENCE FUNCTIONS FOR SUPPORT OF CONNECTION-LESS-MODE NETWORK SERVICE

12.1 General

The following clauses describe the way in which the underlying service assumed by the CLNP is obtained from subnetworks which provide the frame mode bearer service.

The convergence function will map the connection-mode service offered by PSNs which use ECMA-106+ in the signalling channel and ECMA-105+ in the bearer channels to the underlying service assumed by ISO 8473.

The CO-mode service offered by frame mode PSNs is manipulated by the SNDCF so that a virtual logical link is made available for the transmission of a SN-userdata following the generation of an SN-UNITDATA request by the CLNP.

The addresses used in the PSN service request and indication primitives correspond to the E.164 PSN addresses conveyed by the D-channel SETUP messages.

The underlying service assumed by ISO 8473 requires that the bearer channels be capable of supporting a service data unit of up to 512 octets. ISO 8473 provides for segmentation/reassembly for larger messages. Note: For LAPD on D-channels, the maximum value of N201 is 260 octets; this means that this constraint must be removed when using LAPD on other than D-channels and that a

PSN claiming to support CLNS should be able to support a non- standard N201 value greater than or equal to 512 octets.

The mechanism and timing for opening a logical link prior to the transmission of SN-USERDATA are partly local matters, and part of the SNDCF. The opening of a virtual circuit may be initiated by causes such as:

- arrival of a Subnetwork Service Data Unit to be transmitted over the PSN at a time when no link is available,
- the local queue of requests waiting for an existing virtual link reaching a threshold size at which an additional virtual link must be established (if possible) to maintain the requested Quality of Service.

When it has been determined that a new virtual link must be made available, the calling SNDCF performs all functions associated with establishing a virtual link. The called SNDCF performs those operations associated with accepting the call, but generates no SN-UNITDATA indication until the call setup is completed, at which time data packets may be exchanged over the bearer channel. In general, the receipt of data packets on the bearer channel causes the SNDCF to generate an SN-UNITDATA indication to the CLNP. RESET packets, if received, have no effect on the operation of the SNDCF.

The mechanisms for determining when a virtual link is to be cleared following the transmission of SN-userdata by the SNDCF are also local matters. Examples of circumstances that would cause the SNDCF to clear a virtual link are:

- expiration of a timeout period following the transmission of one or more PDUs,
- the local queue of requests does not justify keeping the present number of established virtual links to maintain the requested QoS.

When it has been determined that a virtual link must be cleared, the SNDCF performs all functions associated with releasing a virtual link. The SNDCF will retain user data submitted via SN-UNITDATA requests while attempting to establish a new virtual link.

12.2 Timeout Periods

Timeout periods are used to determine when a virtual link is to be cleared (for example when a virtual link has been idle for a long period of time) or when additional virtual links should be opened (in case of excessively long queue of data units waiting for the initial logical channel).

Implementations may choose to clear a virtual link based on the use of timers. When a virtual link is made available for the transmission of a Subnetwork Service Data Unit a timer is initiated with a value representing the maximum period of time the VC remains idle. Each time a data unit is transmitted by the underlying service, the timer is reset to its initial value. If no data are queued and the timer expires, the virtual link is cleared. The selection of timeout values is a local matter.

12.3 Resolution of Virtual Link Collisions

Two SNDCFs may simultaneously attempt to establish virtual links to each other. It is possible to detect such a collision, since for both SNDCFs an indication for the incoming call may be received while still awaiting confirmation of a previously initiated call. The SNDCF definition will therefore include conventions for the resolution of such collisions.

13. PACKET MODE TERMINAL FAMILY

Figure 38 shows the two terminal types and the five terminal connection scenarios described in the ISDN reference model.

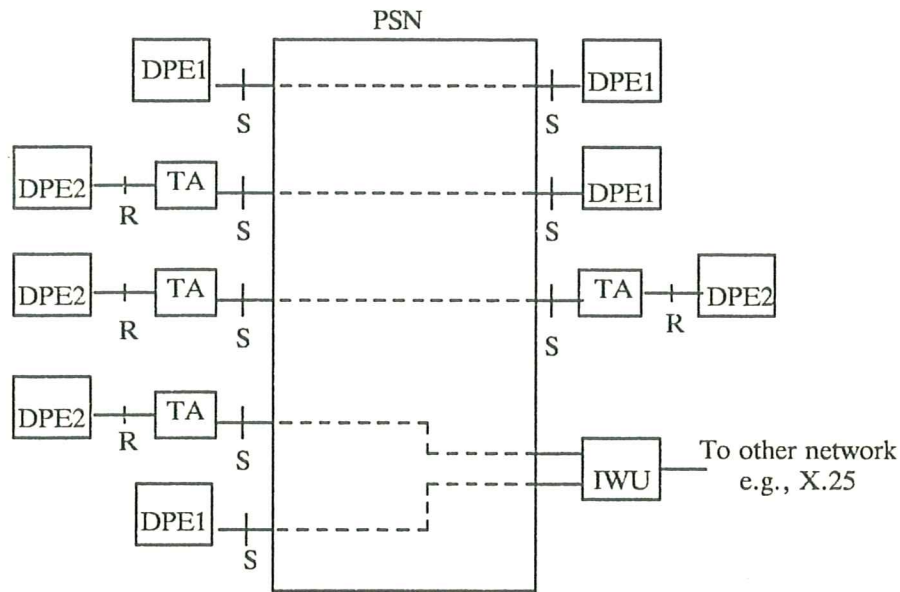


Figure 38 - Terminal Connection Scenarios

The five terminal connection scenarios are:

- DPE-1 to DPE-1 - a connection that may directly support the entire OSI Network Service. Both terminals directly support the ISDN interface and access protocols. If both endpoints support the OSI Network Service, the connection is referred to as an "OSI Environment Network Connection".
- DPE-2 to DPE-1 through a TA - a connection from a terminal which does not directly support the ISDN interface and also may not be able to support the entire OSI Network Service and a terminal that directly supports the ISDN interface and access protocols. If the DPE-2/TA combination is not capable of supporting full OSI Network Service it is referred to as a "Non-OSI Environment Network Connection".
- DPE-2 to DPE-2 through two TAs - a connection between two terminals which cannot directly support the ISDN interface and access. If the DPE-2/TA combinations are not capable of supporting the full OSI Network Service, the connection is referred to as a "Non-OSI Environment Network Connection".
- DPE-2 to other network terminal via a TA and an IWU - a connection that is extended to another network. The IWU performs both terminal adapter functions as well as network functions. Such connections may or may not provide the full OSI Network Service.
- DPE-1 to other network terminal via an IWU - a connection that is extended to another network. The IWU performs only network functions. Such connections may or may not provide the full OSI Network Service.

13.1 Type 1 Terminal Endpoints (DPE-1s)

DPE-1s support the full OSI Network Service and the ISDN access protocols. These terminals may work in either the OSI or Non-OSI connection environment.

13.2 Terminal Adaptors (TAs)

13.2.1 Non-OSI Environment

The Non-OSI environment involves connections for which one or both endpoints provide an R reference point interface as illustrated in Figure 38 and the R reference point interface definition is incapable of passing enough information to provide for the full OSI Network service. In this case, the DPE-2 terminal device cannot directly support the ISDN protocol used at the S reference point. Examples of R interfaces are V.24 and V.35. For these cases, either the DPE-2 is unable to support the full OSI Network Service, or the R interface restricts the DPE-2 access such that the full OSI Network Service cannot be provided. It is noted ECMA-102 rate adaptation does not apply over a frame mode bearer service.

In these cases, the TA may provide a PAD function and map user data at the R reference point to the signalling and bearer channel functions at the S reference point. The PAD connection is an important one which will coexist with the OSI connection environment.

In examining Figure 38, two scenarios for the non-OSI environment can be seen. In one case, terminal adaptors supporting the R interface are inter-connected. In the second case, a terminal adaptor is inter-connected with a DPE-1 which can directly terminate the protocols at the S reference point. In the latter case, for communications to be successful, the DPE-1 must be capable of providing PAD support functions. Many types of PAD functions have been defined. An example of PAD functions already standardized are X.3 type PADs. Appendix D summarizes X.3 PAD functions as well as associated X.28 and X.29 functions.

13.2.2 OSI Environment

The DPE-1 to DPE-1 connectivity case shown in Figure 38 illustrates an OSI type connection. In the context of ISDN, this type of connection is referred to as an ISDN teleservice type connection.

13.3 Lower/Higher Layer Compatibility

Many combinations of protocol suites may be used between the two DPE endpoints. In all cases the lower three layers are provided by the protocol stacks described in this Technical Report. These protocols are indicated in lower layer compatibility information elements. Higher layer protocols carried by the frame mode bearer service are beyond the scope of this Technical Report. However, compatibility between endpoints may be indicated by the Higher Layer Compatibility information element exchange using ECMA-106+ on the Signalling channel.

14. ADDRESSING

Addressing corresponds to calling, called PSN users. The two aspects to be considered are numbering and subaddress.

- numbering for PSN no specific requirement has been identified which is unique to frame oriented bearer services (i.e. same considerations as for circuit oriented service provisions in PSNs).
- sub-addressing

The signalling mechanisms must allow transparent transport of NSAP Addresses between PSN users or between a PSN user and an IWU. No new requirements beyond those already identified in ISO and CCITT standards bodies has been identified.

15. GENERAL MANAGEMENT FUNCTIONS - ADMINISTRATION, MAINTENANCE, AND OPERATIONS

15.1 Administration and Operations

Administrative and operational aspects of frame switching (e.g. endpoint types, PSN services and applicable parameters) are dealt with in previous sections of this technical report.

15.2 Maintenance

Maintenance at the S interface is covered in ECMA TR/34 which is considered to cover all aspects of maintenance pertaining to this Technical Report.

16. FUNCTIONS EXPECTED BY TERMINAL EQUIPMENT OF THE NETWORK

As viewed by terminal equipment, the PSN provides connectivity for user data transfer and a central point of control for the connections. A PSN may be considered to provide the functions of a centrally controlled local area network.

16.1 Signalling Functions

16.1.1 Connection Control

ECMA-106+ allows the PSN to establish virtual circuits on the basis of its own networking capabilities. The PSN may reject a call if it can not provide the requested service, and may accept calls when it can provide the service.

16.1.2 Service Negotiation

The signalling further provides for PSNs to plan their own resources based on call requests. PPSNs, for example, may do bookkeeping functions with regard to buffer management. Based on the window size and frame length negotiated through the network, the PPSN frame handler may allocate resources as it projects its needs.

The PPSN participates in the negotiation process during virtual circuit establishment. If a requested window size and frame length for a particular virtual circuit exceeds the capacity of available frame handler resources, the PPSN may allow the call to be established with a window size less than originally requested. A PCSN has no need to participate in the negotiation process as its resources are not affected by packet mode service operating parameters. See 5.

Since the PSN provides a central control function, it has knowledge of all virtual calls in existence at any given time. Thus, the PSN may allocate its resources in order to maintain the quality of service requested by the endpoints.

16.1.3 Quality of Service

The PSN is responsible for providing a Quality of Service as good or better than that requested by the terminal equipment user. This is done primarily by deciding when and where to provide protocol termination to deliver a certain quality of service. The determination may be made on a call by call or an installation basis. Also see 5.

16.2 Data Transfer Functions

A DPE may request a given service such as circuit switching or frame switching. Virtual circuit connections provided by PPSNs involve queuing of user data units. PPSNs need to provide the following functions:

- preservation of packet sequences: packets should be delivered by the PSN in the same order they are received by the PSN, with the possible exception of advancement of expedited data units;
- negligible data loss rates: the maximum permissible loss rate is for further study.

17. INTERWORKING

Appendix F illustrates the synergy of the ISDN CO-NS packet mode protocol suite with the protocol suites used for X.25 network access as well as for distributed LANs which provide CO-NS service. The functions and mappings to be provided by an interworking unit (for example, to map between in-band and out-of-band virtual channel control) are illustrated. In addition, examples of end-to-end connections involving more than one type of network providing CO-NS service are shown. Appendix E also provides examples of CL-NS interworking.

Appendix F further describes functions of X.25 which should be considered in defining signalling functions associated with the packet mode protocol in order to allow interworking to be done.

18. REQUIRED STANDARDS IN SUPPORT OF THE PACKET MODE PROTOCOL

To support the protocol suite for packet mode applications, a number of extensions need to be made to existing ECMA standards and one or more new ECMA standards may need to be developed.

18.1 Extensions to Standard ECMA-105 for Application of LAPD for Data Transfer

Standard ECMA-105 needs to have minor modifications made to cover the use of the Data Link Connection Identifier (DLCI) when LAPD is used on channels other than the D-channel. Further specification of which ECMA-105 procedures are applicable on non-D-channels is needed. For example, the dynamic window algorithm, and the optional address field extension by one more octet. In addition it is mandatory for terminals requesting frame bearer services to receive and generate reject frames. All modifications and enhancements to ECMA 105 should be made keeping in mind the backward compatibility goal with ECMA 105 as stated in 8.

18.2 Extensions to ECMA-106 for Frame Mode Basic Call Control

Standard ECMA-106 needs to include some new call control elements to support negotiation of standard data facilities such as throughput class and transit delay. The list of parameters to be negotiated may include:

- Layer 2

- . address (DLCI)
- . sequencing modulo
- . window size (k)
- . information field length (N201)
- . acknowledgement timer (T200)
- . idle link audit timer (T203)

- Layer 3

- . address (logical channel number)
- . sequencing modulo
- . window size (W)
- . user-data field length
- . reset request response timer (T22)
- . window status transmission timer (T24)
- . data acknowledgement timer (T25)
- . interrupt response timer (T26)
- . use of the INTERRUPT packet
- . use of the D-bit in DATA packets

NOTE 26

Layer 3 parameters are negotiated end-to-end between DPEs.

- Global Quality of Service parameter set
- PSN Quality of Service parameter set

18.3 Extensions to Standard ECMA-106 for Supplementary Services and Support of Fast Select

ECMA-106 also needs to include a mechanism for registration of facilities similar to the X.25 registration capability. This may be based on the CCITT Rec. I.431/Q.931 REGISTER messages, or some other technique to be determined. In addition ECMA-106+ needs frame mode bearer service negotiation procedures. The specification of control of supplementary services is beyond the scope of this Technical Report.

APPENDIX A

DESCRIPTION OF TELECOMMUNICATIONS SERVICES AND CAPABILITIES

A.1 Service Concept

Telecommunication services are described by attributes that define service characteristics as they apply at a given reference point where an end system accesses the telecommunication service.

Telecommunication services are divided into two broad categories

- Bearer Services, and
- teleservices

A supplementary service (facility) modifies or supplements a basic telecommunications service. It cannot be offered to an end system as a stand alone service. It must be offered together or in association with a basic telecommunication service. The same supplementary service may be common to a number of telecommunications services.

telecommunication service			
bearer service		teleservice	
basic bearer service	basic bearer service + supplementary services	basic teleservice	basic teleservice + supplementary services

A.2 Capabilities Required to Support a Telecommunication Service

The capabilities required for full support of a telecommunication service for an end system connected to a PSN include:

- bearer capabilities, teleservices,
- end system capabilities, when required, and
- operational service capabilities.

The bearer capability defines the network characteristics required from a PSN to support a bearer service as they appear to the end system at the access point. The bearer capability is characterized by information transfer and access attributes. If a PSN accepts a request from an end system for a certain bearer capability, then the PSN must provide the intervention level corresponding to the requested bearer capability in at least one node in the path provided. The PSN may, however, propose a bearer capability corresponding to a lower intervention level.

The end system capabilities are defined in terms of low layer functions relating to layers 1 to 3 and high layer functions associated with layers 4 to 7.

Two different levels of compatibilities between end systems are introduced:

- low layer compatibility (LLC), which relates to the bearer services; and layers 1-3 of teleservices, and
- high layer compatibility (HLC), which relates to layers 4-7 of teleservices.

The operational service capabilities associated with a service include capabilities for maintenance, charging, user control of service features, etc.

As a general rule, during call establishment, two types of elements need to be distinctively defined:

- Type 1 dedicated to end system to PSN context, and
- Type 2 dedicated to end system to end system context.

Both types are essential and optional in the sense that they must be part of the repertoire but do not need to be used when default options can be assumed.

Type 1 is obviously part of the bearer capability request activity of the call control procedures and the bearer capability information element belongs to this class.

The definition and use of the PSN bearer capability and the end to end compatibility information need to be dissociated.

In particular in the case of interworking the IWUs are considered as virtual end systems that emulate the far end user. As such the IWU is involved in the end to end service request and will make use of the compatibility information elements for this purpose.

Compatibility elements for the lower layers are not part of the PSN bearer capability, but are essential to the connection of end systems to a PSN.

Adequate end to end negotiation mechanisms and procedures are required.

APPENDIX B

OSI NETWORK SERVICES

B.1 Overview

Figure B.1 shows the provision of the OSI Network Service. As seen in the figure, OSI Network Service is provided by Layer 3 to Layer 4 in the DPE.

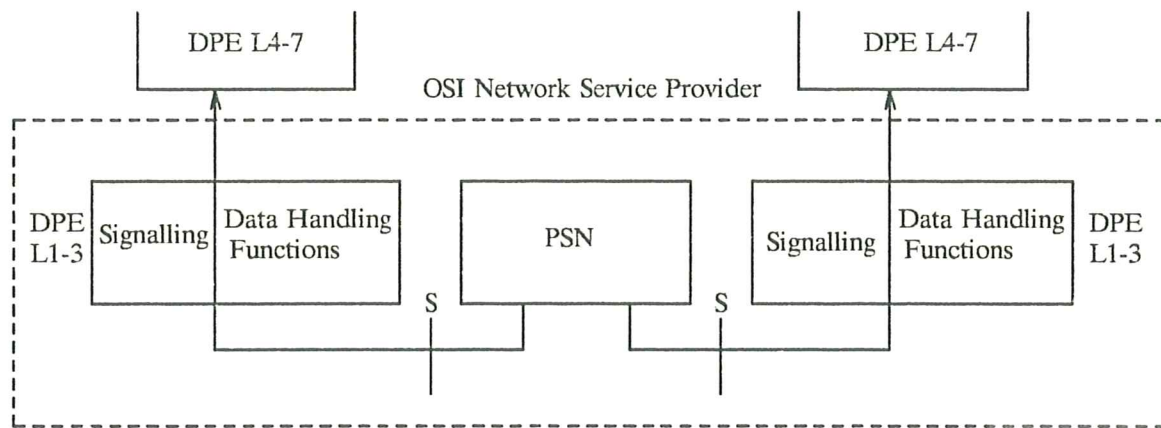


Figure B.1 - OSI Network Service Provision

B.2 Connection-Mode Network Service (CO-NS)

B.2.1 Services provided to the Higher Layers

CCITT Recommendation X.200 specifies the Reference Model for Open Systems Interconnection (OSI). The requirements for providing Connection Mode Network service are defined in CCITT Rec. X.213 and in ISO 8348.

B.2.2 General Requirements for Connection Mode Network Service (CO-NS)

The Network Service (NS) provides for the transparent transfer of data between NS users. It makes invisible to these NS users the way in which supporting communications resources are utilized to achieve this transfer.

In particular, the Network Service provides for the following:

- Independence of underlying transmission media - the Network Service relieves NS users from all concerns regarding how various subnetworks are used to provide the end-to-end Network Service. The Network Service hides from the NS user differences in the transfer of data over heterogeneous subnetworks, with the exception of quality of service.

- End-to-end transfer - the Network Service provides for in-sequence transfer of Network Service Data Units (NSDUs) between NS users in end systems. All routing and relaying functions are performed by the NS Provider including the case where several similar or dissimilar transmission resources are used in tandem or parallel.
- Transparency of transferred information - the Network Service provides for the transparent transfer of octet-aligned NS-user-data and/or control information. It does not restrict the content, format or coding of the information, nor does it ever need to interpret its structure or meaning.
- Quality of Service selection - the Network Services makes available to NS users a means to request and to agree to quality of service for the transfer of data. Quality of service is specified by means of Quality of Service parameters representing characteristics such as throughput, transit delay, accuracy, and reliability.
- NS user addressing - the Network Service utilizes a system of addressing which allows NS users to refer unambiguously to one another.

Clause 11 details how these requirements are met.

B.2.3 Features of the CO-NS

The Network Service offers the following features to an NS user:

- The means to establish a Network Connection (NC) with another NS user for the purpose of exchanging NSDUs. More than one NC may exist between the same pair of NS users.
- The establishment of an agreement between the two NS users and the NS provider for a certain quality of service associated with each NC.
- The means of transferring NSDUs on an NC. The transfer of NSDUs, which consist of an integral number of octets, is transparent, in that the boundaries of NSDUs and the contents of NSDUs are preserved unchanged by the Network Service, and there are no constraints on the NSDU content imposed by the Network Service.
- The means by which the receiving NS user may flow control the rate at which the sending NS user may send NSDUs.
- In some circumstances, the means of transferring separate expedited NSDUs. Expedited NSDUs are limited in length and their transmission is subject to a different flow control from normal data across the NSAP.
- The means by which the NC can be returned to a defined state and the activities of the two NS users synchronized by use of a Reset Service.
- In some circumstances, the means for the NS user to confirm the receipt of data.
- The unconditional, and therefore possibly destructive, release of an NC by either of the NS users or by the NS provider.

B.2.4 CO-NS Network Service Queuing Model

The queue model represents the operation of a Network Connection (NC) in the abstract by a pair of queues linking the two Network Service Access Points (NSAPs). There is one queue for each direction of information flow (see Figure B.2).

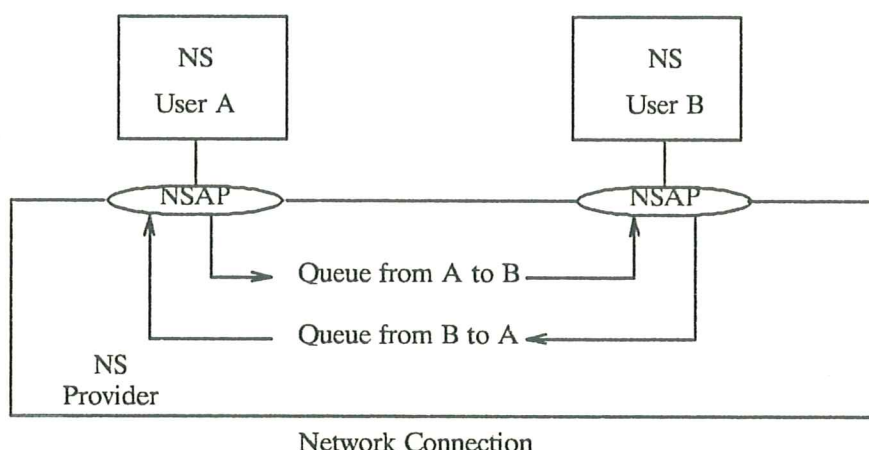


Figure B.2 - Network Service Queuing Model

Each queue represents the flow of data in one direction. The ability of a user to add objects (see ISO 8348 or CCITT Rec. X.213) to a queue will be determined by the behavior of the user removing objects from that queue and the state of the queue. Objects are entered or removed from the queue by NS users as a result of interactions at the NSAPs.

The pair of queues is considered to be available for each potential NC.

B.2.5 Primitives between CO-NS Network and Transport Layer Entities

Tables B.1, B.2 and B.3 summarize the primitives used for interactions between Transport layer entities and the NS provider to meet the OSI Network Service. For the purpose of describing primitive interactions in this section, the NS provider is considered to consist of the Network layer bearer and signalling entities (with their associated management entity). Clause 11 details how the packet mode protocol provides for these primitives and parameters.

Table B.1 summarizes the primitives used at the layer 4 / 3 boundary for the Network Connection (NC) establishment phase. Primitives may or may not have parameters associated with them.

PHASE	SERVICE	PRIMITIVE	PARAMETERS
NC establishment	NC establishment	N-CONNECT request	Called Address Calling Address Receipt Confirmation Selection Expedited Data Selection Quality of Service Parameter Set NS User-Data
		N-CONNECT indication	Called Address Calling Address Receipt Confirmation Selection Expedited Data Selection Quality of Service Parameter Set NS User-Data
		N-CONNECT response	Responding Address Receipt Confirmation Selection Expedited Data Selection Quality of Service Parameter Set NS User-Data
		N-CONNECT confirm	Responding Address Receipt Confirmation Selection Expedited Data Selection Quality of Service Parameter Set NS User-Data

Table B.1 - OSI Network Connection Establishment Primitives

Table B.2 summarizes the release primitives used at the layer 4 / 3 boundary for the Network Connection (NC) release phase. These primitives are used for releasing a Network Connection.

PHASE	SERVICE	PRIMITIVE	PARAMETERS
NC Release	NC Release	N-DISCONNECT Request	Reason Responding Address NS User-Data
		N-DISCONNECT Indication	Originator Reason Responding Address NS User-Data

Table B.2 - OSI Network Connection Release Primitives

Table B.3 summarizes the primitives used at the layer 4 / 3 boundary during the Network Connection (NC) data transfer phase.

PHASE	SERVICE	PRIMITIVE	PARAMETERS
Data Transfer	Normal Data Transfer	N-DATA request	Confirmation Request NS User-Data
		N-DATA indication	Confirmation Request NS User-Data
	Receipt Confirmation	N-DATA ACKNOWLEDGE request	None
		N-DATA ACKNOWLEDGE indication	None
	Expedited data transfer	N-EXPEDITED DATA request	NS User-Data
		N-EXPEDITED DATA indication	NS User-Data
	Reset	N-RESET request	Reason
		N-RESET indication	Originator Reason
		N-RESET response	None
		N-RESET confirm	None

Table B.3 - OSI Network Connection Data Transfer Primitives

B.2.6 Time Sequence of Primitives for CO-NS

Figure B.3 illustrates the time sequence of primitive interactions during the Network Connection Establishment and Release phases. In Figure B.3, as well as in Figure B.4, the vertical lines represent the boundary between the Network Service Provider and the transport layer entity. Thus, the space between the vertical lines represents the Network Connection. Not all possible cases are

illustrated; refer to CCITT Rec. X.213 or ISO 8348 for additional cases.

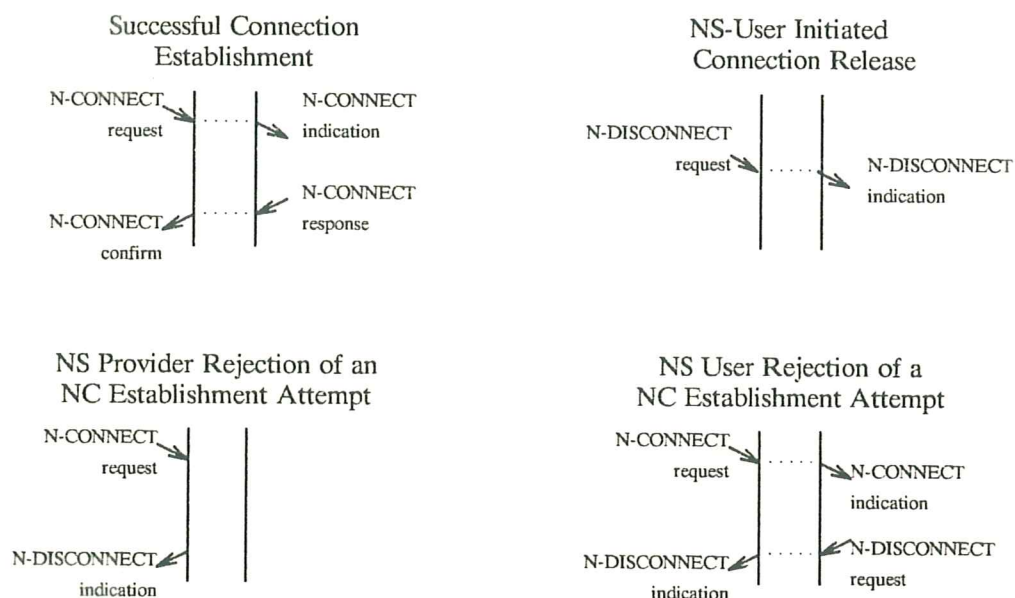


Figure B.3 - Summary of Network Service Primitive Time Sequences - Network Connection Establishment and Release Phases

Figure B.4 illustrates the time sequence of primitives during the data transfer phase. Some cases are shown. During the data transfer phase, CCITT Rec. X.213 and ISO 8348 define how various NSDUs may be handled in queues relative to each other. More examples are found in those documents.

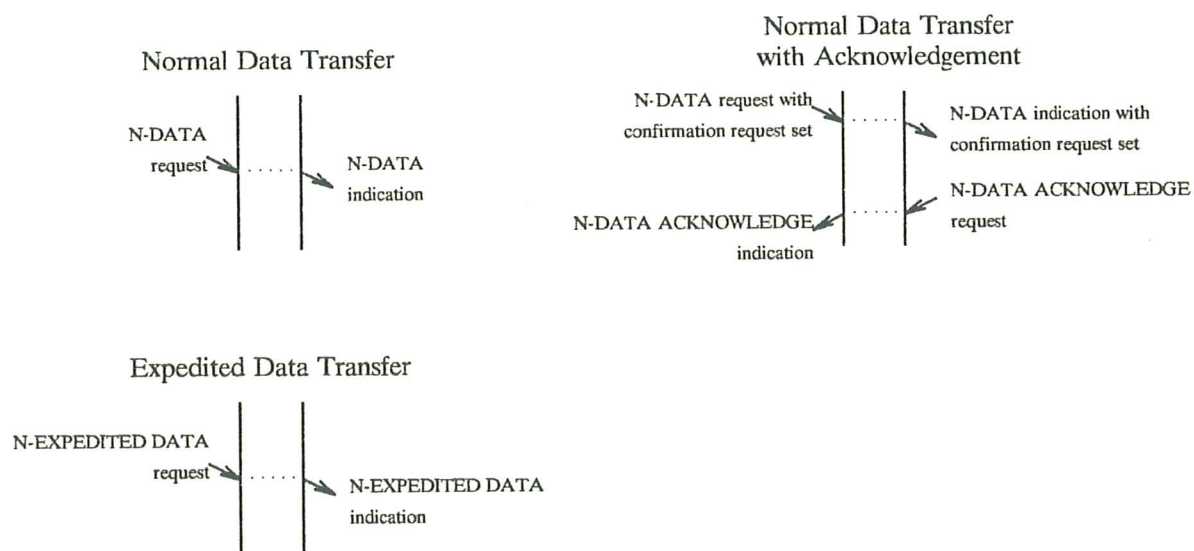


Figure B.4 - Summary of Network Service Primitive Time Sequences - Data Transfer Phase

B.2.7 State Transitions for Sequences of Primitives at Network Connection Endpoint for CO-NS

Figure B.5 presents a state transition diagram for sequences of primitives within the establishment, maintenance and disestablishment of a network connection. In the Figure, States 1, 2 and 3 apply to the Network Connection establishment Phase. For example, State 1, the idle (null) state, is reached via sending of a N-DISCONNECT primitive. It is also the state in which the model is entered. State 2, the Outgoing Connection Pending state may be reached via sending of an N-CONNECT request. This state may be exited via the receipt of a N-DISCONNECT primitive (transition to State 1) or by the receipt of a N-CONNECT confirm message (transition to State 4). State 3, the Incoming Connection Pending state may be reached via the receipt of a N-CONNECT indication. This state may be exited via the sending of a N-DISCONNECT primitive causing a transition to state 1 or by the sending of a N-CONNECT response and a transition to state 4.

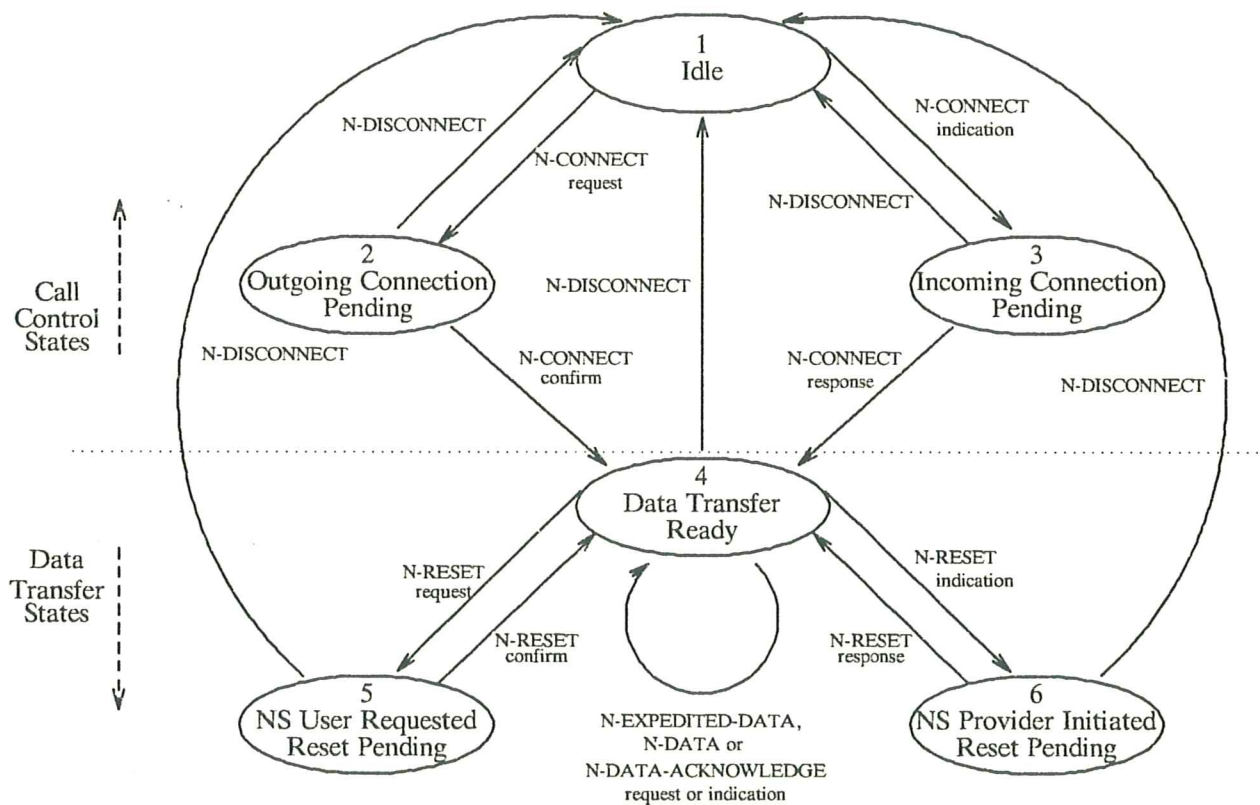


Figure B.5 - State Transition Diagram for Sequences of Primitives at an NC Endpoint

B.2.7.1 Data Transfer Phase

Figure B.5 also shows States 4, 5 and 6 which apply to the Data Transfer phase. After state 4 is reached, lower layers of the Data Transfer protocol are activated and the link is initialized. A Network Connection reset is performed by sending of N-RESET request and moving to State 5. The Reset is considered complete after receiving a N-RESET confirm causing a return to state 4. The Network Service provider may also initiate a reset as shown by State 6. In this case the

Network Service provider sends a N-RESET indication which causes the DPE to move to State 6. State 6 is exited when the DPE responds with a N-RESET response.

B.3 Connectionless-Mode Network Services (CL-NS)

B.3.1 Services Provided to the Higher Layer

Connectionless-Mode Network Service is specified in ISO 8348 Addendum 1 which complies with the OSI Seven Layer Model. CL-NS service is not defined by CCITT but is defined by ECMA and ISO standards. The characteristics of Connectionless-Mode Network Service are valuable in applications which involve short-term request/response interactions, exhibit a high level of redundancy, must be flexibly reconfigurable, or derive no benefit from guaranteed in-sequence delivery of data.

Connectionless-Mode Network Service is the transmission of a single unit of data from a source Network Service Access Point (NSAP) to one or more destination Network Service Access Points without establishing a connection.

B.3.2 General Requirements for Connectionless-Mode Network Service (CL-NS)

In contrast to a connection-mode service, an instance of the use of connectionless-mode service does not have a clearly distinguishable lifetime. In addition, the connectionless-mode service has the following characteristics:

- it requires only a pre-existing association between the peer-entities involved which determines the characteristics of the data to be transmitted, and a two-party agreement between each peer-entity and the service provider; no dynamic peer-to-peer agreement is involved in an instance of the use of the service,
- all of the information required to deliver a unit of data (destination address, quality of service selection, service options, etc.), is presented to the Network Layer together with the data to be transmitted, in a single service access which is not required to relate to any other service access, and
- each unit of data transmitted is entirely self-contained, and can be routed independently by the network provider.

B.3.3 Features of the CL-NS

In addition to the features of 3.2 the following services are defined:

- a means by which Network service data units of arbitrary length are delimited and transparently transmitted from one source NSAP to a destination NSAP in a single Network service access, without first establishing or later releasing a network connection, and
- associated with each instance of CL mode transmission, certain measures of quality which are agreed between the Network service provider and the sending network service user when the CL mode transmission is initiated.

B.3.4 CL-NS Network Service Queuing Model

The queuing model represents the operation of Network Connectionless-Mode Service in the abstract. It describes the Connectionless-Mode Network Service as a queue (see Figure B.6) between any two NSAPs between which an a priori association exists. The queue is permanent and has finite but indeterminable size.

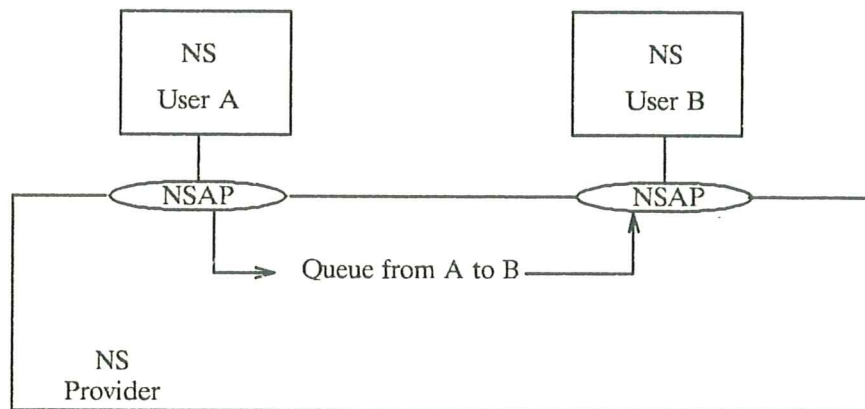


Figure B.6 - Connectionless-Mode Network Service Queuing Model

More details on this queuing model and its operation may be found in ISO 8348 Addendum 1.

B.3.5 Primitives between CL-NS Network and Transport Layer Entities

The service is a CL-NS such as described in ISO 8348 Addendum 1. The network service primitive of interest here is summarized below. Further description and use of the primitives is to be found in ISO 8348 Addendum 1 and ISO DIS 8473. See Table B.4 below.

Primitives	parameters
N-UNITDATA Request and Indication	destination address source address Quality-of-service user/data

Table B.4 - CL Network service primitives

It is noted that this primitive has to be offered by the protocol providing the CL-NS according to ISO 8473. It is indicated for information only and is beyond the scope of this Technical Report.

B.3.6 Time Sequence of Primitives for CL-NS

Figure B.7 illustrates the time sequence of primitive interactions for Connectionless-Mode data transfer.

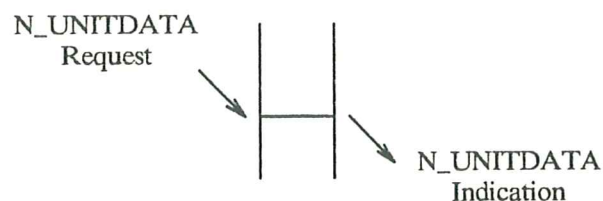


Figure B.7 - N_UNITDATA Primitive Time Sequence Diagram

B.3.7 State Transitions for Sequence of Primitives at Network Connection Endpoint for CL-NS

Figure B.8 shows a possible overall sequence of NS primitives at one NSAP. In this Figure:

- the IDLE state represents the initial and final state of the primitive sequence, and
- the use of a state transition diagram to describe the allowable sequence of service primitives does not impose any requirements or constraints on the internal organization of any implementations of the network service.

network service.

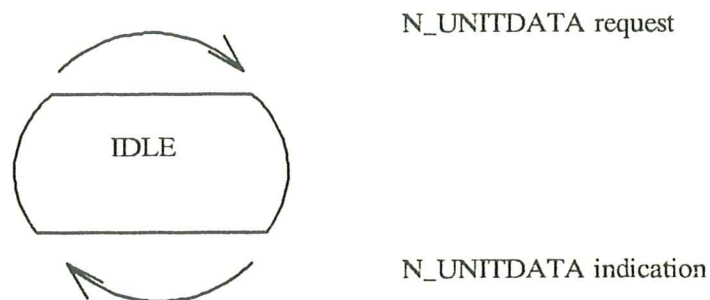


Figure B.8 - Connectionless-Mode Network Service State Transition Diagram

B.3.8 Connectionless-Mode Network Layer Organization

The various functions involved in the provision of the OSI Network service may be separated. ISO has studied this point and proposes a structure for the Network layer described in ISO 8648 Internal organization of the Network Layer and referred to later in this document as the IONL. Due to the different contexts that can be envisaged (i.e. different data link layer services), an intermediate set of "CONVERGENCE FUNCTIONS" is proposed that guarantees function independence such as depicted in Figure B.9.

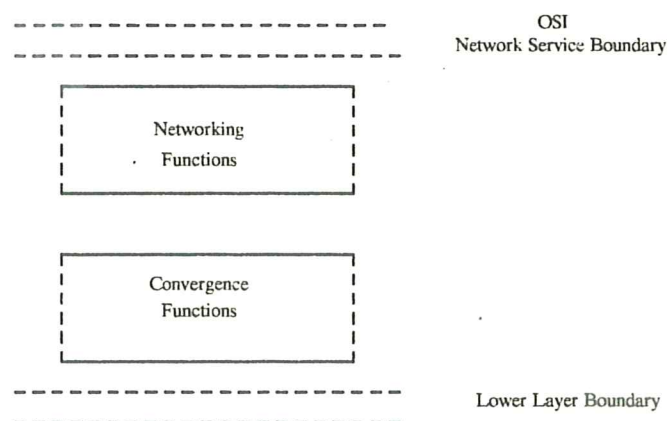


Figure B.9 - A coarse presentation of the IONL

These convergence functions are implemented by the subelements considered in the IONL. Namely four sets of functions are identified in the IONL: Routing and relaying Subnetwork independent convergence protocol (SNICP), the subnetwork dependent convergence protocol

(SNDP) and the Subnetwork Access protocol (SNAP). The SNAP can be considered as existing as part of the subnetwork. This is the case of PSN/ISDN interfaces where the SNAP is provided in part by ECMA-106+. In the case of connectionless-mode network service, the SNICP is ISO 8473 Internet protocol, while Ad Hoc SNDPs or subnetwork dependent convergence functions (SNDP) need to be defined for any CO subnetwork; such SNDP are presently developed for ISO 8208 and ISO 8802 (see ISO 8473 Addendum 1). The principle of a similar SNDP for the PSN subnetwork can be retained, the definition of which is given in 12.

The proposed model is shown in Figure B.10.

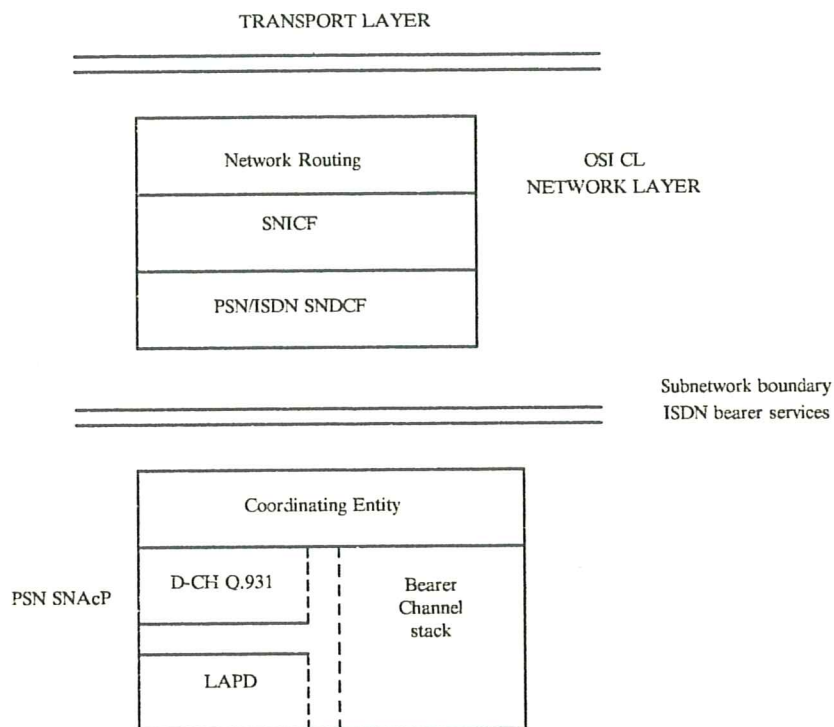


Figure B.10 - A possible model for the support of CL-NS by PSN

The subnetwork (i.e. the PSN) service required consists of the single SN-UNITDATA primitive which conveys the source and destination subnetwork point of attachment addresses, a subnetwork QoS parameter and a minimum of 512 octets of user data.

The general model for providing the underlying service assumed by the CL-NS protocol (CLNP) in conjunction with a real subnetwork (e.g. PSN/ISDN) that uses a connection-mode network access protocol is as follows:

The generation of the SN-UNITDATA request by the CLNP may cause a connection (virtual circuit, logical link...) to be made available for the transmission of the user data. If a connection cannot be made available, the data request is discarded. The receipt of subnetwork specific PDU(s) containing SN-USERDATA causes the SNDP to generate a SN-UNITDATA indication to the CLNP.

The general model for providing the underlying service assumed by the CL-NS protocol (CLNP) in conjunction with a real sub-network that uses a connectionless-mode access protocol (e.g., over D-channel) is for further study.

APPENDIX C

CONGESTION CONTROL MECHANISMS FOR FRAME RELAY BEARER SERVICE

C.1 Introduction

The normal operation of the LAPD protocol is such that endpoints detect the loss of frames and retransmit lost frames. Studies have shown that the recovery procedures can cause congestion to increase in networks providing frame relay bearer service. This Appendix proposes that an algorithm be defined to control the offering of frames to the network when congestion is observed or suspected. Congestion in one direction of a link connection is treated independently of congestion in the other direction. The algorithm discussed in this annex applies to the station transmitting in the direction of the congestion. To insure operational "fairness", this algorithm is mandatory for all DPEs or PSN nodes which fully terminate the LAPD protocol when using frame relay bearer services, or when a frame relay switch is visible when using frame switching services.

C.2 Dynamic Window Mechanism

The dynamic window algorithm consists of modifying the transmitter's window when congestion is first detected and then as it decreases. If the transmitter always uses a transmit window size, k , of 1, this algorithm need not be invoked. If the transmitter can use larger transmit window sizes, then in the absence of congestion the transmitter uses a transmit window size k equal to a maximum possible value, designated k_{max} . Thus it can have as many as k_{max} frames outstanding, or unacknowledged, at any time.

C.2.1 Trigger Mechanism

The following trigger conditions have been identified:

- Congestion is indicated by loss of I frames. Lost I frames are detected in two ways. One is the receipt of a REJ frame, which indicates that the receiver detected the loss of an I frame. The other is the expiration of the transmitter's acknowledgement timer, the sending of an RR frame with the P bit set to ONE, and the ensuing receipt of an I frame or an S frame in which the F bit is set to ONE, but in which the value of $N(R)$ in the frame is not equal to the transmitter's $V(S)$ value when the frame with the P bit set to 1 was sent.
- Receipt of a network generated message "network congestion" (throttle message)

"Network congestion" is a special LAPD message that is handled by the network with priority and is given a high probability of being delivered. The "Network Congestion" message will be received and interpreted by the closest Layer 2 entity which can be either a node or a terminal. The Layer 2 entity receiving this message shall take action as described in 2.2. The method of implementation of this mechanism is for determination within the context of ECMA-105+ standardization.

C.2.2 Reaction to Trigger Mechanism

When congestion is indicated by a trigger mechanism, the dynamic window algorithm is invoked, and the transmitter reduces its transmit window size k to some smaller value. Thereafter, when a certain number, k_{step} , of I frames are successfully transmitted and acknowledged, k is increased by some value, k_{delta} . As I frames are successfully transmitted, k will gradually increase until it again reaches its maximum value k_{max} . At this point the algorithm ends. In a sample version, the dynamic window control algorithm could take the form:

- reduce k to k_{min} , for example 1, on receipt of a trigger,
- increase k gradually, using fixed values for k_{step} and k_{delta} .

More complex versions of the algorithm may include one or more of the following options for the increase of the window:

- increase k gradually, using values for k_{step} and k_{delta} that are a function of the current value of k and for the decrease of the window on receipt of a trigger,
- reduce k to k_{min} , where k_{min} equals 0,
- reduce k by k_{delta-} , where k_{delta-} is a function of the current value of k ,
- reduce k by d_{delta-} , where k_{delta-} is a function of the type of trigger received (lost I frame, or network congestion message). The precise definition of the algorithm is a matter for ECMA-105+ standardization.

C.2.3 Additional Considerations

A dynamic window mechanism triggered by detection of congestion by the DPE as well as by network congestion messages provides an elegant and robust congestion control mechanism:

- congestion messages allow the PSN to initiate congestion control timely, even in anticipation of congestion,
- the mechanism is tolerant to the loss of network messages, as congestion control measures as well as their termination is not exclusively dependent on these network messages,
- congestion detection and control by the DPEs protects even against sudden and severe congestion.

The drawback of the dynamic window mechanism triggered by detection of lost I frame, vs. its sensitivity for transmission errors: a transmission error is seen as an indication of possible congestion. An effective congestion control requires a prompt and important reduction of the window size. As a consequence, transmission errors result in an effective (average) window size well below the maximum window size, and therefore a reduced throughput even in absence of congestion. This effect becomes important for large window sizes. Algorithms currently available are tested only for small to medium window sizes, or for large window sizes in virtually error free environments. Additional study is needed for the development of algorithms applicable to large window sizes in environments with a medium error rate, necessary for the support of high throughputs over for example H₁₂ channels.

C.2.4 Example of Dynamic Window Algorithm

This section presents an example of a dynamic window algorithm which is being used over wide-area networks with small to medium window sizes. The example is given in structured prose.

The algorithm is as follows:

If (a REJ is received) or (a solicited I-format or S-format response with the F bit set to ONE is received and the receive sequence number, N(R), is less than the end user equipment's poll state variable, V(P)), then

If the layer 2 transmit window size, TW, is greater than 1 then

Set the working window size, Ww, to ONE.

Set the information acknowledged counter, Ia-Ct, to ZERO.

Set the send state variable, V(S), to the receive sequence number, N(R).

Retransmit the I-format frame, the send sequence number of which equals the receive sequence number N(R).

Do while the working window size, Ww, is less than the maximum transmit window size, TW, holds.

Do while acknowledgement not received holds.

If (REJ is received) or (solicited I-format or S-format response with the F bit set to ONE is received and the receive sequence number, N(R), is less than the end user equipment's poll state variable, V(P)), then

Exit the algorithm and start again.

Increment I-format frame acknowledge count by the receive sequence number, N(R), minus the last received N(R) variable, V(A), modulus n (* Ia-Ct := Ia-Ct + ((N(R) - V(A)) *))

If the I-format frame acknowledged count, Ia-Ct, is greater than Ww then

Set the remainder of I-format frame acknowledged count, Ia-Ct, divided by Ww to I-format frame acknowledged count, Ia-Ct. (* Ia-Ct := remainder (Ia-Ct / Ww)*).

Set the working window size, Ww, to the minimum of working window plus the quotient of the above divide, or the maximum transmit window size, TW.

The following notes are applicable to this procedure

- i) The algorithm is triggered when an end user equipment detects an error condition that requires retransmitting I-format frames. In the case of LAPD procedures this happens when one of the following occurs:
 - . a REJ is received, or
 - . an I- or S-format frame with the F bit on is received and the N(R) value is less than the end user equipment's poll state variable V(P).
- ii) If the maximum transmit window size (TW) is ONE, the algorithm need not be invoked. The algorithm should always be invoked if TW is greater than ONE.
- iii) When an error is detected and the transmit window is greater than ONE, the working window is set to ONE, Ia-Ct initialized, and the I-format frame whose sequence number equals the N(R) value of the last frame received is retransmitted.
- iv) Each time the working window is incremented, it is tested against the end user equipment's maximum transmit window size (TW). If they are equal, the algorithm terminates.
- v) The key to the algorithm is that the working is gradually increased as acknowledgments are received. This procedure is covered in steps v) through vii).
- vi) If an acknowledgment is received, Ia-Ct is incremented by the number of I-format frames acknowledged. V(A) is the last N(R) previously received. The arithmetic is performed over

- the field of integers from 0 to modulus minus 1.
- vii) When the $la-Ct$ reaches Ww , the working window is incremented by q where q is the quotient of $la-Ct$ divided by Ww . Ww should never exceed TW . $la-Ct$ is set to r where r is the remainder of $la-Ct$ divided by Ww .

If a lost frame is detected during the time the working window is less than the maximum transmit window TW , the end user equipment starts at the beginning of the algorithm again.

APPENDIX D

SUMMARY OF CCITT RECOMMENDATIONS X.3, X.28, AND X.29

SUMMARY OF CCITT X.3, X.28, AND X.29 PACKET ASSEMBLY/DISASSEMBLY (PAD) FACILITY RECOMMENDATIONS APPLICABLE TO PACKET MODE PAD TYPE TERMINAL ADAPTERS

D.1 PAD Recommendations

The Packet Assembly/Disassembly Facility (PAD) provides the necessary functions to allow start-stop DTEs to interwork with packet networks. For the Connection-Mode Packet Data Transport case, this means conversion of the start-stop data stream into packetized data following the Packet Mode Protocol. CCITT has provided three Recommendations (X.3, X.28, and X.29) concerning PAD functionality and the protocols required to control packet mode communications in the PAD environment.

Figure D.1 shows the relationships between the PAD, a start-stop DTE, and a packet-mode DTE, and where the CCITT Recommendations apply. This annex summarizes these recommendations and indicates how they would be applied in an ISDN packet mode environment.

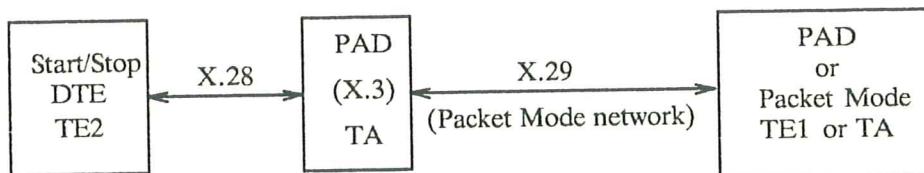


Figure D.1 - PAD Recommendation Relationships

The functions of the PAD itself are described in CCITT Rec. X.3. The protocol between the start-stop DTE and the PAD is specified in CCITT Rec. X.28. The X.28 protocol provides a mechanism for the start-stop DTE user to command the PAD, and for the PAD to indicate the results of the command requests to the start-stop DTE user. The third protocol, found in Rec. X.29, provides a means for the remote DTE (which may be a Host computer or another PAD) to communicate with the PAD for purposes of determining the settings of parameters, changing the parameters, indicating a break signal, providing an invitation to clear, etc.

The Packet Mode Protocol PAD operation follows these Recommendations where they apply in the Packet Mode Protocol environment. An example of where they do not apply is call control. The Packet Mode Protocol, being based on the ISDN protocol reference model, uses out of band call control per ECMA106 so that the CALL REQUEST packets, for example, are not supported. Those aspects of the X.3, X.28, and X.29 Recommendations dealing with call control do not apply in the Packet Mode Protocol application.

D.1.1 X.3 Functionality

In accordance with Rec. X.3, the following functions are performed by a PAD:

- assembly of characters into packets;
- disassembly of the user data field of packets;
- handling of resetting and interrupt procedures;
- generation of data for display on the start-stop DTE; the data is sent via X.28 PAD service signals;
- a mechanism for forwarding packets at the appropriate time, e.g. when a packet is full or when an idle timer expires;
- a mechanism for handling a break signal from the start-stop DTE;
- optional editing of PAD command signals, i.e. messages sent from the start-stop DTE to the PAD for control of the PAD; and
- a mechanism for setting and reading the current value of the PAD parameters.

Optionally, the PAD can include the following functions:

- a mechanism for the selection of a standard profile. A standard profile is a list of X.3 parameters and their settings that have been agreed upon and standardized;
- automatic detection of data rate, code, parity and operational characteristics; and
- a mechanism for the remote end of the communication to request a virtual call between the start-stop mode DTE and another DTE. This function allows a Host computer to, for example, redirect a call so that a start-stop DTE is connected to another Host computer.

D.2 X.3 Parameters

Rec. X.3 provides a set of parameters for use in controlling the operation of the PAD and the start-stop DTE. The functions that are controlled via the parameters are divided into three major areas:

- management of the procedures between the start-stop DTE and the PAD;
- management of the assembly and disassembly of packets; and
- management of additional functions dealing with the operational characteristics of the start-stop DTE (e.g., line lengths, editing characters and functions, selection of local echo).

The 1984 version of Rec. X.3 has twenty-two parameters that have been standardized. The parameters can be categorized into six general categories:

- Local Escape,
- Data Presentation,
- Flow Control,
- Operation Options,
- DTE Requirements, and
- Packetizing Control

Table D.1 indicates the division of the PAD parameters by number into these categories.

Category	X.3 Parameter
Local Escape	1
Data Presentation	2,9,10,13,14, 15,16,17,18,19,20,22
Flow Control	5,12
Operation Options	6,8
DTE Requirements	7,11,21
Packetizing Control	3,4

Table D.1 - Categories of PAD Parameters

In Table D.2, the parameter reference numbers, names, and simple descriptions of the PAD parameters are provided with an indication of the parameter category to which it applies.

Number	Name	Function	Category
1	PAD Recall	Character to enter local mode	Local Escape
2	Echo	Whether or not to perform local echo	Data Presentation
3	Data Forwarding Character selection	Character to signal that packet is complete and should be transmitted	Packetizing Control
4	Idle Timer Delay	Select value of idle timer	Packetizing Control
5	Ancillary device control	Whether or not to use X-on/X-off flow control on DTE output	Flow Control
6	PAD Service Signals	Format for PAD service signals	Operation Option
7	Break Operation	How do handle break signals from the DTE	DTE Requirement
8	Discard Output	Allows packets for DTE to be flushed	Operation Option
9	Padding after CR	Amount of padding required for carriage return	Data Presentation
10	Line folding	Length of line (for printing DTEs)	Data Presentation
11	Speed	Speed of DTE	DTE Requirement
12	Flow Control	Enables/Disables flow control of PAD output by DTE	Flow Control
13	Linefeed after CR	Whether to send LF character after CR	Data Presentation
14	Padding after LF	Amount of padding required for line feed	Data Presentation
15	Editing	Enables/Disables Editing in data transfer	Data Presentation
16	Character delete	Selects character used as character delete	Data Presentation
17	Line delete	Selects character used as line delete	Data Presentation
18	Line Display	Character to cause line to be displayed	Data Presentation
19	Editing PAD Service signals	Selects editing for PAD service signals	Data Presentation
20	Echo mask	Selection of characters to be echoed when using local echo	Data Presentation
21	Parity	Parity checking enabled or disabled	DTE Requirement
22	Page wait	Enable/disable of page wait	Data Presentation

Table D.2 - X.3 Parameters

D.3 X.28 Functionality

CCITT Rec. X.28 provides for the communication between a start-stop DTE and an X.3 PAD. The communication is required to request the PAD to setup, maintain, and clear packet mode calls on its behalf. In addition, X.28 provides a means for reading and setting the X.3 PAD parameters at the local PAD from the start-stop DTE. To provide these functions, the PAD operates in two basic states: a PAD command state where the start-stop DTE communicates directly with the PAD to request establishment of a virtual link, change PAD parameters, or clear a virtual link; and a data transfer state where the start-stop DTE communicates over the virtual link and the PAD control functions are no longer involved in the connection except to provide editing functions, if requested. An escape mechanism using the PAD recall character (defined by an X.3 parameter) allows transferring from the data transfer state to the command state.

In X.28, signals from the start-stop DTE are called PAD command signals. Signals from the PAD to the start-stop DTE are called PAD service signals. PAD command signals provide the following functions:

- requests to establish or clear virtual link calls,
- selection of X.3 profile,
- selection of individual X.3 parameter values,
- provide a read out of current parameter settings,
- request sending of an interrupt packet, and
- request a reset of the virtual link.

PAD service signals provide the following functions:

- transmit call progress information,
- acknowledge receipt of PAD command signals, and
- transmit the status of the PAD (i.e., whether the PAD is engaged in a virtual link call or not).

An example of call establishment at the R reference point is given in Figure D.2.

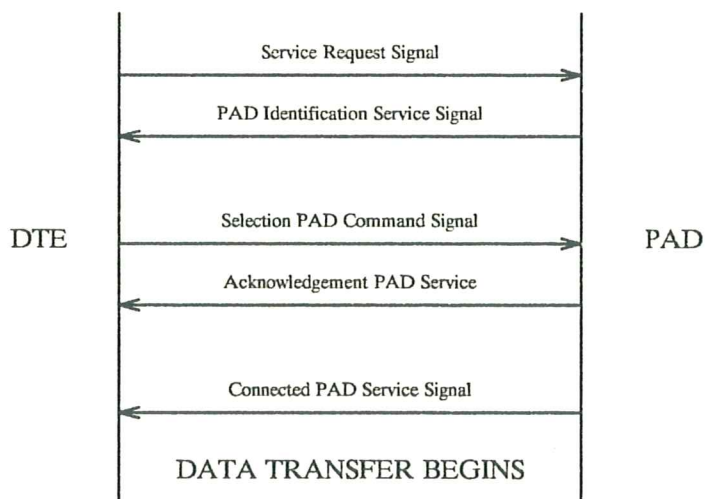


Figure D.2 - X.28 Call Establishment

Figure D.3 gives an example of an incoming call.

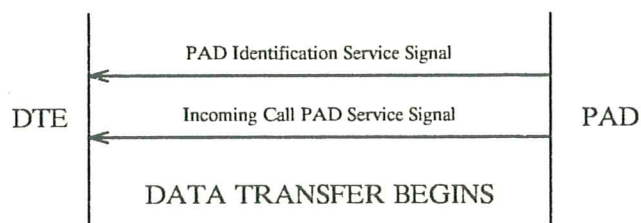


Figure D.3 - X.28 Incoming Call

Figure D.4 illustrates call clearing in X.28.

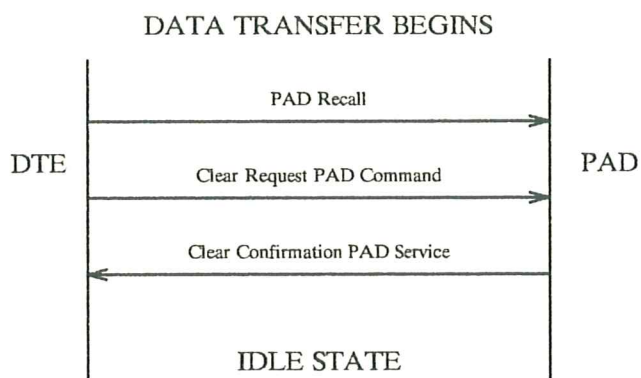


Figure D.4 - X.28 Call Clearing

D.4 X.29 Functionality

X.29 provides for PAD-to-PAD or PAD-to-packet mode DTE communications for purposes of control of the PAD by the remote endpoint. X.29 uses the qualified data service (Q-bit procedures) provided by the Packet Mode Protocol network layer. X.29 PAD messages are transferred in packet sequences where $Q = 1$. The following functions are supported by X.29:

- reading, setting, and reading and setting of remote PAD parameters,
- inviting the remote PAD device to clear,
- sending an indication of BREAK to remote PAD device,
- reporting error conditions to the remote PAD device, and
- inviting the remote PAD device to reselect the called DTE.

The PAD messages of X.29 can be divided into three categories. The first category consists of messages concerning the state of X.3 PAD parameters, the second category consists of operational messages, and the third category consists of messages to request user features. Table D.3 lists the PAD messages in each category.

Category	Messages
X.3 Parameters	Set Read Set-and-Read Parameter Indication
Operational Messages	Indication of Break Error
Features	Invitation to Clear Reselection

Table D.3 - X.29 PAD Messages

In the first message category, the SET, READ, and SET-AND-READ messages are used to request the remote PAD to take the corresponding actions concerning the parameters called out in the messages. The remote PAD responds with the PARAMETER INDICATION message indicating the results of its actions. If a requested PAD parameter is not implemented in the remote endpoint, this is indicated in the PARAMETER INDICATION message. In the second message category, the INDICATION OF BREAK message is used (depending on the setting of PAD parameter 7, the X.3 break handling parameter) to transmit, to the remote end, the receipt of a break signal from the start-stop DTE. Error messages are used to notify the remote end of an error condition detected by the near-end PAD/DTE. In the third category, the INVITATION TO CLEAR message notifies the remote end that it has transmitted all the data that it intends to and the remote end is free to clear the connection. The INVITATION TO RESELECT message notifies the remote PAD that it should transmit all previously received data to the start-stop DTE, clear the call, and then establish a new call to the DTE whose address is given in the INVITATION TO RESELECT message.

Figure D.5 shows an example of a parameter set-and-read operation. A parameter set operation is similar except that a PARAMETER INDICATION message is sent only if an error occurred (i.e. requested PAD parameters are not available or not implemented in the PAD) in setting parameters at the PAD.

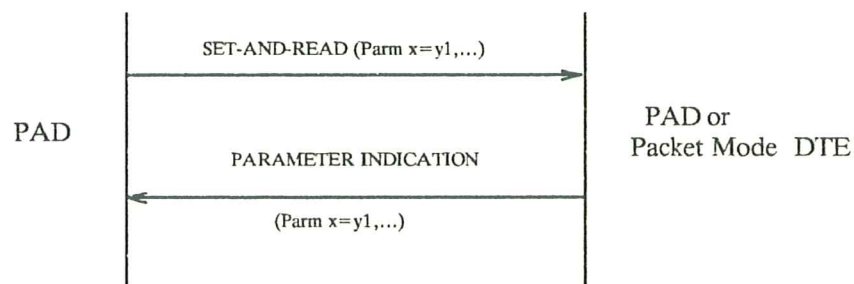


Figure D.5 - Set and Read Parameters

Figure D.6 shows an example of how the PAD processes a break signal from the start-stop DTE. As can be seen in this Figure, the X.29 message sequences depend on the setting of X.3 parameter number 7.

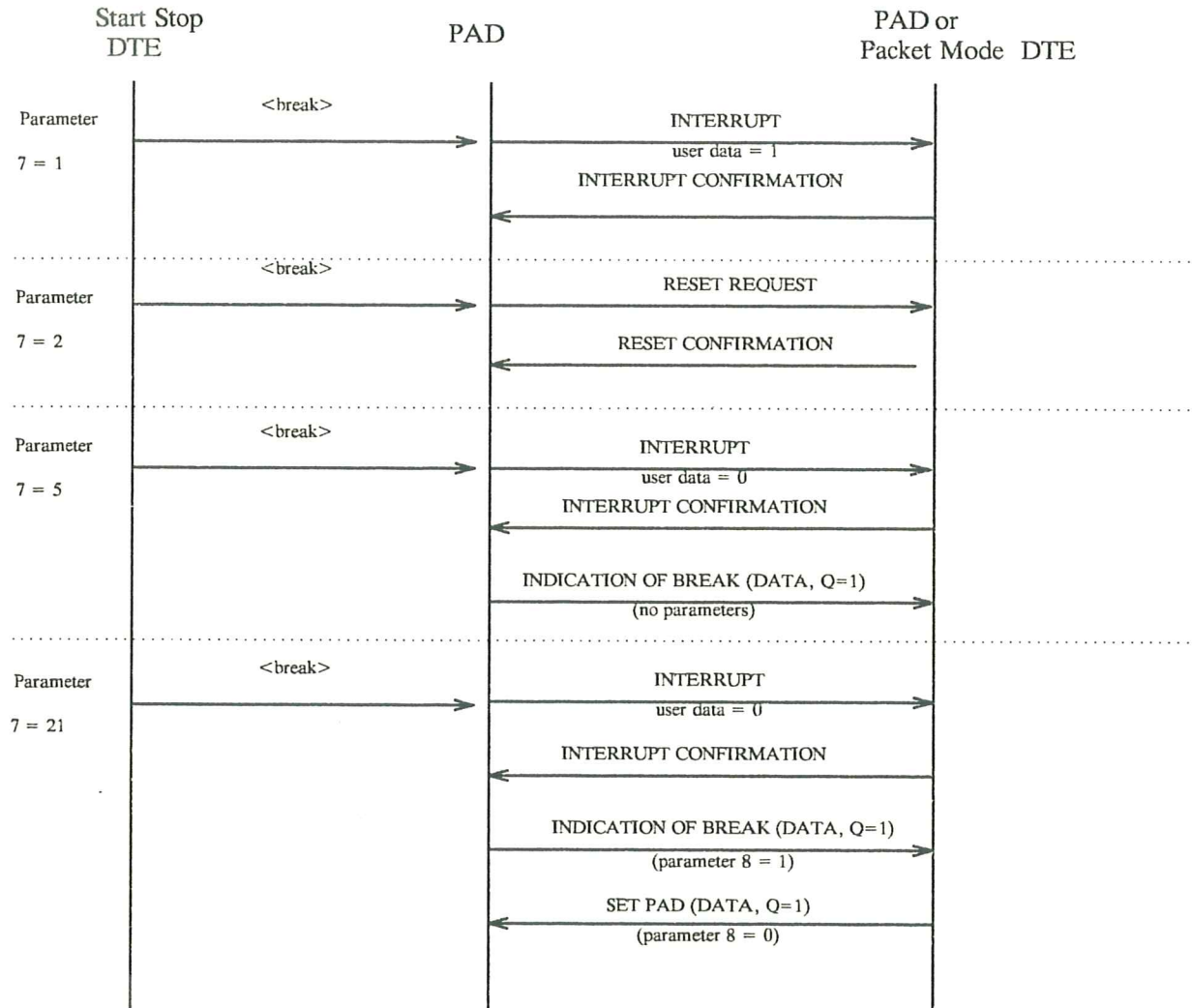


Figure D.6 - X.29 break Signal Processing by PAD

Figure D.7 shows an example of PAD processing of the INTERRUPT and INDICATION OF BREAK messages.

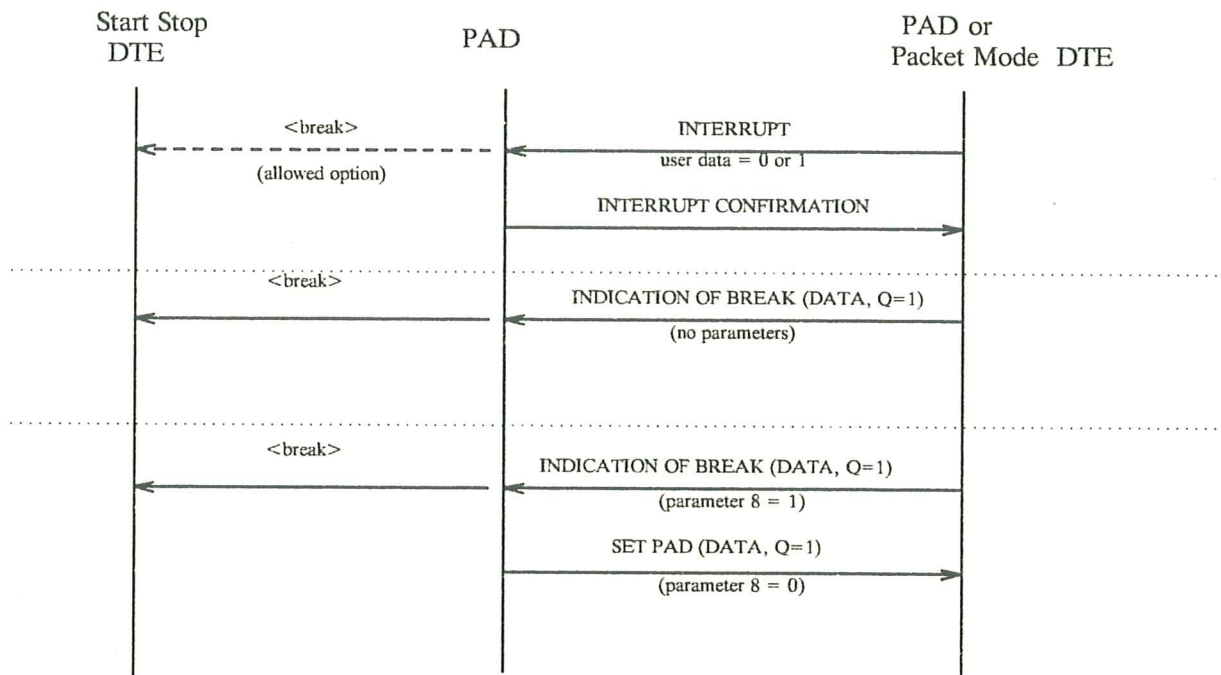


Figure D.7 - PAD Processing of INTERRUPT and INDICATION OF BREAK

Figure D.8 shows an example of an error condition in a set-and-read operation. The same interaction occurs for all X.29 error conditions.

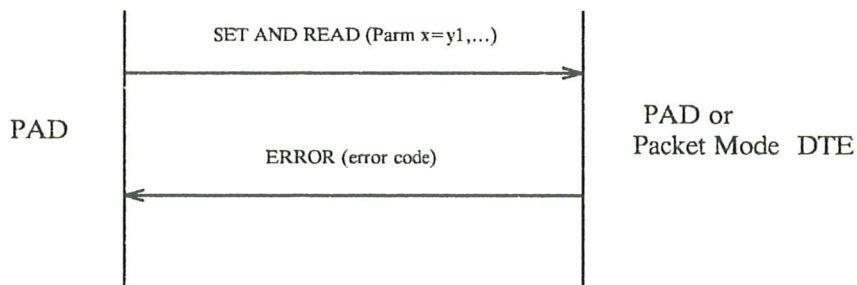


Figure D.8 - Error Condition During Set and Read Operation

Figure D.9 shows an example of the invitation to clear procedures.

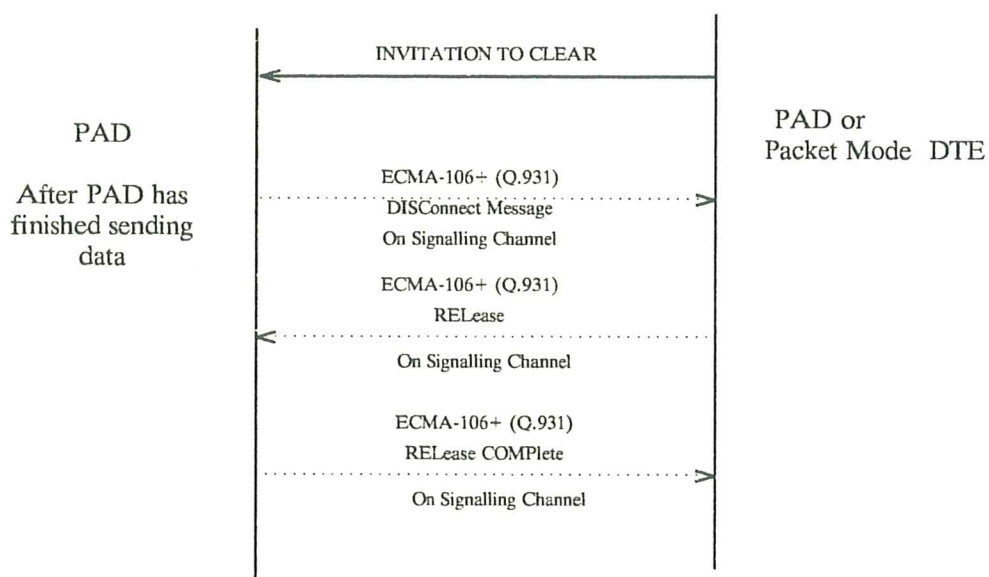


Figure D.9 - Invitation to Clear Procedure

Figure D.10 shows an example of the reselection procedures. The reselection procedure is an optional procedure.

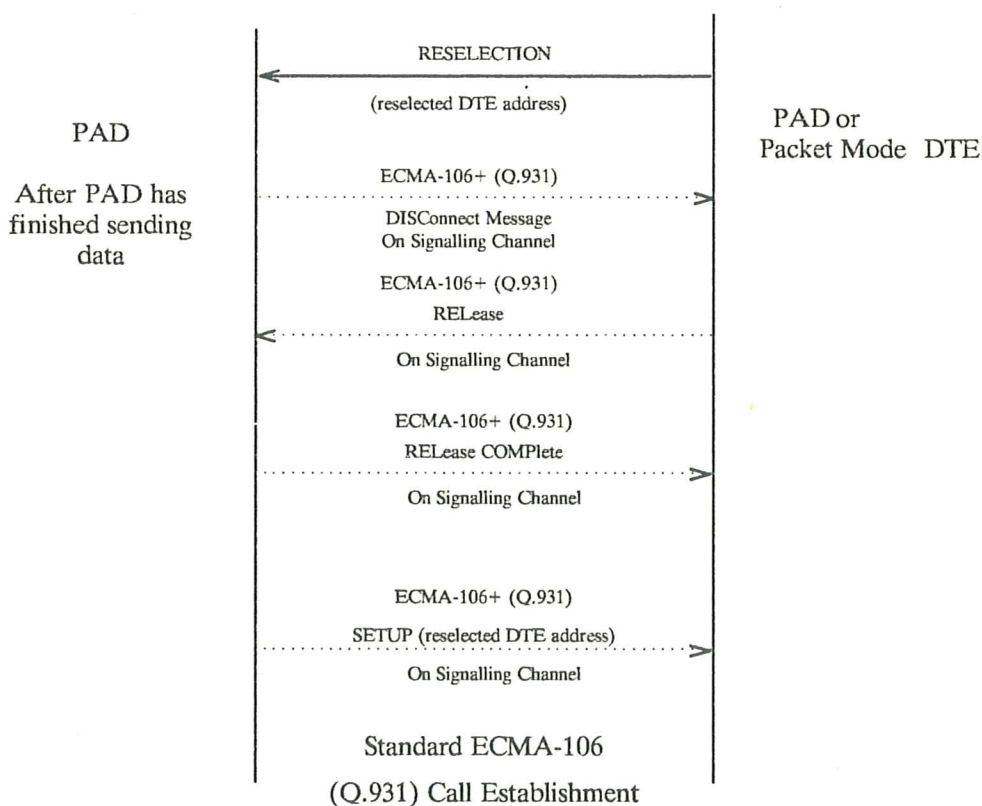


Figure D.10 - Reselection Procedure

APPENDIX E

EXAMPLES OF INTERWORKING SCENARIOS

E.1 Interworking Scenarios

The interworking scenarios considered in this Appendix are examples only and are included purely for tutorial purposes.

E.2 Examples of CO-NS Interworking

E.2.1 CO-NS Protocol Suite Synergies

Figure E.1 illustrates the synergy of the packet mode protocol suite used for provision of the Connection-Mode Network Service (CO-NS) with the protocol suite recommended by ISO and CCITT for Wide Area Network access (i.e. X.25) and by ISO for provision of CO-NS on 8802 Distributed Local Area Networks.

As shown in Figure E.1, X.25 is used as an access protocol to Wide Area Networks or Packet Switched Data Networks. (PSDNs). At the link layer, a single link is provided for transport of one or more virtual links at Layer 3. The link layer protocol, LAPB, provides a connection-mode service on a point-to-point link via multiple frame acknowledged information transfers. At Layer 3 the X.25 Packet Layer Protocol is used. Both virtual call control states and data transfer states are included.

ISO has taken the position that, for conformance purposes, 8802-type distributed LANs that provide Connection-Mode Network Service will use X.25 PLP (ISO 8208) at Layer 3.

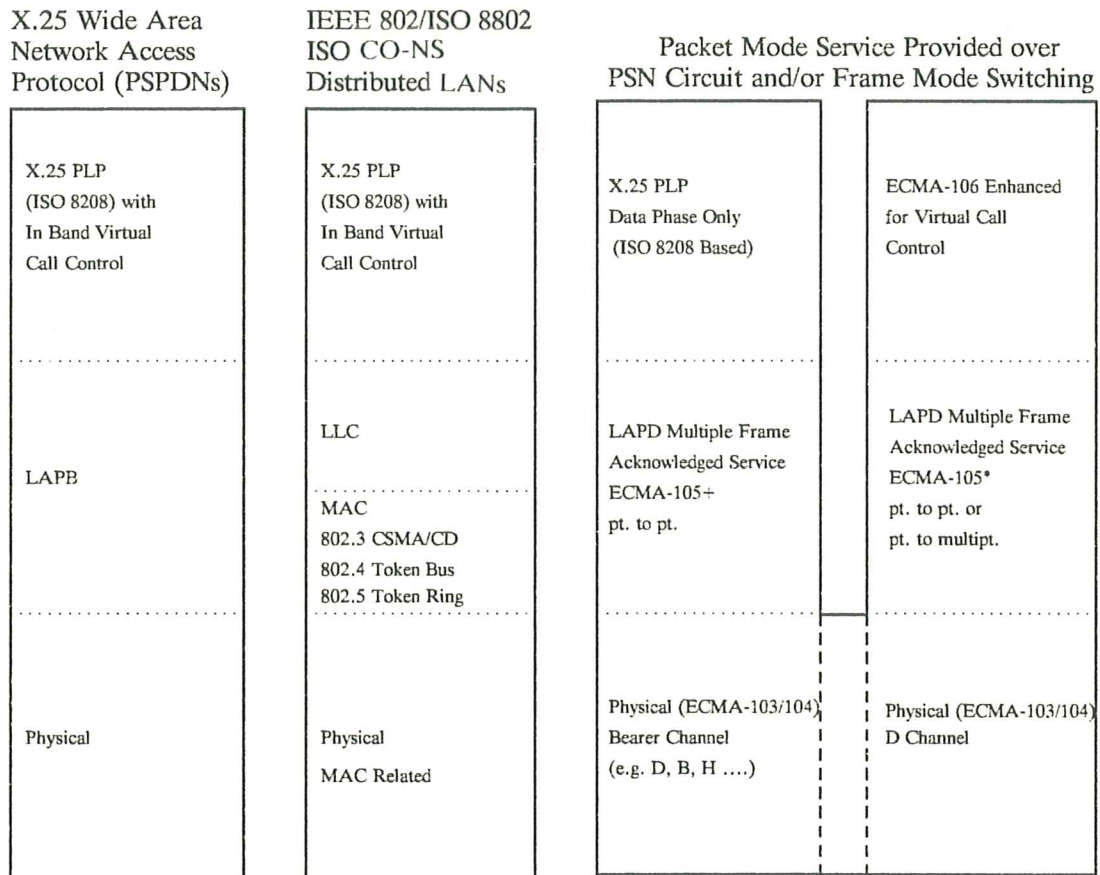


Figure E.1 - Protocol Suites for provision of Connection Mode Network Service

In the PSN frame mode protocol suite which is the subject of this report, the data phase only (d states) portion of the X.25 PLP is used at Layer 3. The equivalent of p state (virtual call control) functionality as well as facility registration is provided via enhancements to the ECMA-106 (Q.931) protocol. At the link layer the LAPD protocol is used on both the channel used for control and the channel used for carrying user data.

E.2.2 Protocol Interworking Scenarios

Interworking for two different situations between a packet mode X.25 DTE (a terminal DPE-1 or TA which uses LAPD at the link layer and X.25 PLP Data Phase at the network level) and an X.25 (e.g. X.31) DTE, and an X.25 PSDN Network are shown in Figures E.2 and E.3 respectively.

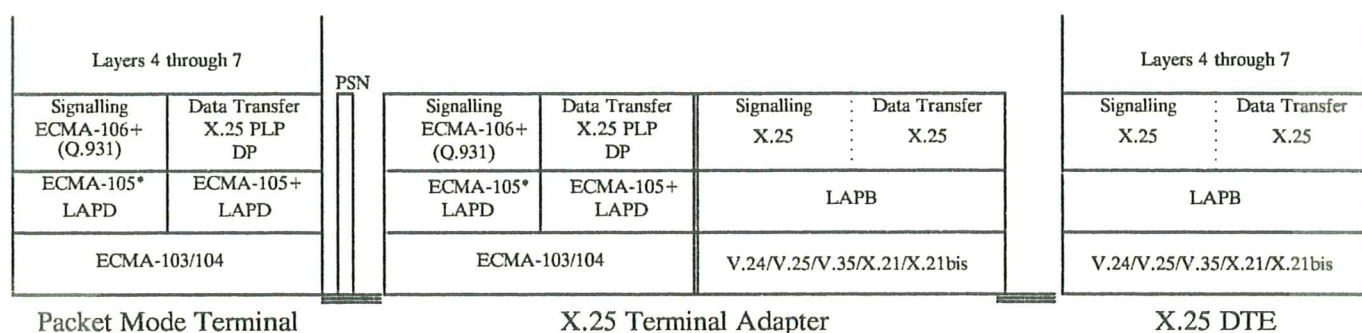


Figure E.2 - Interworking Between Packet Mode Terminal and an X.25 DTE

The PSN intervenes with the same signalling protocol stack as shown for the Packet Mode Terminal, and with the data transfer protocol stack up to Layer 2.

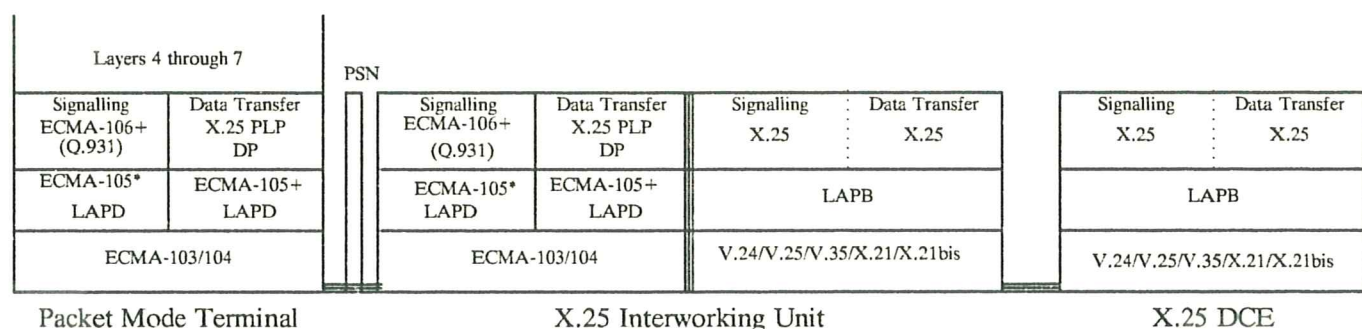


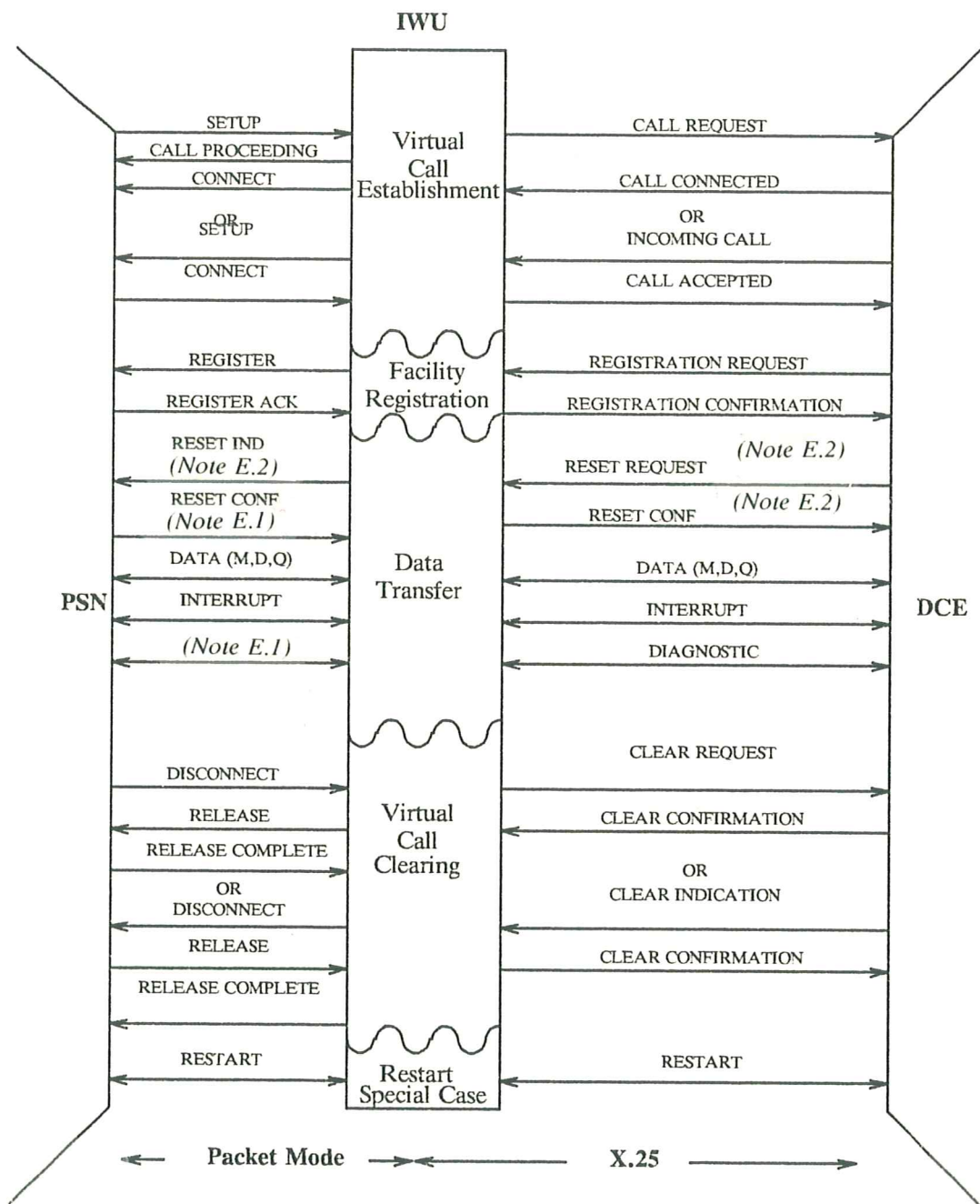
Figure E.3 - Interworking with an X.25 PSDN

The PSN intervenes with the same signalling protocol stack as shown for the Packet Mode Terminal, and with the data transfer protocol stack up to Layer 2.

One possible correspondence between ECMA-106+ (Q.931) based signalling elements and X.25 call control elements is shown in Figure E.4. No time sequences are implied by this diagram, only correspondences are shown. During the data phase a one-to-one correspondence may exist between packets on both sides of the interface. If segmenting or re-assembly operations are performed, in the interworking unit (i.e. if packet sizes are different on both sides of the interworking unit) a different number of packets will appear at each side of the interface during the data phase.

E.3 Examples of Interworking and End-to-End Connections

Figure E.5 illustrates an example of an end-to-end connection between a DPE-1 (e.g., Host Computer) on the left side of a PSN using the X.25 PLP Data Phase (DP) at Layer 3 and LAPD at Layer 2 and an X.25 PAD which is behind a Public Switched Data Network. At the IWU, mapping between the two protocol suites is done. Within the PSN, a virtual circuit is established between the Host and the IWU via out of band control. Note that the PSN could be either a PCSN or a PPSN. If it is a PCSN, it provides only a circuit switched path between the DPE-1 and the IWU.



NOTE E.1

Diagnostic Information Carried in Cause Field of Appropriate ECMA-106 + Message (e.g. STATUS or INFORMATION).

NOTE E.2

Opposite direction also may occur if Reset originated on PSN side.

Figure E.4 - Mapping of Virtual Call Control and Data Transfer Elements Across An IWU

After the virtual circuit connection is established, X.29 procedures are used in the data transfer phase using qualified data transfers for establishing the mode of PAD operation during subsequent user data transfers. In addition, X.29 procedures are used, for example, for end-to-end indication of BREAK carried in INTERRUPT packets.

During the data transfer phase, the sliding window flow control mechanism at Layer 3 is used to insure that buffers are not overflowed at protocol processing points as, for example, in the IWU.

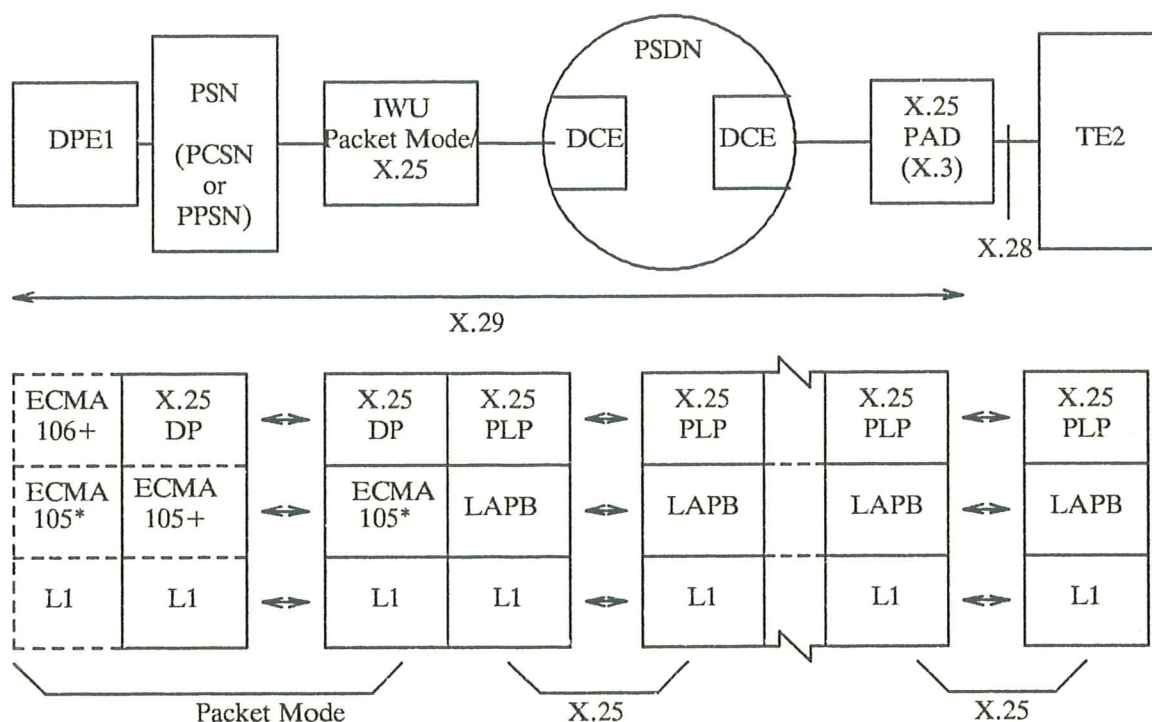


Figure E.5 - DPE-1 Connection to PAD

Figure E.6 illustrates an example of an end-to-end OSI connection through two PSNs interconnected via a PSDN. In this example two DPEs are interconnected.

As shown, the end-to-end connection involves two IWUs. Within the PSNs, the compatibility of protocols used for data transfer is established via lower layer compatibility information elements in ECMA-106+ (Q.931) messages. The protocols used at layers 4-7 are indicated by higher layer compatibility elements in ECMA-106+ (Q.931) messages.

Figure E.7 illustrates one example of interworking between an PSN using Packet Mode procedures and an 8802-type distributed LAN providing CO-NS service in conformance with ISO guidelines. The connection provided is an OSI Connection. In this case, the IWU is a LAN Adapter.

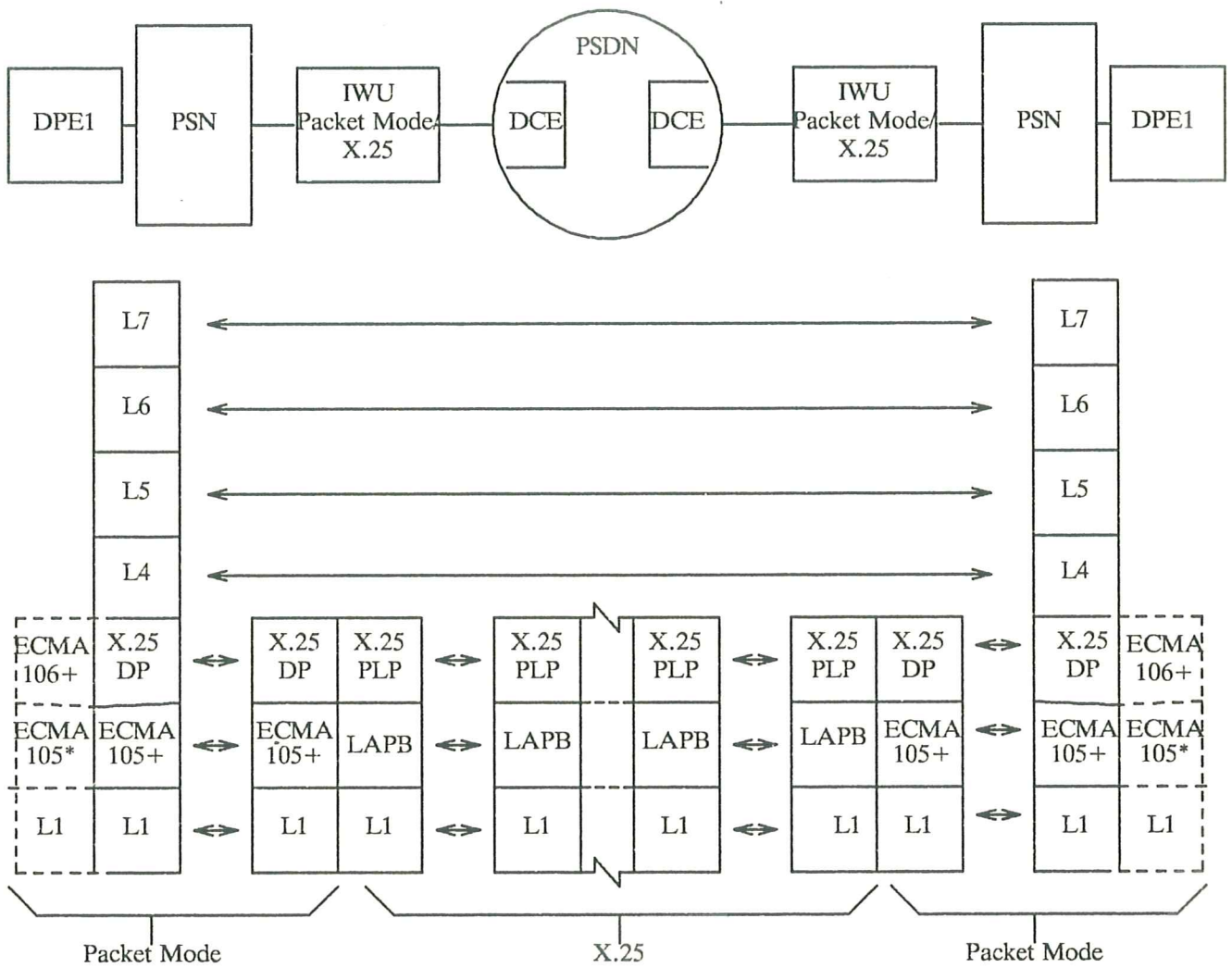


Figure E.6 - DPE-1 to DPE-1 Connection Through a PSDN

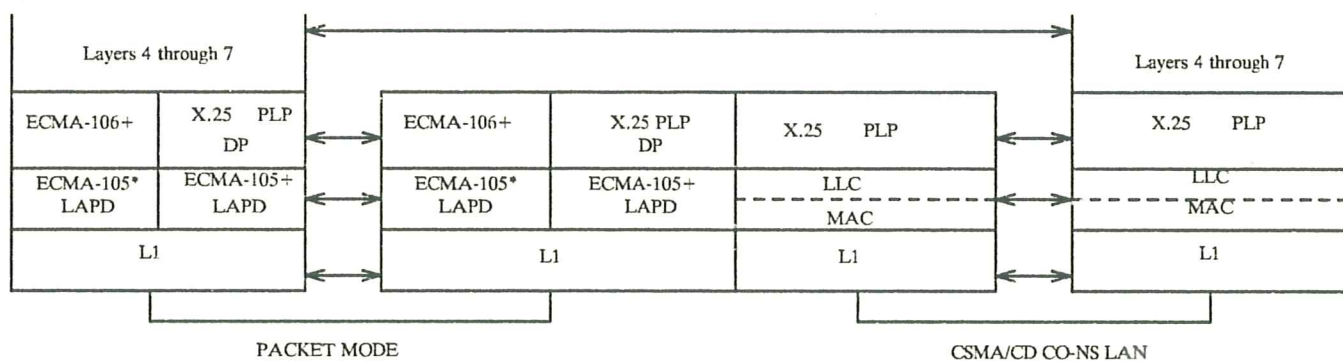
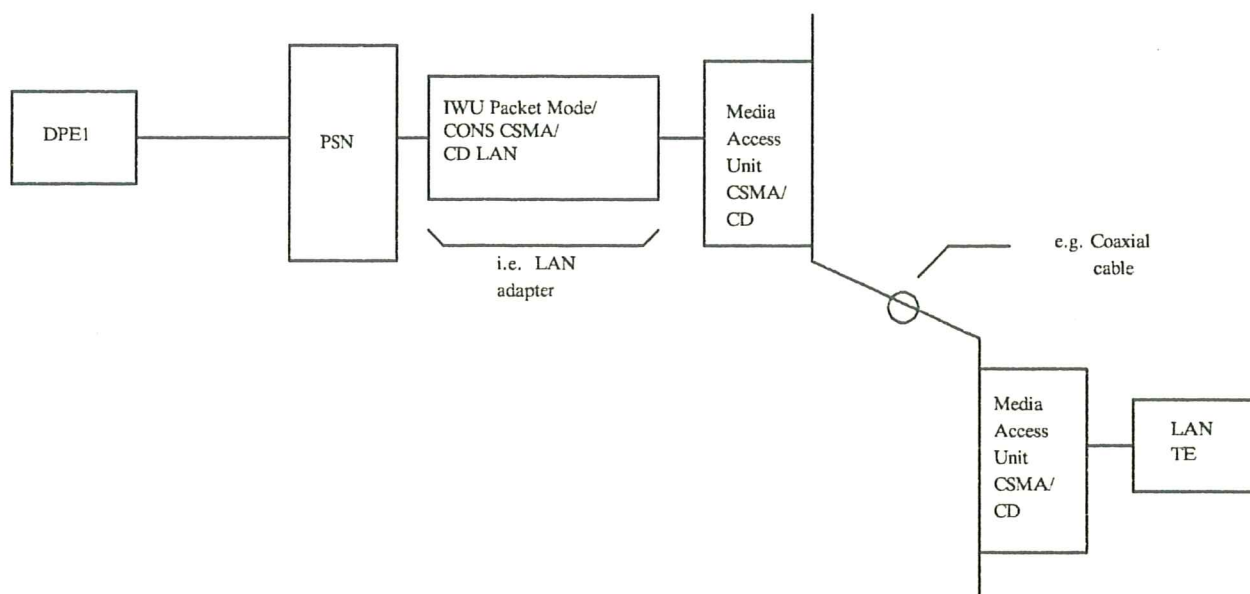


Figure E.7 - Interworking Between PSN and a LAN using X.25 PLP

E.4 Examples of A Connectionless-Mode Network Interworking Scenario

Figure E.8 illustrates an example of CL-NS mode interworking between a LAN and a frame switching network. Use is made of a sub-network dependent convergence protocol which allows the CL-NS 8473 protocol to run over a CO-NS sub-network.

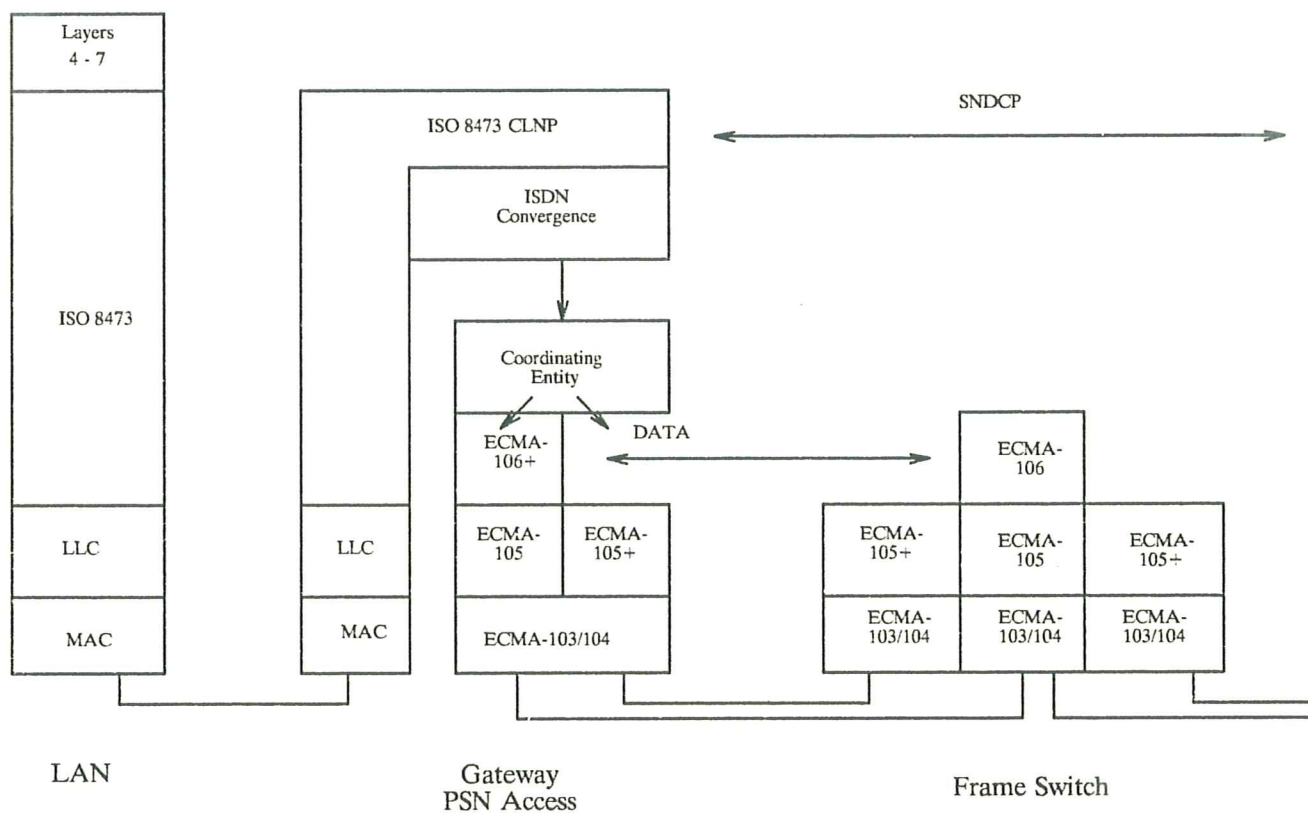


Figure E.8 - CL-NS Mode Interworking between a LAN and a Frame Switching Network

APPENDIX F

X.25 FACILITIES IN FRAME MODE

FEATURES PROVIDED BY X.25 AND NEEDED SIGNALLING FUNCTIONS TO PROVIDE X.25-LIKE FACILITIES USING THE FRAME MODE PROTOCOL

F.1 Introduction

This Appendix summarizes requirements for signalling functions needed to meet the requirements of mode service providing X.25-like facilities.

F.2 Comparison of X.25 Features to Frame Mode Protocol Features

F.2.1 Analysis of X.25 features

An in-depth analysis is provided of the X.25 features and their provision in the PSN X.25-like frame-mode service. Detailed descriptions of X.25 features are not repeated here. In many cases, related X.25 facilities are grouped together.

As an aid in the analysis, the following symbols are used to classify each X.25 feature:

- I = Inherent X.25 feature (e.g., a packet field)
- E = Essential X.25 service or optional user facility (per X.2)
- A = Additional X.25 optional user facility (per X.2)
- D = CCITT-Specified DTE facility
- O = X.25 feature or facility used in support of the OSI Network Service

The designations I, E, A, and D are mutually exclusive. The designation "O" can be applied to any of I, E, and D (it does not apply to A). Furthermore, the following symbols are used to classify how the X.25 feature relates to Q.931 (ECMA-106) enhancements and the packet mode protocol:

- Q = in (the 1984 Red Book version of) Rec. Q.931
- F = in (the 1984 Red Book version of) Rec. Q.931 but with at least some aspect for further study (e.g. no procedures or no encoding specified)
- L = in the packet mode proposal (above 1984 Red Book Rec. Q.931 capabilities)
- N = not mentioned in (the 1984 Red Book version of) Rec. Q.931 nor inherently necessary for the packet mode protocol

For example, the X.25 Calling Address Field (see 2.1) is classified as [I,O;Q]. This means it is an inherent feature of X.25 signalling needed to support the OSI Network Service; it also has a currently-defined Q.931 counterpart (i.e. the Originating Address Information Element with "Type of Address" not equal to "subaddress").

To meet the requirements of an X.25-like service, it is recommended that, at a minimum, all features of X.25 "signalling" designated I, E, and O be accommodated.

F.2.1.1 Addressing Capabilities

X.25 provides the following addressing capabilities for call setup and release:

- Calling and Called Address Fields (Classification: I,O;Q for both fields): while these fields are usually used to carry X.121 numbers, they also can be used to carry F.69 or E.163 numbers with the use of prefixes. The functionality of these fields is provided by the Origination and Destination Address Information Elements.
- Calling and Called Address Extension Facilities or AEFs (Classification: D,O;Q for both facilities): these facilities are used to carry an OSI Network Service Access Point (NSAP) Address or other type of address that is not used by public networks. The Origination and Destination Address Information Elements with "Type of Address" equal to "subaddress" almost provides the same functionality. The only difference is that, X.25 uses two bits in the AEFs to indicate the usage of the facilities (i.e. NSAP Address, partial NSAP Address, non-OSI address).

It should be noted that X.25 operation requires calling and called addresses to be made known to both X.25 DTEs involved in a virtual call. However, the CCITT Standardized Facility Information Element seems to provide flexibility with respect to satisfying this requirement.

F.2.1.2 Logical Channel Capabilities

The X.25 logical channel capabilities consist of the following:

- Logical channel identifier signaled in X.25 packets (Classification: I,O;L): while X.213 deals in terms of a single Network Connection (NC), it is recognized that a locally-defined parameter is needed to differentiate among multiple NCs; the logical channel identifier provides this function. The use of the ECMA-105 Data Link Connection Identifier (DLCI) provides the equivalent function.
- Incoming/Outgoing Calls Barred Facilities (Classification: E;N for both facilities): these facilities prohibit the presentation of calls for a given direction. Similar functionality is not proposed for the packet mode protocol.
- One-Way Outgoing and Incoming Logical Channel Facilities (Classification: E;N and A;N, respectively): these facilities reserve logical channels for use for call origination by the DTE and DCE, respectively. Similar functionality is not proposed for the packet mode protocol.
- Logical-channel-ranges parameters, that is, LIC, or Lowest Incoming Channel, etc. (Classification: I;N): segregation of the DLCI values for ensuring an outgoing or incoming "link" is not proposed for the packet mode protocol.

F.2.1.3 User Data Capabilities

The capabilities for carrying user data during X.25 call setup and clearing are reflected in the following:

- Fast Select Facility (Classification: E,O;F): similar functionality is not necessary for use of the User-User Information Element. This facility is mentioned in the CCITT Standardized Facilities Information Element as a binary, continuous facility. However, its use in X.25 is on a per-call basis without any previous subscription.
- Indication of Restricted Response when using the Fast Select Facility (Classification: E;F): similar functionality would be needed for interworking with X.31 terminals as well as with PSDNs.

- Fast Select Acceptance Facility (Classification: E;F): similar functionality is not necessary to protect terminals that can not process the User-User Information Element since it can be ignored according to Q.931. This facility is mentioned in the CCITT Standardized Facilities Information Element.
- User Data Field of X.25 Call Setup and Clearing packets (Classification: I,O;Q): this functionality is provided by the User-User Information Element, although 128 octets of data, as provided in X.25, may not always be available.

F.2.1.4 Flow Control Parameter Capabilities

The parameters related to flow control capabilities are the Layer 3 window and packet sizes for each direction of data transmission. This set of capabilities consists of the following:

- Flow Control Parameter Negotiation (Subscription) Facility (Classification: E;F): this facility is mentioned in the CCITT Standardized Facilities Information Element.
- Flow Control Parameter (i.e. Packet and Window size) Negotiation (Per-Call) Facility (Classification: E;F): requires the above a priori subscription. Similar functionality is to be provided in ECMA-106 enhancements.
- Non-standard Default Window and Packet Sizes (Subscription) Facilities (Classification: A;N for both facilities): similar functionality may be proposed for the packet mode protocol.

F.2.1.5 Throughput Designation Capabilities

Several X.25 facilities provide the functionality of designating the throughput for a given call. This throughput differs from the Information Transfer Rate of the Bearer or Low Layer Compatibility Information Element in that the Information Transfer Rate refers to the throughput of the underlying bearer capability. Thus, X.25 specifies throughputs ranging from 75 bits per second (bps) through 48000 bps, inclusive. Higher throughput rates for an individual call have been noted as for further study. This set of capabilities consists of the following:

- Default Throughput Classes Assignment Facility (Classification: A;N): this facility allows specification of the throughput class pertaining to all virtual circuits at an interface; in its absence, the access-line rate serves as the default.
- Throughput Class Negotiation (Subscription) Facility (Classification: E,O;F): this facility is mentioned in the CCITT Standardized Facilities Information Element.
- Throughput Class Negotiation (Per-Call) Facility (Classification: E,O;L): requires the above a priori subscription. Similar functionality is to be provided in ECMA-106 enhancements.
- Minimum Throughput Class Negotiation Facility (Classification: D,O;N): this facility allows two DTEs to exchange information pertaining to the minimum throughput acceptable for the call.

F.2.1.6 Transit Delay Designation Capabilities

Two X.25 facilities provide the functionality of designating the transit delay for a given call. This set of capabilities consists of the following:

- Transit Delay Selection And Indication Facility (Classification: E,O;N): this facility is used to indicate to the DTE the transit-delay value attributable to the network for a given call.
- End-to-End Transit Delay Negotiation (Classification: D,O;N): this facility allows two DTEs to exchange information pertaining to the desired and minimum transit delay to apply to the call.

These functions are to be included in ECMA-106 enhancements.

F.2.1.7 D-Bit Capabilities

There are two X.25 features related to this set of capabilities; these are:

- The "D-bit" position (bit 7 of octet 1) of call setup packets (Classification: I,O;L): this bit allows two X.25 DTEs to negotiate whether the Delivery Confirmation service of the OSI Network Service will be used on a given call. Similar functionality is to be provided in enhancements to ECMA-106.
- D-bit Modification Facility (Classification: A;N): similar functionality is not proposed for the packet mode protocol.

F.2.1.8 Expedited Data Negotiation

The X.25 feature to provide this capability is the Expedited Data Negotiation Facility (Classification: D,O;N). This facility allows two DTEs to negotiate whether the Expedited Data service of the OSI Network Service will be used on a given call. Similar functionality is to be provided in enhancements to ECMA-106.

F.2.1.9 Call-Clearing Diagnostic Information

There are two X.25 features that provide information pertaining to the reason for clearing a call; these are:

- Clearing Cause (Classification: I,O;Q): this provides the reason why a call was cleared and, with the partitioning of the cause-code space in 1984 X.25, and as further clarified in ISO 8208, some indication of where the call was cleared (e.g., public network, private network, X.25 DTE). Similar functionality is provided in the Cause Information Element of ECMA-106.
- Clearing Diagnostic Code (Classification: I,O;N): this provides additional information on call clearing and consists of a code space distinct from the clearing-cause code space. In providing the OSI Network Service, it is necessary for the X.25 DTE to signal, in an X.25 DTE- originated CLEAR REQUEST packet, the reason for the clearing. Such diagnostics are not in CCITT X.25 but are specified in ISO 8208. It does not appear that ECMA-106 provides a similar additional code space to the cause-code space although octet 5 of the Cause Information Element does provide a field for such additional information. Furthermore, it appears that cause and diagnostic code information of ISO 8208 can be signaled if bits 7 and 6 of octet 3 of the Cause Information Element are set to ZERO-ONE.

F.2.1.10 Charging Capabilities

Several X.25 facilities provide the functionality of designating a charging party for a call and of indicating the associated charges. These are:

- Reverse Charging Facility (Classification: A;F): indicates that the called X.25 is to be charged for the call. This functionality appears to be available to DTEs in the CCITT Standardized Facilities Information Element although it is not singled out as an X.25 facility.
- Reverse Charging Acceptance Facility (Classification: A;F): this functionality appears to be available in the CCITT Standardized Facilities Information Element. However, Q.931 classifies this facility as both per-call and continuous whereas it is only "continuous" (i.e. by subscription) in X.25.
- Network User Identification (Subscription) Facility (Classification: A;N): this allows the a priori establishment of a third-party billing identity. Similar functionality is not proposed for the packet mode protocol.
- Network User Identification (Per-Call) Facility (Classification: A;N): this allows the per-call specification that charges for the call be assigned to a pre-established third party. Similar functionality is not proposed for the packet mode protocol.

- Local Charging Prevention Facility (Classification: A;F): this prevents an X.25 DTE from accruing any charges and appears to be specified in the CCITT Standardized Facilities Information Element ("X.25" is missing as a modifier in Q.931). Similar functionality is not proposed for the packet mode protocol.
- Charging Information Request (Subscription) Facility (Classification: A;F): this facility requests that charging information be provided at the end of every call. It is mentioned in the CCITT Standardized Facilities Information Element.
- Charging Information Request (Per-Call) Facility (Classification: A;F): this facility requests that charging information be provided at the end of this call. It is also mentioned in the CCITT Standardized Facilities Information Element, although it is not clear if the per-call and continuous usage in Q.931 are identical to the relationship of this and the previous facility in X.25. Similar functionality is not proposed for the packet mode protocol.
- Charging Information Indication Facility (Classification: A;N): this facility supplies the actual charges for a call.

F.2.1.11 Closed User Group Capabilities

The set of X.25 closed user group (CUG) capabilities allows access to X.25 DTEs to be restricted. Similar functionality is not proposed here unless, for interworking purposes, it is desirable for a packet mode protocol device to belong to the same CUG as an X.31 device or an X.25 DTE attached to a PSDN (in this case, accommodation of at least items (a) and (f) below is necessary). The X.25 facilities consist of the following:

- a) CUG Facility (Classification: E;N)
- b) CUG With Outgoing Access Facility (Classification: A;N)
- c) CUG With Incoming Access Facility (Classification: A;N)
- d) Incoming Calls Barred Within A CUG Facility (Classification: A;N)
- e) Outgoing Calls Barred Within A CUG Facility (Classification: A;N)
- f) CUG Selection Facility (Classification: E;N)
- g) CUG With Outgoing Access Selection Facility (Classification: A;N)

F.2.1.12 Bilateral Closed User Group Capabilities

The set of X.25 bilateral closed user group (BCUG) capabilities allows access to be restricted between two DTEs. Similar functionality is not proposed for the packet mode protocol. The X.25 facilities consist of the following:

- BCUG Facility (Classification: A;N)
- BCUG With Outgoing Access Facility (Classification: A;N)
- BCUG Selection Facility (Classification: A;N)

F.2.1.13 RPOA Capabilities

The set of RPOA capabilities, which allows an X.25 DTE to specify one or more transit networks to be transited for a call, consists of the following:

- RPOA Subscription Facility (Classification: A;N): this facility, allows a list of transit networks to be specified a priori to apply to all calls unless overridden for a single call.
- RPOA Selection Facility (Classification: A;F): this facility allows a list of transit networks to be specified to apply to a given call only. Similar functionality appears to be provided by the Transit Network Selection Information Element if used in a SETUP message.

F.2.1.14 Hunt Group Facility

The X.25 Hunt Group Facility (Classification: A;N) provides a distribution function for incoming calls having an address associated with the hunt group. Similar functionality is not proposed for the packet mode protocol.

F.2.1.15 Call Redirection Capabilities

The set of capabilities related to call redirection consists of the following X.25 facilities:

- Call Redirection Facility (Classification: A;N): this subscription X.25 facility provides for the redirection of incoming calls to an X.25 DTE when, for example, it is busy or out of order. Similar functionality is not proposed for the packet mode protocol.
- Call Redirection Notification (Classification: A;Q): this per-call X.25 facility is used to notify a DTE that an incoming call is a result of a redirection at another interface. This facility carries the address of the originally-called DTE. This appears to be equivalent to the functionality X.25 of the Redirecting Address Information Element. The X.25 facility also carries a reason for the redirection; the equivalent functionality does not appear to be contained in Q.931. It should also be noted that a "call redirection/diversion notification" facility is mentioned as a per-call, binary facility in the CCITT Standardized Facilities Information Element; the relationship of this usage (for invocation/revocation) of this facility to its usage in X.25 is not clear (X.25 does not require previous notification of usage). The functionality of the X.25 facility is not proposed for the packet mode protocol.
- Called Line Address Modified Notification Facility (Classification: A;N): this facility indicates the reason why the Called Address in an X.25 CALL CONNECTED packet is different than the Called Address in the CALL REQUEST packet. As such, it has no equivalent in Q.931. However, the Connected Address Information Element in Q.931 provides the similar functionality of the Called Address in the CALL CONNECTED packet. Functionality similar to the X.25 facility is not proposed for the packet mode protocol.

F.2.1.16 Extended Packet Sequence Numbering

This X.25 facility (Classification: A;N) allows for the use of modulo 128 numbering during the data-transfer phase of the X.25 Packet Layer. This facility is mentioned as a binary, continuous facility in the CCITT Standardized Facilities Information Element; however, this usage appears to be to indicate invocation/revocation rather than a procedural definition. Similar functionality is to be provided in ECMA-106 enhancements.

F.2.1.17 Packet Retransmission

This X.25 facility (Classification: A;N) allows an X.25 DTE to request retransmission of DATA packets across the X.25 DTE/DCE interface. This facility is mentioned as a binary, continuous facility in the CCITT Standardized Facilities Information Element; however, this usage appears to be to indicate invocation/revocation rather than a procedural definition. Similar functionality is not proposed for the packet mode protocol.

F.2.1.18 On-line Facility Registration Capabilities

This set of X.25 capabilities consists of the following:

- On-line Facility Registration Facility (Classification: A;N): subscription to this facility allows a DTE to invoke/voke other X.25 facilities through the use of Registration packets. Similar functionality is not proposed for the packet mode protocol.
- Registration Packets (Classification: A;F): these packets provide the vehicle through which registration (invocation/revocation) of X.25 facilities is "signalled." The functionality, which can be provided by the ECMA-106 REGISTER messages, is considered sufficient.

F.2.1.19 Permanent Virtual Circuits

Permanent Virtual Circuit (PVC) service (Classification: E;N) is one of the two packet services (Virtual Call being the other) of X.25. As such, it does not involve any "signalling" before data transfer can begin. Similar functionality is not proposed for the packet mode protocol. However, consideration could be given to a similar service where the relationship of "source" and "sink" LAPD DLCIs is established administratively and invoked at the establishment of the physical interface.

F.2.1.20 New OSI Network Service Parameters

Two new Quality of Service (QoS) parameters have been proposed for X.213. These are:

- Protection, which allows a user to indicate security requirements for a given Network Connection (to permit, for example, route selection and the possible use of encryption); and
- Priority, which allows a user to indicate the need to keep a Network Connection versus the need to gain a Network Connection.

While similar functionality is not proposed for the packet mode protocol, it should be noted that flexibility in defining the packet mode protocol and services should be maintained to meet the requirements of maintaining alignment with CCITT Rec. X.213 as it evolves.

APPENDIX G

NETWORK TOPOLOGIES

G.1 Introduction

In Clause 7 the concepts of frame switching and frame relaying are discussed. This Appendix gives examples which illustrate those concepts.

G.2 Network Topologies

Figure G.1 below illustrates an example of a network topology in which the network would not be required to fully terminate the packet mode protocol (i.e. provide frame relay bearer service). Here, the network provides a link layer relay function only to provide a virtual circuit path between user interfaces which terminate on the same network switching vehicle. At throughputs less than 64 Kbps as shown in Clause 7 such a connection will not exceed the maximum window size limits and thus the link layer relay service may be provided.

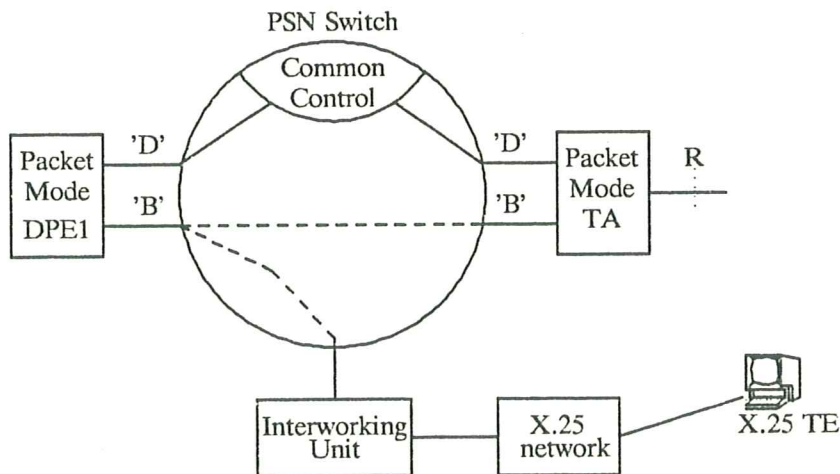


Figure G.1 - Packet Mode within a single PSN Switch

As per the example topology shown in Figure G.1, the packet mode DPE-1 on the left would have simultaneous virtual connections (differentiated via the Layer 2 address) established, one with the packet mode TA on the right and one with the interworking unit used to interface an X.25 network. The level of termination in the PSN switch could then be point "b" of Figure 12.

A second example of a possible network topology is shown in Figure G.2 below. In this case the bearer protocols used in the access are fully terminated in each switch used for providing the virtual channel connections between the TA on the left and the DPE-1 on the right (i.e., frame switching).

This would be required when the limits for either window size or frame loss described in Clause 7 are exceeded. The level of termination between the TA and the DPE-1 would then be point "c" of Figure 12.

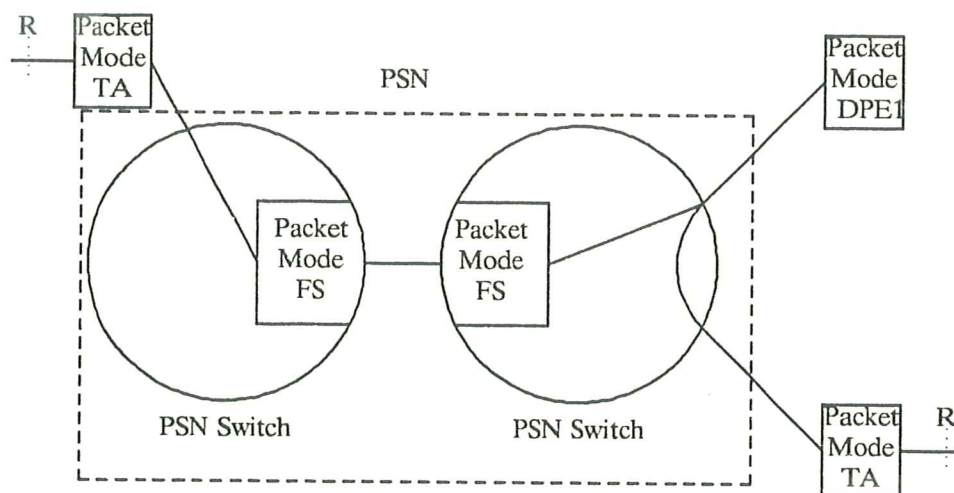


Figure G.2 - Packet Mode between two PSN Switches

Note, however, that the network does not terminate the protocol in providing the connection between the DPE-1 and TA which both access the PSN switch on the right. The network might only terminate at point "b" of Figure 12 between these endpoints.

A third example of a network topology is shown in Figure G.3.

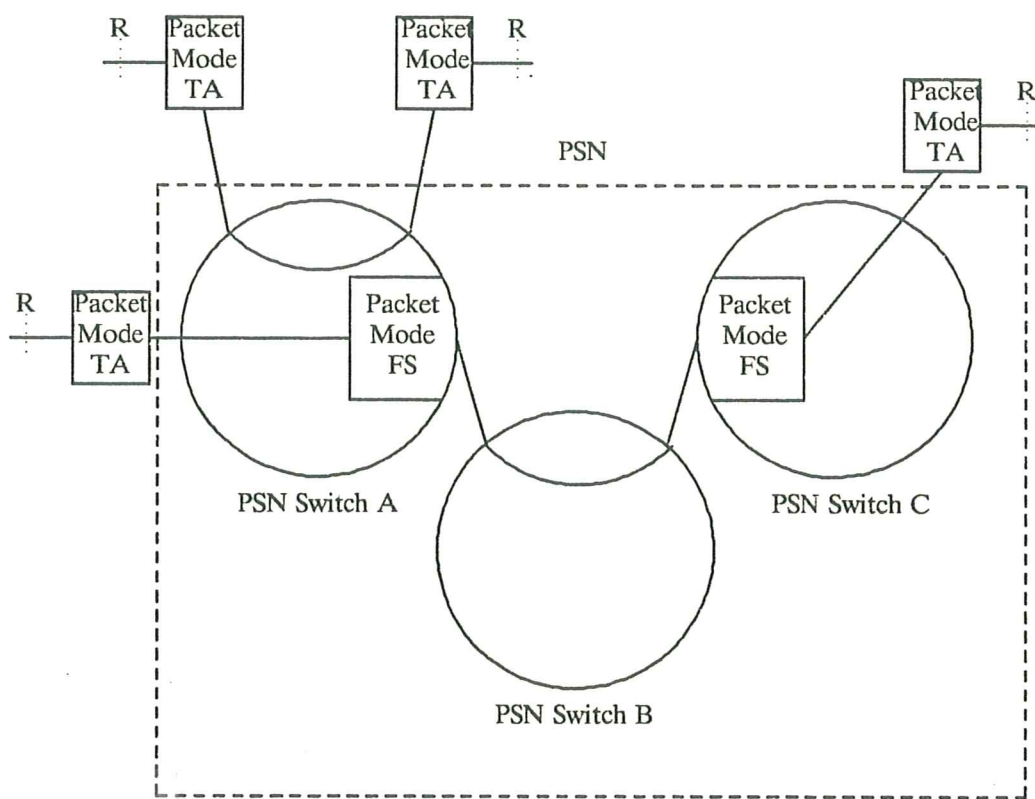


Figure G.3 - Packet Mode over Network Relay

If the conditions for frame relay service in Clause 7 are met, network switch B may not be required to do full protocol termination in order to provide a tandem switched virtual circuit path. It may only offer point "b" of Figure 12 level termination, or even just point "a" if, for example, it provides a circuit switched path.

For networks serving users without severe transit delay or high throughput requirements, a general philosophy for congestion control might be to fully terminate the protocols at the network edges in order to "protect" the network from overflow conditions and for maintaining full account of data transferred through the network.

G.3 Quality of Service Considerations

As described in Clause 7, there is a relationship between Quality of Service parameters and the degree of protocol processing performed at a node. The topological implications of the processing/congestion control trade-off are those of determining when congestion protection is required for a given topology. In general, the more complex the topology, the greater the risk of congestion, and the greater the need for flow control processing. Conversely, a simple topology coupled with high bandwidth interconnections has a low risk of congestion, but a need for high throughput. For this case, elimination of protocol processing is beneficial to gain higher throughput and lower transit delay.

A further consideration of throughput class provision for a connection involving two or more network switches (such as in Figures G.2 and G.3) is the bandwidth of the physical channels used for the connection. In order to provide for the same high throughput when operating with a given window size in the endpoints (which may be optimized for single switch operations) in this case, full protocol termination may be required in the Packet Handlers if the bandwidth of the interconnecting channel is small (e.g. B-Channel). Full protocol termination may not be needed if a wider bandwidth channel is used (e.g. H-channel). The factors involved in these considerations are fully discussed in Clause 7.

APPENDIX H

EXAMPLES OF CHANNEL ESTABLISHMENT AND RELEASE SIGNALLING SEQUENCES

Call Establishment and Release for CO-NS

An example of call establishment and release procedures using Standard ECMA-106 is given in Figure H.1. In the example, a call is placed through a single PSN between two DPE-1 endpoints. The Connection-Mode Network Service call phases are indicated to the left of the Figure. This scenario assumes frame switching in the PSN.

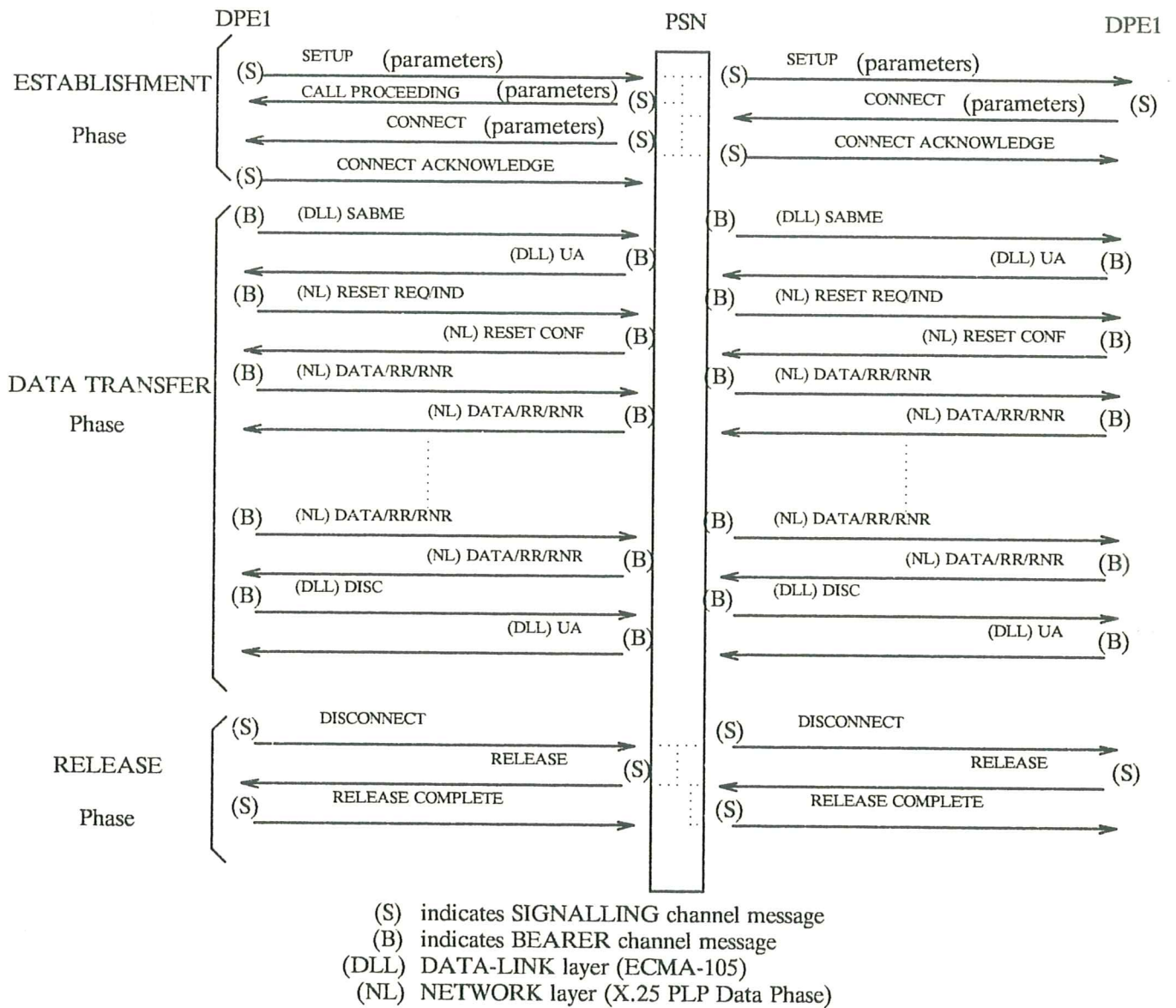


Figure H.1 - Call Setup and Teardown Scenario

APPENDIX I

JUSTIFICATION FOR ISO 8208 PACKET TYPES NOT USED FOR PROVISION OF CO-NS OVER FRAME BEARER SERVICES

I.1 ISO 8208 Packet Types Not Used for Data Transfer

To determine whether the limited set of packet types identified for use on the bearer channel is sufficient to provide the capabilities of X.25 (e.g. when interworking with an X.25 network), each of the unused packet types must be examined to see that the function of that packet type is provided by the signalling channel protocol.

I.1.1 Call Request / Incoming Call

These two packet types are the same packet with different names depending on whether the message is being sent or received. The functions of these packets are to request or announce a call and to negotiate facilities. These functions are provided using the SETUP message of ECMA-106+.

I.1.2 Call Accepted / Call Connected

These two packets are the same packet with different names to indicate whether the packet is being received or sent. The functions of these packets are to accept or confirm acceptance of a call and to complete the negotiation of facilities. These functions are provided with the CONnect message of ECMA-106+.

I.1.3 Clear Request / Clear Indication

These two packets are the same packet with different names to indicate whether the packet is being sent or received. The function of these packets is to indicate that the call is to be cleared. The same function is accomplished using the DISConnect message of ECMA-106+.

I.1.4 Clear Confirmation

This packet is used to confirm the clearing of the call. The equivalent function is performed by the RELease, or RELease COMPlete messages of ECMA-106.

I.1.5 Reject

The REJECT message and associated retransmission mechanism provide an optional facility in X.25, one classified as an "additional" facility. For reasons of network compatibility, use of the REJECT facility is not allowed for a DCE. Because of this, the facility is asymmetric and of marginal utility and for these reasons is not included in the Packet Mode protocol.

I.1.6 Restart Request / Restart Indication

These two packets are the same packet with different names to indicate whether the packet is being sent or received. The function of these packets is to indicate the need to restart all of the logical channels/logical links on a specified physical channel or interface (i.e., clear all active virtual channels). This can be accomplished through the use of the REStArt message of ECMA-106*.

I.1.7 Restart Confirmation

This packet is used to acknowledge the request to restart all the logical channels or logical links on a specified physical channel or interface. This function is provided by the REStArt ACKnowl- edge message of ECMA-106+.

I.1.8 Diagnostic

This packet is used to carry diagnostic information regarding a particular call. The equivalent function is performed using the STAtus ENQuiry, STAtus, and INFORmation messages of ECMA-106*.

I.1.9 Registration Request

This packet is used to register for network facilities. The equivalent function is performed using the REGister messages of ECMA-106+.

I.1.10 Registration Confirmation

This packet is used to indicate the granting or denying of network facilities to the terminal. The equivalent function is performed using the REGister ACKnowledge, and REGister REJect messages of ECMA-106*.

APPENDIX J

LIST OF ACRONYMS

BCUG	Bilateral Closed User Group
Bn/H	B-Channel sub n, H.Channel
CBO	Continuous Bit/Byte Stream Operation
CC	Connection Control
CCITT	International Telegraph and Telephone Consultative Committee
CD	Collision Detection
CE	Coordinating Entity
CEI	Connection Endpoint Identifier
CEPT	Conference of European Posts and Telecommunications Administrations
CL	Connectionless
CLNP	Connectionless Network Protocol
CL-NS	Connectionless Network Service
CO	Connection Oriented
CO-NS	Connection-Mode Network Service
CR	Call Reference
CR	Carriage Return
C/R	Command/Response
CRC	Cyclic Redundancy Check
CSMA	Carrier Sense Multiple Access
CSMA/CD	Carrier Sense Multiple Access / Collision Detection
CUG	Closed User Group
DCE	Data Circuit - Terminating Equipment
D-CH	D-Channel
DISC	Disconnect
DL	Data Link
DLCI	Data Link Connection Identifier
DLL	Data Link Layer
DM	Disconnected Mode
DP	Data Phase
DPE	Data Processing Equipment
DTE	Data Terminal Equipment
ES	End System
FBER	Frame Bearer Error Rate
FCS	Frame Check Sequence
FH	Frame Handler
FR	Frame Relay
FRMR	Frame Reject Mode Request
FS	Fame Switch

HDLC	High-level Data Link Control
HLC	High Layer Compatibility
IEC	International Electrotechnical Commission
IONL	Internal Organization of the Network Layer
IP	Interworking Port
IS	Intermediate System
ISDN	Integrated Services Digital Network
ISO	International Organization for Standardization
Ia-Ct	I-format Fame Acknowledged Count
IWU	Interworking Unit
LAN	Local Area Network
LAPB	Link Access Procedure-Balanced
LAPD	Link Access Procedure < <D> >
LCI	Logical Channel Identifier
LF	Line Feed
LIC	Lowest Incoming Channel
LL	Logical Link
LLC	Low Layer Compatibility
LLME	Low Layer Management Entity
LSDU	Link Service Data Unit
MAC	Media Access Control
MCC	Management to Call Control
MCE	Management to Coordinating Entity
MDL	Management to Data Link Layer
MNLP	Management to Network Layer Packet
MNLS	Management to Network Layer Signalling
MNR	Management to Network Routeing
MPH	Management to Physical Layer
MPX	Multiplexer
N	Network
NC	Network Connection
NLP	Network Layer Packet
NLS	Network Layer Signalling
NPDU	Network Protocol Data Unit
N(R)	Receive Sequence Number
NR	Network Routeing
NS	Network Service
NSAP	Network Service Access Point
NSDU	Network Service Data Unit
OSI	Open Systems Interconnection
PAD	Packet Assembler / Disassembler
PCSN	Private Circuit Switched Network
PDU	Protocol Data Unit
PH	Packet Handler
PH	Physical Layer
PLP	Packet Layer Protocol
PPCSN	Private Packet and Circuit Switched Network

PPSN	Private Packet Switching Network
P(R)	Packet Receive variable
PSDN	Packet Switched Data Network
PSN	Private Switching Network
PSPDN	Packet Switched Public Data Network
PT	PSN Terminator
PVC	Permanent Virtual Circuit
QoS	Quality of Service
REJ	Reject
RNR	Receive Not Ready
RPOA	Recognized Private Operating Agency
RR	Receive Ready
RT	Round-Trip
SABME	Set Asynchronous Balanced Mode Extended
SAP	Service Access Point
SAPI	Service Access Point Indicator
SG	Study Group
SN	Subnetwork
SNAcP	Subnetwork Access Protocol
SNDCF	Subnetwork Dependent Convergence Functions
SNICF	Subnetwork Independent Convergence Functions
SNDP	Subnetwork Dependent Convergence Protocol
SNICP	Subnetwork Independent Convergence Protocol
TA	Terminal Adapter
TE	Terminal Equipment
TEI	Terminal Endpoint Identifier
TPDU	Transport Protocol Data Unit
TW	Transmit Window Size
UA	Unnumbered Acknowledgement
UI	Un-numbered Information
VC	Virtual Channel
VL	Virtual Link
V(x)	Variable, argument x
Ww	Working Window Size

