GA27-3345-2

The X.25 Interface For Attaching SNA Nodes To Packet-Switched Data Networks General Information Manual

IBM

The X.25 Interface For Attaching SNA Nodes To Packet-Switched Data Networks General Information Manual

Third Edition (March 1985)

This third edition continues to be based on CCITT Recommendation X.25 as published in the 'Yellow Book' instead of the 'Red Book' version, adopted by the VIIIth Plenary Assembly in 1984. Text in Part I that differs from that in the previous edition is identified by vertical bars in the left margin of this edition.

PART II of this edition is expanded to include detailed specification of the protocols, formats and procedures for the Enhanced Logical Link Control (ELLC) offered by some IBM SNA X.25 DTEs for use on SNA-to-SNA connections, as well as those employed by some IBM SNA X.25 DTEs on SNA-to-SNA and SNA-to-Non_SNA connections.

PREFACE

This manual describes the elements, including optional user facilities, of CCITT Recommendation X.25 - INTERFACE BETWEEN DATA TERMINAL EQUIPMENT (DTE) AND DATA CIRCUIT TERMINATING EQUIPMENT (DCE) FOR TERMINALS OPERATING IN THE PACKET MODE ON PUBLIC DATA NETWORKS (Geneva, 1976; amended Geneva, 1980) - that are applicable to IBM SNA network nodes that can attach to X.25-based Packet-Switched Data Networks (PSDNs)

Note: This third edition continues to be based on CCITT Recommendation X.25 as published in the 'Yellow Book' instead of the 'Red Book' version, adopted by the VIIIth Plenary Assembly in 1984.

Excerpts from CCITT Recommendation X.25 (Geneva, November 1980), including sections 1.1 - 1.2, 2.1 - 2.4 (except LAP procedures), 3.1 - 3.5, 4.1 - 4.6, 6.1 - 6.3, 6.5 - 6.8, 7.1 - 7.2, 7.4 (except Datagrams), Annex A (except Datagrams), Annex B, Annex C, Annex D and Annex E are reprinted in this manual.

IBM SNA data terminal equipment (DTEs) that use the X.25 recommendation to interface to PSDN data circuit-terminating equipment (DCEs) are referred to in this document as IBM SNA X.25 DTEs. Elements of CCITT Recommendation X.25 (1980) are selected by IBM to support two basic categories of connections:

a. SNA-to-SNA:

   connections between SNA X.25 DTEs, via virtual calls or permanent virtual circuits, or both, are accommodated through intervening packet-switched data network(s).

b. SNA-to-non_SNA:

   connections between SNA X.25 DTEs and non-SNA X.25 DTEs, via virtual calls or permanent virtual circuits, or both, are accommodated through intervening packet-switched data network(s).

The DTE/DCE interfaces for SNA-to-SNA connections and SNA-to-non_SNA connections differ only at the packet level; therefore, the definitions and descriptions of the physical level and the link level apply equally to both types of connections.

Information in this manual must not be construed as describing any specific IBM product (machine or program) or service. Neither can it be construed to mean that all or any specific IBM products necessarily provide only, or all of, the X.25 DTE/DCE interface functions described herein.

In addition, note that the ELLC, QLLC and PSH Protocols defined in this manual describe existing implementations of end-to-end control functions that are required above the X.25 DTE/DCE Interface. Further end-to-end controls applicable for use with X.25-based network services may be implemented as requirements become more clearly identified. Readers are cautioned to refer to appropriate IBM product description and operation manuals for information regarding the availability and characteristics of X.25 DTE/DCE interface functions supported by specific IBM products.

The reader is assumed to be conversant with both CCITT Recommendation X.25 and SNA. A list of applicable references is included, at the end of part I, to help the less informed reader to understand these subjects.

This manual is composed of two parts:

PART I - contains an overview of the relationship between SNA and X.25; and,

PART II - is patterned after excerpts from CCITT Recommendation X.25 (Geneva, November 1980) with modifications identified as noted in the introduction to Part II.

PART I

This part presents an overview of the relationships that exist between SNA and X.25 composed of:

Chapter 1, "INTRODUCTION," which briefly describes the evolution of CCITT Recommendation X.25, IBM's statement of direction relative to its support and the evolution of IBM's support

Chapter 2, "ARCHITECTURAL CONSIDERATIONS," which states the architectural relationships between SNA and X.25; it also states the SNA assumptions upon which IBM X.25 support is predicated.

Chapter 3, "X.25 ELEMENTS IN IBM SNA X.25 DTEs," which describes the basic elements of CCITT Recommendation X.25 selected by IBM for SNA-to-SNA connections and for SNA-to-non_SNA connections using virtual circuit services provided by X.25-based PSDNs.

Chapter 4, "OTHER SYSTEM CONSIDERATIONS," which briefly describes security, reliability, availability and serviceability as they relate to the operation of SNA in PSDN environments.

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1.0 INTRODUCTION

Maturing packet-switching technology continues to gain acceptance among Telecommunications Administrations, as well as information processing communities, throughout the world during the nineteen-eighties. Packet-switched data network services are now available for public use in numerous countries and several such networks are being operated for private use by corporate enterprises and government agencies. PSDNs are currently being installed in both the public and private sectors around the world and still others are being planned to begin operations within the decade.

1.1 EVOLUTION OF THE X.25 DTE/DCE INTERFACE

The International Telegraph and Telephone Consultative Committee (CCITT) has developed Recommendation X.25 to facilitate attachment of customer data terminal equipment to public PSDNs. It was first adopted[8] at the CCITT VIIth Plenary Assembly in 1976 to provide a "standard" interface between customer-provided data terminal equipment (DTE) and public PSDN data circuit-terminating equipment (DCE) (commonly referred to as the X.25 DTE/DCE interface).

In 1978, updates contained in a provisional recommendation[9] were approved by the CCITT. A revised version[1] incorporates additional enhancements approved by the CCITT plenary assembly at Geneva in November of 1980.

Numerous Telecommunications Administrations, Recognized Private Operating Agencies (RPOAs) and Common Carriers have either implemented, or published plans to implement, PSDNs with DTE/DCE interfaces based on CCITT Recommendation X.25. Some of these are summarized in Table I-1 based on information publicly available as of December 1984. Several private PSDNs have also adopted versions of the X.25 DTE/DCE interface as a method of attachment.

Increasing numbers of users of public and private PSDNs specify DTEs that are capable of attaching via X.25 DTE/DCE interfaces. They desire vendor-independent, common attachment interfaces such that DTEs of one vendor can communicate effectively with DTEs of other vendors through public or private PSDNs, or both.

Elements of the X.25 DTE/DCE interface can help to meet the former requirement. They enable DTEs to connect to PSDNs, to establish connectivity to other DTEs through one or more PSDNs and to transfer data packets from one DTE to the other. While such connectivity is essential to effective communication, <u>it cannot be assumed that simply because two devices can connect to a PSDN via the X.25 DTE/DCE interface that they can communicate with each other in any useful way.</u>

Effective communication between DTEs requires additional protocols at one or more levels above the packet level of the X.25 DTE/DCE interface. Efforts are currently being made within the standards community to develop a standard networking protocol, referred to as Open Systems Interconnection (OSI), to meet the needs of such higher levels. These efforts are taking place within the International Organization for Standardization (ISO)[2], the International Telephone and Telegraph Consultative Committee (CCITT)[4], the European Computer Manufacturers Association (ECMA)[5], the Institute of Electrical and Electronic Engineers (IEEE)[3] and various other organizations.

The ISO has published a Basic Reference Model for OSI[2]. The protocols that allow effective communication between diverse IBM SNA X.25 DTEs such as data processing, distributed computing and office systems are provided by the higher levels of SNA. Reference 15 describes some relationships that exist between SNA[22,23,24,25,26] and the ISO Basic Reference Model for OSI[2]. Analyses[6,7,27,30] have shown that X.25 DTE/DCE interfaces specified for various public and private PSDNs generally differ to some extent. Such differences have been attributed to differing implementation time frames or interpretations of the Recommendation, or both. Such diversity has been recognized by the Common Carriers, Administrations and Recognized Private Operating Agencies (RPOAs). Efforts by some of these organizations to minimize such differences by generally agreeing to implement a less permissive X.25 Recommendation[1,7,16,21] has, thus far, met with limited success. Thus, it can be anticipated that, as X.25 continues to evolve, network specific differences in interface definition will probably continue for the foreseeable future.

CCITT Recommendation X.25 has continued to evolve during the 1980-1984 plenary period and additional functional capabilities have been adopted. IBM anticipates, however, that such additional capabilities will not impair the operation of DTE implementations based on the version of CCITT Recommendation X.25 adopted by the VIIth Plenary Assembly at Geneva in November 1980 and published in the 'Yellow Book' and that are reflected in this manual. Additional capabilities adopted for CCITT Recommendation X.25 by the VIIIth Plenary Assembly are being evaluated to ascertain their applicability to DTEs in SNA environments and decisions regarding support of such additional capabilities will be based on future business and technical considerations.

Table I-1: Some Plans and Implementations for Networks offering X.25 Interfaces

Country	Network	Availability
ARGENTINA	ARPAC	1983
AUSTRALIA	AUSTPAC	1983
AUSTRIA	PKTNET	1982
BELGIUM	DCS	1982
BRAZIL	RENPAC	1984
CANADA	DATAPAC	1977
	INFOGRAM	1982
CHILE	(ECOM)	1981
DENMARK	DATAPAK	1983
EUROPE	EURONET	1979
FINLAND	DATAPAK	1983
FRANCE	TRANSPAC	1978
GERMANY	DATEX-P	1981
HONG KONG	CWNET	1984
	DATAPAC	1984
INDONESIA	PACKSATNET	1984
IRELAND	EIRPAC	1984
ISRAEL	PKTNET	1982
ITALY	ITAPAC	1984
JAPAN	DDX-P	1980
	VENUS	1982
KOREA	DACOM-NET	1984
LUXEMBURG	LUXPAC	1983
MALAYSIA	MAYPAC	1984
MEXICO	TELEPAC	1982
NETHERLANDS	DATANET-1	1981
NEW ZEALAND	PSN	1984
NORWAY	DATAPAK	1983
PORTUGAL	PKTNET	1984
SINGAPORE	TELEPAC	1982
SOUTH AFRICA	SAPONET	1982
SPAIN	CTNEX25	1982
SWEDEN	DATAPAK	1984
SWITZERLAND	TELEPAC	1983
TAIWAN	PACNET	1984
UNITED KINGDOM	PACKT-SS	1981
UNITED STATES of AMERICA	ACCUNET	1983
	TELENET	1980
	TYMNET	1980
YUGOSLAVIA	JUGOPAK	1985

This table is an illustrative reference only. It reflects some of the information publicly available as of December 1984 which will doubtless change as X.25 network plans mature and implementations progress.

1.2 IBM STATEMENT OF DIRECTION

In May of 1980 IBM made the following public announcement about its use of CCITT Recommendations X.21 and X.25:

"IBM encourages the use of international standards as the basis for interfaces to public data networks providing circuit-switched, packet-switched and leased-circuit services. IBM continues to participate in and contribute to international standards efforts to develop and enhance these interfaces. Services with interfaces based on

CCITT Recommendations X.21 and X.25 provide users with new alternatives for transmission that supplement the functions provided by IBM's Systems Network Architecture (SNA), and should be made available to IBM's customers.

"It i products to public data networks with X.21 and X.25 interfaces. For example, in accordance with IBM's 1978 statement of Direction regarding X.21, IBM announced in December 1979 the capability of attaching certain SNA products to Nippon Telegraph and Telephone's leased-circuit and circuit-switched X.21-based services in Japan. IBM has also released product adaptations that permit certain products to utilize X.25-based services in Canada, France, the Federal Republic of Germany and the Netherlands[17],[18]. [The first of these X.25 product adaptations was announced in 1977.]

"Announcement of attachment capability supporting additional products or functions, or for other public data networks with X.21 or X.25 interfaces, will be based on IBM's technical and business judgement in addressing the requirements of its customers."

1.3 EVOLUTION OF IBM X.21 AND X.25 INTERFACES

In 1980, an X.21 general information manual was published[13]. It describes the CCITT Recommendation X.21 interface to public data networks (PDNs) as implemented in data terminal equipment by IBM. Included are:

- A brief overview of CCITT Recommendation X.21
- Information on the functional, mechanical, and electrical characteristics specified in CCITT Recommendation X.21
- Information on the operation of both the circuit-switched and leased-circuit network service interfaces defined in CCITT Recommendation X.21.

IBM also announced in 1980, for certain products, support of X.21 circuit-switched services in Denmark, Finland, Norway and Sweden.

Since May of 1980 IBM has announced X.25 capability for numerous products to attach to many different PSDN's around the world.

CCITT Recommendation X.25 defines three levels of the DTE/DCE interface that PSDNs use as a design guide for X.25-based services:

1. Physical Level — the mechanical, electrical, functional and procedural characteristics to activate, maintain and deactivate the physical link between the DTE and the DCE.
2. Link Level — the link access procedure for the interchange of data across the link between the DTE and the DCE.
3. Packet Level — the packet format and control procedures for the exchange of packets containing control information and user data between the DTE and the DCE.

CCITT Recommendation X.25 describes the three levels and the range of services that may be provided by PSDNs from the perspective of the DCE. This manual provides information on the three levels of CCITT Recommendation X.25 (1980) and describes architectural and design choices made by IBM to meet the requirements of its customers from the perspective of IBM SNA X.25 DTEs.

The services, functions, facilities, and parameter ranges described herein for IBM SNA X.25 DTE's are based on reference 1, the revised X.25 Recommendation approved by the CCITT plenary assembly at Geneva in November, 1980.

This X.25 general information manual expounds further on IBM's use of elements of X.25 at all three levels. It addresses only those elements required to support connections between IBM SNA X.25 DTE's and other X.25 DTE's (SNA or non-SNA) using virtual call and permanent virtual circuit services provided by PSDNs. It does not address direct DTE-to-DTE connections without an intervening PSDN; nor does it address IBM SNA X.25 nodes functioning as DCEs.

IBM support of other X.25-related recommendations, such as packet assembly/disassembly (PAD) functions[9],[19], are beyond the scope of this manual.

2.0 ARCHITECTURAL CONSIDERATIONS

Packet-switched data network services can provide an efficient and economical method for transporting information in some instances. However, application requirements, geographical considerations and applicable tariffs often dictate the use of other services and facilities for transporting information. Virtual circuit (VCs) are, therefore, integrated into SNA so as not to preclude concurrent use of other services and facilities offered by Communication Carriers, Telecommunications Administrations and Recognized Private Operating Agencies (RPOAs) around the world.

Because of the pervasiveness of X.25 DTE/DCE interfaces, IBM encourages common interpretation and implementation to the fullest extent possible. This document advances this goal by describing the elements deemed necessary to support two basic categories of connections:

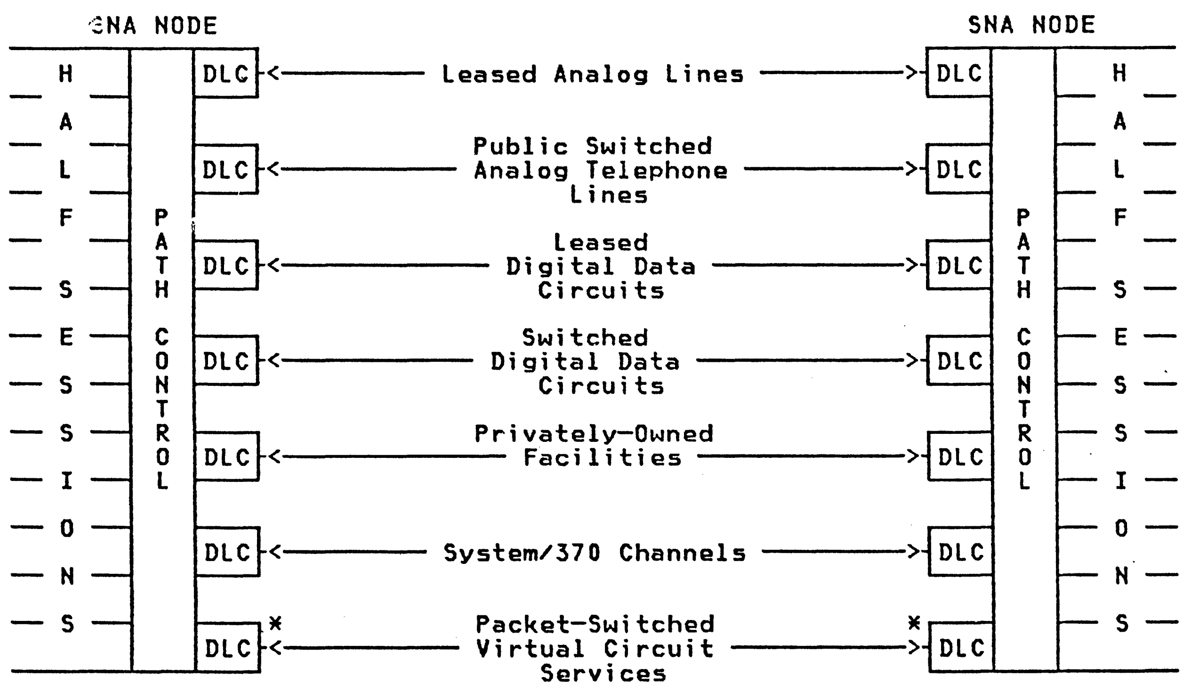
- SNA-to-SNA Connections that allow IBM SNA X.25 DTEs to be connected to each other via virtual call or permanent virtual circuit services, or both; and,

- SNA-to-non_SNA Connections that allow IBM SNA X.25 DTEs to be connected to non-SNA DTEs via virtual call or permanent virtual circuit services, or both.

It describes architectural directions for both categories of connections but focuses primarily on the elements of CCITT Recommendation X.25 (1980) required to support SNA-to-SNA connections.

2.1 SNA-TO-SNA CONNECTIONS

One objective of Systems Network Architecture is to afford users the broadest possible range of telecommunications services and facilities to meet their requirements. Figure 1 depicts some of the data transmission services and facilities available to SNA customers in various parts of the world.



* - This DLC (Data Link Control) contains Logical Link Control (LLC) and Virtual Circuit Protocol (VCP) components, described in the text.

Figure 1. Coexistence of Data Transmission Services and Facilities: within SNA

Computer network architectures, in general, provide for the interconnection of physically distributed functions via various types of data transmission facilities. Such directly connected nodes are termed 'adjacent' within SNA. The Data Link Control (DLC) elements provide the protocols used to transfer information between adjacent SNA nodes.

Some SNA nodes, such as clusters and terminals[10], attach to only one adjacent SNA node via a single real link. Such single-link nodes are treated as single-virtual-circuit X.25 nodes as shown in Figure 2 on page I-6. SNA nodes that can connect to multiple SNA adjacent nodes over different physical links, or multi-drop links, are treated as multiple point-to-point virtual-circuit connections as shown in Figure 3 on page I-7. In the multi-access configuration, SNA nodes have the capability of connecting to multiple SNA adjacent nodes using multiple virtual circuits via one or more X.25 DTE/DCE interfaces.

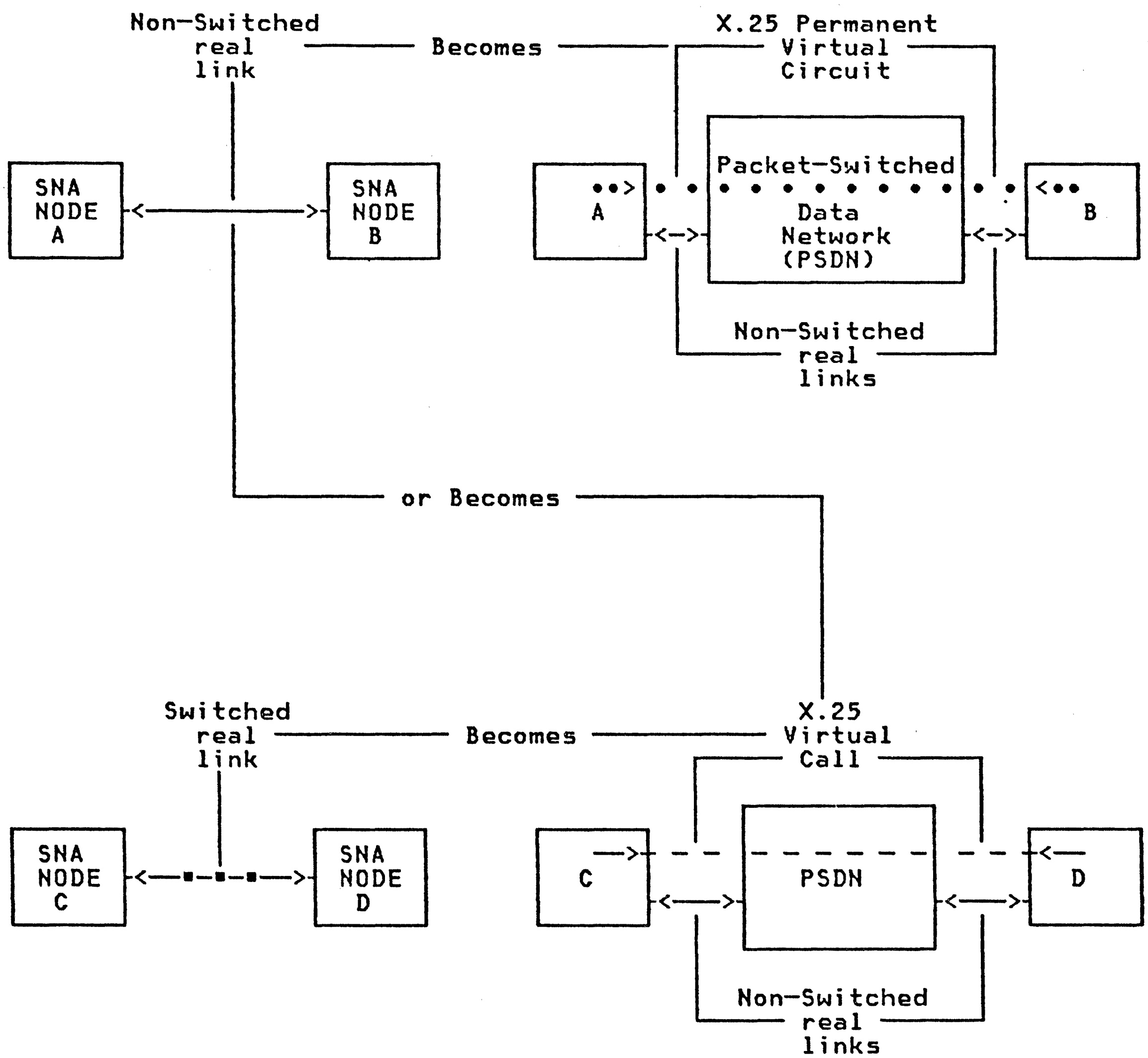
SNA nodes interconnected by virtual circuit services remain logically adjacent and the X.25 virtual circuit protocol (VCP) provides the mechanism to transfer information between these adjacent network nodes. Therefore, virtual circuits serve similar functions in the system as other data transmission services and facilities and naturally appear at the same architectural level.

This natural structure provides for the coexistence of the various data transmission services and facilities, as well as a desirable multiplexing capability. For example, all traffic flowing between adjacent network nodes is readily multiplexed onto a single facility.

To permit concurrent use of data link control and virtual circuit protocol services, all of the properties of the former must be available in the latter. IBM SNA X.25 DTEs employ Logical Link Control (LLC) protocols to provide certain adjacent node services and optionally, to enhance the quality of service exhibited by underlying network services, in environments where SNA nodes are connected through one or more PSDNs. These protocols are known as QLLC, which uses 'Qualified' data packets to transfer data link control information between the two SNA nodes, and ELLC which employs LLC headers carried in the user data field of data packets to provide optional circuit assurance and data integrity capabilities. Once data link connectivity has been established, SNA Path Information Units (PIUs)[23] are transferred in normal, unqualified data packets. PIUs that exceed the maximum user data area of the data packet are transferred as packet sequences concatenated by the More Data Mark ('M' bit).

Note: Some initial IBM SNA X.25 DTE implementations do not support the QLLC, ELLC and 'M' bit procedures. They perform adjacent node services and segmentation/concatenation using a Physical Services Header (PSH)[29]. All IBM SNA X.25 DTEs may not support the Enhanced Logical Link Control (ELLC) procedures.

It is not an objective to restrict any actual implementations of the X.25 DTE/DCE interface functions within IBM products to the elements described here. Network specific options may impose additional requirements that must be met to make specific IBM SNA X.25 DTEs viable in some countries. Decisions to support national options are based on technical and business considerations that are beyond the scope of this manual.



Legend:

- —▪—▪—▪— Switched Telephone Connection
- ••>• •<•• Permanent Virtual Circuit
- —>— —<— Virtual Call
- ├<———>┤ Link Level Connection

Figure 2. Real Links Become X.25 Virtual Circuits: for SNA-to-SNA Connections

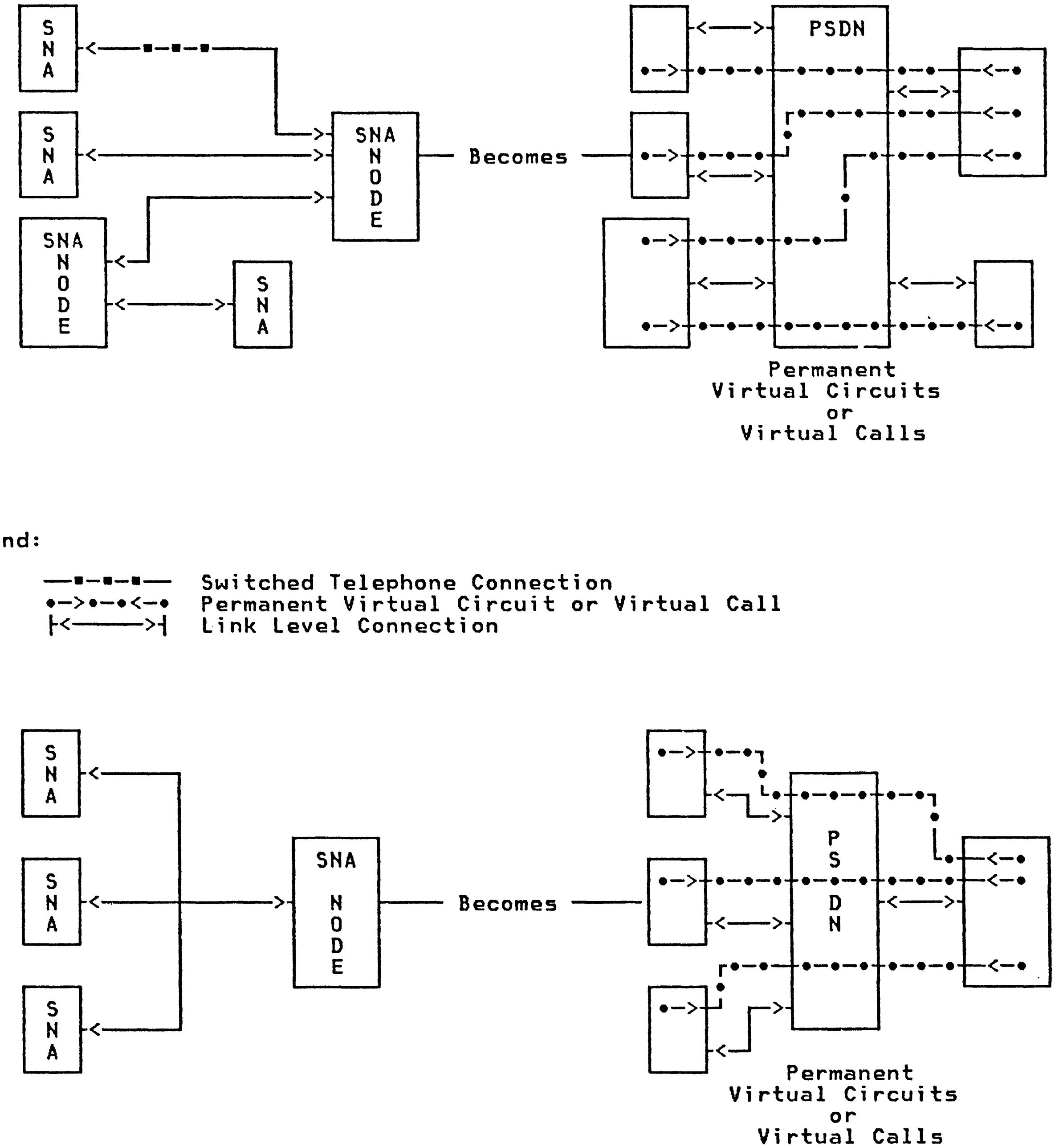


Figure 3. X.25 Multi-Access: for SNA-to-SNA Connections

2.2 SNA-TO-NON SNA CONNECTIONS

SNA-to-non_SNA connections provide a mechanism for the exchange of data between an application program that resides in an SNA node and a remote non-SNA terminal. For example, remote non-SNA terminals can be non-SNA X.25 DTEs or start/stop terminals attached to a packet assembly/disassembly (PAD) PSDN facility as defined by CCITT Recommendations X.3, X.28 and X.29. Three types of operation defined for SNA-to-non_SNA connections are mapped, transparent and hybrid. No standard protocol is assumed above the packet level of CCITT Recommendation X.25 for SNA-to-non_SNA connections. Higher level protocols remain a matter to be agreed upon between the individual non-SNA terminal and the supporting application program within the SNA network.

2.2.1 Mapped Operation

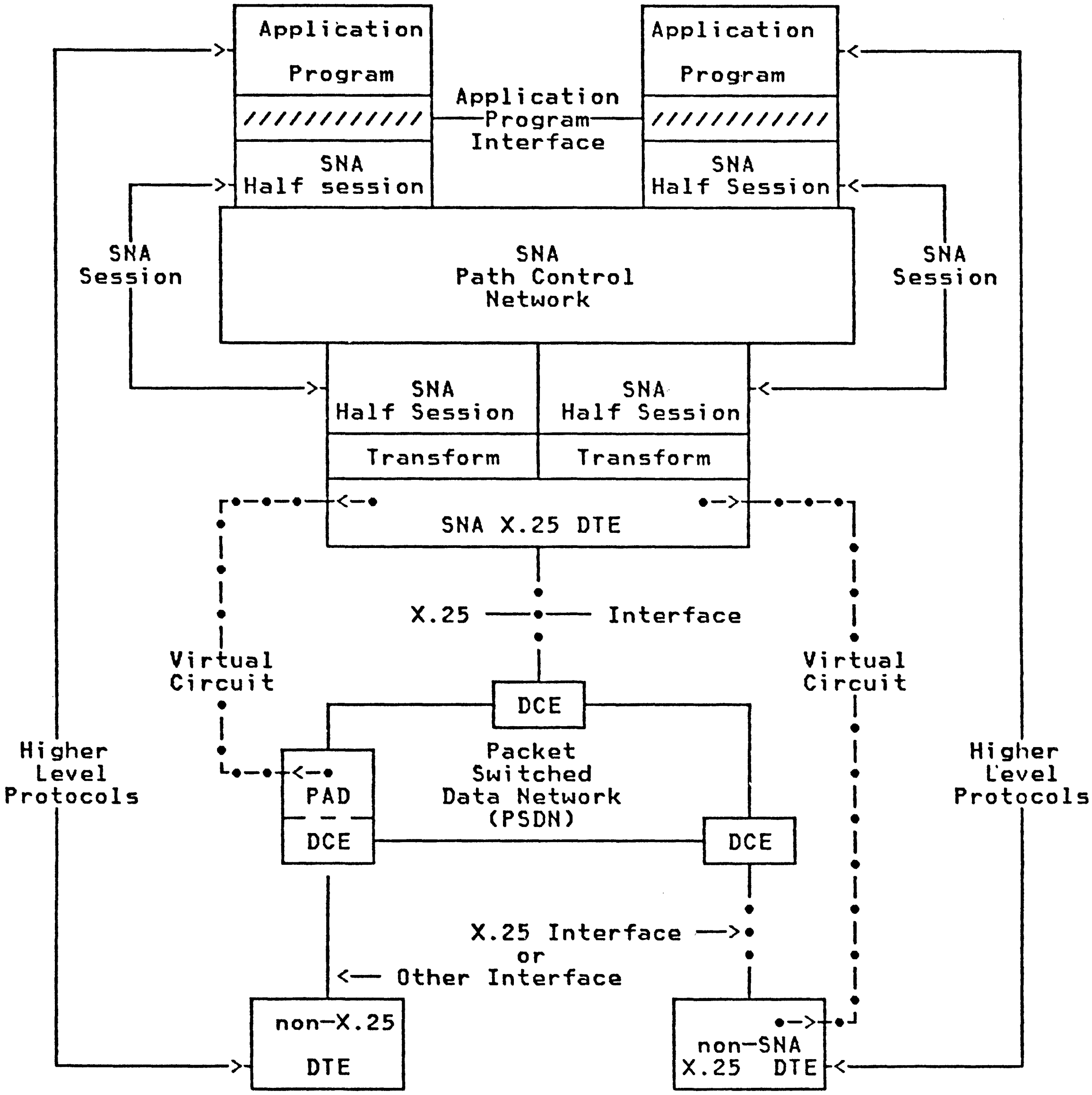
Mapped operation allows X.25 packet level protocols to be mapped to and from similar SNA protocol subsets directly at the SNA X.25 DTE/DCE interface. Thus, virtual circuits can be mapped to SNA sessions, on a one for one basis, as depicted in Figure 4 on page I-9. A host application program can communicate with the non-SNA without any X.25 sensitivity. However, the application and the remote node must each understand the data streams being exchanged and process them accordingly.

2.2.2 Transparent Operation

In transparent operation, X.25 packet level protocols can be implemented in an application program (outside the structure of SNA). In this case, the X.25 packet level protocols are transported, transparently, within SNA between the application program and the X.25 DTE/DCE interface and SNA sessions can support one or more virtual calls.

2.2.3 Hybrid Operation

In hybrid operation, X.25 packet level protocols are neither fully mapped nor fully transparent. A host application program may perform some X.25 packet level functions as in transparent operation while the remaining X.25 packet level functions are performed at the SNA X.25 interface.



Note: Non-X.25 DTEs may be supported by PSDN PAD functions as defined by CCITT Recommendations X.3, X.28 and X.29.

Figure 4. One-to-One Session Mapping to Virtual Circuits: for SNA-to-non_SNA Connections

2.3 MULTIPLE DTE/DCE INTERFACES

Some IBM SNA X.25 DTEs can support multiple X.25 DTE/DCE interfaces. To do so is a product-specific choice based on traffic requirements and the need to directly access two or more networks concurrently.

Some optional user facilities (e.g., modulo 128 packet sequence numbering) require an X.25 DTE/DCE interface that is separate from the interface that supports the normal facility (e.g., modulo 8 packet sequence numbering).

Each X.25 DTE/DCE interface is assumed to correspond to a unique address agreed upon with the network Administration.

3.0 X.25 ELEMENTS IN IBM SNA X.25 DTES

The elements of CCITT Recommendation X.25[1] selected for use in IBM SNA X.25 DTEs are described in this section. Physical level, link level and packet level interfaces are addressed. End-to-end protocols that reside at one or more levels above the packet level are not described.

SNA-to-SNA and SNA-to-non_SNA connections differ only at the packet level. Therefore, descriptions of the physical level and the link level are common to both types of connections.

Tables contained in subsequent sections use the following terminology:

All - for functions provided by all IBM SNA X.25 DTEs.

Some - for functions that may be provided by selected IBM SNA X.25 DTEs to meet specific functional requirements and marketing objectives.

None - for functions normally not provided by IBM SNA X.25 DTEs.

3.1 PHYSICAL LEVEL

A summary of IBM SNA X.25 DTE physical level characteristics is provided in Table I-2. During an interim period, described in reference 1, IBM SNA X.25 DTEs use CCITT Recommendation X.21_bis[9] for non-switched circuits. However, some IBM SNA X.25 DTEs also support the X.21 interface[12,13,14] for non-switched circuits; it will become the primary support at the end of the interim period.

At speeds of 19.2 kilobits per second (kbit/s) and below, IBM X.21_bis implementations conform to CCITT Recommendation V.24[11] with V.28[11] electrical characteristics. At signaling speeds in excess of 19.2 kbit/s, IBM X.21_bis implementations conform to CCITT Recommendation V.35[11]. Some products may provide other non-X.21 interfaces as required for attachment to specific network services.

All links operate duplex (two-way simultaneous) at one or more of the X.25 speeds listed in Table I-2. The particular speed or speeds supported by IBM SNA X.25 DTEs is product specific. Some IBM SNA X.25 DTEs may also support one or more of the additional speeds shown in Table I-2. X.21 switched and X.21_bis switched are not used at the physical level of the X.25 DTE/DCE interface by IBM SNA X.25 DTEs.

Table I-2: Summary of Physical Level Characteristics	IBM SNA X.25 DTEs
X.21 Switched	None
X.21_bis Switched	None
X.21 Non-Switched	Some*
X.21_bis Non-Switched	All*
Duplex Transmission Facility	All
X.25 Speeds - 2.4 kbit/s	Some
4.8 "	Some
9.6 "	Some
48.0 "	Some
Additional Speeds - 1.2 kbit/s	Some
19.2 "	Some
56.0 "	Some
64.0 "	Some
* During the interim period, after which X.21 will be required and X.21_bis will be optional	

3.2 LINK LEVEL

CCITT Recommendation X.25 defines two link access procedures (LAP and LAPB) for the link level. IBM SNA X.25 DTEs use the balanced procedure, LAPB. The symmetrical procedure, LAP, is used only by certain early IBM DTE implementations but will not be used in new IBM SNA X.25 DTE implementations.

The IBM SNA X.25 DTE link level is required to be compatible with the DCE link level as defined in reference 1. Thus, certain choices and clarifications of the balanced procedure are required for DTEs. These are given, for IBM SNA X.25 DTEs, below:

1. The information field of all I-frames transferred across the DTE/DCE Interface must contain an integral number of octets (eight-bit bytes).
2. IBM SNA X.25 DTEs do not generate the Idle Channel State as a normal sequence.
3. IBM SNA X.25 DTEs detect but do not, necessarily, consider the Idle Channel State to be an error condition; they may assume that the DCE has temporarily suspended transmission.
4. IBM SNA X.25 DTEs support modulo '8' sequence numbering; modulo '128' sequence numbering is not used at the link level, since this option is not provided fpr by CCITT Recommendation X.25 (Geneva, November 1980)[1].
5. IBM SNA X.25 DTEs that implement supervisory and unnumbered commands transmit all such commands with the poll (P) bit set to one.
6. Upon receipt of a command frame with the poll bit set to one, IBM SNA X.25 DTEs set the final (F) bit to one in the next response frame transmitted.
7. Exceptional conditions may be reported by IBM SNA X.25 DTEs to the DCE using the FRAME REJECT (FRMR) response as defined in reference 1. They maintain the frame rejection condition until it is reset by the DCE or until higher level DTE recovery is initiated locally.
8. IBM SNA X.25 DTEs, upon receipt of a FRMR response, are responsible for returning the link to operational mode by initiating a link resetting procedure. However, to assure synchronization, initiation of the link resetting procedure may be preceded by a link disconnection procedure.
9. After receiving a RECEIVE NOT READY (RNR) frame, IBM SNA X.25 DTEs wait until receipt of a RECEIVE READY (RR) or REJECT (REJ) frame before transmitting additional information (I) frames unless or until the link resetting procedure is completed. During this period of time, they will send an RR or RNR command frame in order to ascertain the status of the DCE.
10. Information (I) frames contain only one packet each.
11. IBM SNA X.25 DTEs may employ a nested time-out function to avoid prematurely declaring link/stations inoperative because of transient errors on the transmission link.

3.3 PACKET LEVEL

The packet level elements are considered for two categories of connections via PSDNs, SNA-to-SNA and SNA-to-non_SNA.

3.3.1 SNA-to-SNA Connections

The IBM SNA X.25 DTE packet level is required to be compatible with the DCE packet level as defined in reference 1. This section gives the packet level elements required for SNA-to-SNA communication, and defines how IBM SNA X.25 DTEs use the packet level procedures, formats, and facilities in clarification of reference 1.

SNA-to-SNA communication is via virtual call (VC) or permanent virtual circuit (PVC) services, or both. Datagram services are not used. A given SNA X.25 DTE may contain virtual call capability or permanent virtual circuit capability, or both. Table I-3 lists the packet types used on SNA-to-SNA connections that affect given virtual calls (VC) and given permanent virtual circuits (PVC) and that affect all VCs and PVC at the X.25 DTE/DCE interface (I/F). Table I-4 lists the packet types that are not used on SNA-to-SNA connections.

Table I-3: Packet Types Used by IBM SNA X.25 DTEs on SNA-to-SNA Connections*

PACKET TYPES		X.25 SERVICE VC	PVC	I/F
ACCEPTED –	INCOMING CALL	X		
	CALL CONNECTED	X		
	CLEAR INDICATION	X		
	DCE CLEAR CONFIRMATION	X		
	DCE DATA	X	X	
	DCE RECEIVE READY	X	X	
	DCE RECEIVE NOT READY	X	X	
	RESET INDICATION	X	X	
	DCE RESET CONFIRMATION	X	X	
	RESTART INDICATION			X
	DCE RESTART CONFIRMATION			X
	DIAGNOSTIC			X
TRANSMITTED –	CALL REQUEST	X		
	CALL ACCEPTED	X		
	CLEAR REQUEST	X		
	DTE CLEAR CONFIRMATION	X		
	DTE DATA	X	X	
	DTE RECEIVE READY	X	X	
	DTE RECEIVE NOT READY	X	X	
	RESET REQUEST	X	X	
	DTE RESET CONFIRMATION	X	X	
	RESTART REQUEST			X
	DTE RESTART CONFIRMATION			X

VC – Affects given Virtual Calls
PVC – Affects given Permanent Virtual Circuits
I/F – Affects all VCs and PVCs at the DTE/DCE Interface

* All packet types are not necessarily used by all IBM SNA X.25 DTEs

Table I-4: Packet Types Not Used by IBM SNA X.25 DTEs on SNA-to-SNA Connections

PACKET TYPES		X.25 SERVICE VC	PVC	DGM
NOT ACCEPTED –	DCE INTERRUPT	X	X	
	DCE INTERRUPT CONFIRMATION	X	X	
	DCE DATAGRAM			X
	DATAGRAM SERVICE SIGNAL			X
NOT TRANSMITTED –	DTE INTERRUPT	X	X	
	DTE INTERRUPT CONFIRMATION	X	X	
	DTE DATAGRAM			X
	DTE REJECT	X	X	

3.3.1.1 Initialization

The packet level DTE/DCE interface is initialized before virtual call and permanent virtual circuit procedures begin. IBM SNA X.25 DTEs execute the DTE restart procedure after link level initialization is complete. The X.25 DTE/DCE interface becomes operational upon successful completion of the restart procedure. The restart procedure is used after normal link level activation and after link level failure recovery for packet level initialization.

3.3.1.2 Data Transfer

Data is exchanged between IBM SNA X.25 DTEs using virtual calls or permanent virtual circuits, or both. IBM SNA X.25 DTEs may transmit:

1. DTE DATA
2. DTE RECEIVE READY and
3. DTE RECEIVE NOT READY packets.

They accept and respond to:

1. DCE DATA
2. DCE RECEIVE READY and
3. DCE RECEIVE NOT READY packets.

These packets are used as described in reference 1 except as noted in this section. DTE REJECT (REJ) packets are not used.

The characteristics of data packets used on SNA-to-SNA connections are summarized in Table I-5.

Table I-5: Characteristics of Data Packets Exchanged on SNA-to-SNA Connections	IBM SNA X.25 DTEs
Qualifier Bit, 'Q = 0' 'Q = 1'	All All*
Delivery Confirmation Bit, 'D = 0' 'D = 1'	All None
Packet Sequence Numbering, Modulo '8' Modulo '128'	All Some
More Data Bit, 'M = 1' transmitted 'M = 1' accepted	All* All*
User Data Fields Contain Integral Number of Octets Only	All
Maximum User Data Length = 128 Octets = 16, 32, 64, 256, 512 or 1024 Octets	All Some
Window Size = '1' ≤ 'W' < '8' (Modulo '8') < '128' (Modulo '128')	All Some

* Some IBM SNA X.25 DTE implementations do not support the QLLC, ELLC and 'M' bit procedures. They perform adjacent node services and segmentation/concatenation using Physical Services Headers.

DTEs that use PSHs and do not accept 'M = 1' require the maximum User Data field sizes at the local and remote DTE/DCE interfaces to be identical.

The Qualifier bit 'Q=1' is transmitted by IBM SNA X.25 DTEs to identify Logical Link Control (LLC) information. The Delivery Confirmation bit 'D=1' is not used by IBM SNA X.25 DTEs.

All IBM SNA X.25 DTEs allow modulo '8' packet sequence numbering; some may also allow modulo '128' packet sequence numbering.

IBM SNA X.25 DTEs use the More Data Mark (M-bit) for packet sequence generation and interpret the 'M' bit on received packets to properly reassemble received packet sequences.

IBM SNA X.25 DTEs, which require user data to be an integral number of octets, accommodate a maximum user data field length of '128' octets. Window sizes, W, of $1 \le W < 8$ are used for modulo '8' packet sequence numbering. Window sizes, W, of $1 \le W < 128$ are used for modulo '128' packet sequence numbering.

Some IBM SNA X.25 DTEs may also allow optional maximum User Data fields of '16', '32', '64', '256', '512', or '1024' octets.

3.3.1.3 Call Control

For control of virtual calls, IBM SNA X.25 DTEs may transmit:

1. CALL REQUEST
2. CALL ACCEPTED
3. CLEAR REQUEST and
4. DTE CLEAR CONFIRMATION packets.

They may accept and respond to:

1. INCOMING CALL
2. CALL CONNECTED
3. CLEAR INDICATION and
4. DCE CLEAR CONFIRMATION packets.

Call control packets are used as described in reference 1. Clarifications for the use of call control packets on SNA-to-SNA connections are summarized in Table I-6.

Table I-6: Use of Call Control Packets on SNA-to-SNA Connections.		IBM SNA X.25 DTEs
General Format Identifier	= '0001' = '0010'	All Some
User option to specify Calling DTE Address in	CALL REQUEST	All
Facilities Field in —	CALL REQUEST INCOMING CALL CALL ACCEPTED CALL CONNECTED	Some Some Some Some
Call User Data (CUD) Field in —	CALL REQUEST and INCOMING CALL	All
Calling and Called DTE Address length field in	CALL ACCEPTED	Some
DTE Originated Diagnostic Code in	CLEAR REQUEST CLEAR INDICATION	All All

The General Format Identifier (GFI) is encoded '0001' for modulo '8' packet sequence numbering, or '0010' when extended packet sequence numbering is used.

The first octet of the Call User Data field is a Protocol Identifier (see §-6.2.1.6, in part II) that has particular significance and is required. In addition to the network-specific significance specified in CCITT Recommendation X.25 for bits 8 and 7, IBM SNA X.25 DTEs use:

- bit 2 to distinguish between SNA-to-SNA connections and SNA-to-non_SNA connections that may coexist at the same DTE/DCE interface; and,
- bit 3 to specify the particular logical link control to be used on SNA-to-SNA connections.

IBM SNA X.25 DTEs set the contents of the Clearing Cause field to x'00' and place a diagnostic code in CLEAR REQUEST packets for delivery, by PSDNs, to partner DTEs in CLEAR INDICATION packets.

IBM SNA X.25 DTEs may optionally supply a Calling DTE address in CALL REQUEST packets. The facilities field in CALL REQUEST, INCOMING CALL, CALL ACCEPTED, and CALL CONNECTED packets may be used to specify optional user facilities.

Some optional user facilities require explicit support functions to be provided by DTEs; others, designated 'User Choice', do not. Table I-7 summarizes those facilities that are available with all, some or none of the IBM SNA X.25 DTEs on SNA-to-SNA connections. 'User choice' means that availability of the facility is not dependent upon any explicit support functions in IBM SNA X.25 DTEs; support for the facility is provided entirely on the DCE side of the X.25 DTE/DCE interface.

When subscribed optional user facilities are indicated in INCOMING CALL packets, IBM SNA X.25 DTEs may analyze the facility parameter field and either:

- Accept the call with no further comment in CALL ACCEPTED packets.
- Negotiate using the facility field in CALL ACCEPTED packets.
- Reject the call using CLEAR REQUEST packets with an appropriate diagnostic indication.

IBM SNA X.25 DTEs may reject calls that indicate unsubscribed optional user facilities in INCOMING CALL packets by issuing a CLEAR REQUEST packet with an appropriate code in the diagnostic field.

All IBM SNA X.25 DTEs detect national facility marker(s) indicated in INCOMING CALL packets. Some may also recognize and act upon non-X.25 facilities.

Table I-7: Optional User Facilities for SNA-to-SNA Connections	IBM SNA X.25 DTEs
Nonstandard Default Packet Sizes	All
Nonstandard Default Window Sizes	All
Default Throughput Classes Assignment	User Choice
Incoming Calls Barred	User Choice
Outgoing Calls Barred	User Choice
Single Closed User Group	User Choice
Single Closed User Group with Outgoing Access	User Choice
Single Closed User Group with Incoming Access	User Choice
Incoming Calls Barred Within a Closed User Group	User Choice
Outgoing Calls Barred Within a Closed User Group	User Choice
Reverse Charging Acceptance	User Choice
One-Way Logical Channel Outgoing	Some
One-Way Logical Channel Incoming	Some
Reverse Charging	Some
Flow Control Parameter Negotiation	Some
Throughput Class Negotiation	Some
Multiple Closed User Groups	Some
Multiple Closed User Groups with Outgoing Access	Some
Multiple Closed User Groups with Incoming Access	Some
Extended Packet Sequence Numbering	Some
RPOA Selection	Some
Fast Select	None
Fast Select Acceptance	None
Packet Retransmission	None
Bilateral Closed User Group	None
Bilateral Closed User Groups with Outgoing Access	None

3.3.1.4 Error Notification in the Data Transfer Phase

During the data transfer phase, IBM SNA X.25 DTEs convey Error Notifications across the DTE/DCE interface in the Cause and Diagnostic Code fields of:

1. CLEAR REQUEST
2. RESET REQUEST and
3. RESTART REQUEST packets.

They process error notification information received from DCEs in the Cause and Diagnostic Code fields of:

1. CLEAR INDICATION
2. RESET INDICATION and
3. RESTART INDICATION packets.

Contents of Diagnostic Code and Diagnostic Explanation fields of DIAGNOSTIC packets are used for error notification.

These packet types are used as described under "Initialization" on page I-12 after link level activation and for error notification. Errors detected by DCEs are described in reference 1. Errors detected by IBM SNA X.25 DTEs are indicated in the Diagnostic Code field of CLEAR REQUEST, RESET REQUEST or RESTART REQUEST packets for delivery, by PSDNs, to affected remote DTEs in CLEAR INDICATION, RESET INDICATION and RESTART INDICATION packets. Table I-8 provides clarifications for the use of error notification packets on SNA-to-SNA connections.

Table I-8: IBM SNA X.25 DTE Use of Error Notification Packets on SNA-to-SNA Connections	IBM SNA X.25 DTEs
General Format Identifier (GFI) in all packets = b'0001' = b'0010'	All Some
Clearing Cause Field in CLEAR REQUEST packets = x'00'	All
Resetting Cause Field in RESET REQUEST packets = x'00'	All
Restarting Cause Field in RESTART REQUEST packets = x'00'	All
Diagnostic Code Field in CLEAR, RESET and RESTART REQUEST	All

3.3.1.5 Actions of the DTE in Unusual Circumstances

1. DTE Time-Outs

   After issuing a CALL REQUEST, CLEAR REQUEST, RESET REQUEST and RESTART REQUEST, IBM SNA X.25 DTEs start a time-out. This timer is reset upon receipt of the corresponding confirmation packet from the DCE.

   If the time-out expires prior to receipt of the corresponding confirmation packet from the DCE, IBM SNA X.25 DTEs may retransmit the request packet and restart the timer. This retransmission procedure may occur 'n≥0' times. If the retransmission procedure is not successful, the failure is reported to the higher levels of SNA.

2. DTE-Detected Errors

   Errors detected by IBM SNA X.25 DTEs are categorized as follows:

   I - those that result from receipt of unsupported packet types (e.g., DCE INTERRUPT or DCE DATAGRAM packets).

   II - those that can result from discrepancies between the DTE and DCE interpretations of the state of some subscribed interface parameter. (e.g., receipt of an INCOMING CALL packet on a logical channel assigned for permanent virtual circuit service).

   III - those most likely resulting from a malfunction of the DCE (e.g., receipt of an unsolicited DCE RESTART CONFIRMATION packet).

   IV - those caused by failures at the physical level or the link level (e.g., dropping of the Data Set Ready indication).

   For category 'I' and 'II' errors, IBM SNA X.25 DTEs clear the virtual call or reset the permanent virtual circuit if such an action is permitted without violating any procedure. The error condition is reported to the higher levels of SNA; the received packet is discarded.

For category 'III' errors, IBM SNA X.25 DTEs transmit a RESTART REQUEST packet across the DTE/DCE interface, place all virtual circuits in an inoperative state and report the error condition to the higher levels of SNA.

For category 'IV' errors, IBM SNA X.25 DTEs place the LAPB link and all the virtual circuits at the DTE/DCE interface in an inoperative state and report an interface failure to the higher levels of SNA.

3. DCE-Detected Errors

   DCEs indicate detected error types in the Cause and Diagnostic Code fields of RESET INDICATION, CLEAR INDICATION and RESTART INDICATION packets and in the Diagnostic Code and Diagnostic Explanation fields of DIAGNOSTIC packets.

   IBM SNA X.25 DTEs act as a function of the severity of the situation, taking into account the Call Progress Signal descriptions provided in CCITT Recommendation X.96. When the response to a CALL REQUEST is a CLEAR INDICATION with a cause field of severity D1 or D2 (as defined in CCITT Recommendation X.96) and in the case of local procedure errors, IBM SNA X.25 DTEs report the contents of the Clearing Cause and Diagnostic Code fields to higher levels of SNA and await further instructions. When a RESET or CLEAR INDICATION is received during the data transfer phase, a virtual call is cleared and the virtual circuit is placed in an inoperative state, unless successful recovery is effected at the ELLC level. Contents of the Clearing Cause and Diagnostic Code fields are reported to higher levels of SNA. When a RESTART INDICATION packet is received, all of the virtual circuits of the DTE/DCE interface are placed in an inoperative state unless successful recovery is effected at the ELLC level. Contents of the restarting Cause and Diagnostic Code fields are reported to higher levels. When a DIAGNOSTIC packet is received, contents of the Diagnostic Code and Explanation fields are reported to higher levels. No logical channel state changes occur as a result of receiving DIAGNOSTIC packets.

4. Unsuccessful Calls

   DCEs indicate that virtual calls cannot be completed by inserting the appropriate codes in the Clearing Cause and Diagnostic Code fields of CLEAR INDICATION packets. When these codes indicate network congestion, out-of-order or number busy, IBM SNA X.25 DTEs either retry the operation or refer the retry to a higher level. The number of retries may be a system generation parameter for DTEs.

3.3.2 SNA-to-non SNA Connections

On SNA-to-non_SNA connections, the X.25 packet level functions, formats and facilities supported are defined by the application program as a function of the requirements of the non-SNA X.25 DTE.

In transparent operation, IBM SNA X.25 DTEs may elect to accept and transmit all packet formats defined in CCITT Recommendation X.25, except DTE REJECT, DATAGRAM and DATAGRAM SERVICE SIGNAL packets.

3.3.2.1 Packet Types

The packet types shown in Table I-9 may be allowed on SNA-to-non_SNA connections in addition to those shown in Table I-3.

Table I-9: Additional Packet Types Available on SNA-to-non_SNA Connections	X.25 SERVICE		
PACKET TYPES	VC	PVC	I/F
ACCEPTED – DCE INTERRUPT	X	X	
– DCE INTERRUPT CONFIRMATION	X	X	
TRANSMITTED – DTE INTERRUPT	X	X	
– DTE INTERRUPT CONFIRMATION	X	X	
VC – Affects given Virtual Calls PVC – Affects given Permanent Virtual Circuits I/F – Affects all VCs and PVCs at the DTE/DCE Interface			

The characteristics of data and call control packets used for SNA-to-non_SNA connections are as summarized in Tables I-5 and I-6, respectively, for SNA-to-SNA connections, except that the Delivery Confirmation ('D' bit) procedure may be used by some DTEs on SNA-to-non_SNA connections.

3.3.2.2 Use of Call Control Packets

The first octet of the Call User Data field (called the Protocol Identifier (PI)) in CALL REQUEST packets is used to distinguish packets on SNA-to-SNA connections from those on SNA-to-non_SNA connections at a given SNA X.25 DTE/DCE Interface. The setting of bits 8, 7 and 2 to '1's in the first octet of the Call User Data field indicates an SNA-to-SNA connection.

Codings of the first octet of the Call User Data field in which bits 8 and 7 are set to '1's and bit 2 is set to '0' indicates an SNA-to-non_SNA connection.

3.3.2.3 Error Notification

The coding of the Diagnostic Code field in RESTART REQUEST, CLEAR REQUEST and RESET REQUEST packets is not standardized for SNA-to-non_SNA connections. Therefore, IBM SNA X.25 DTEs do not assign any value to this field. However, they do accept and pass, to higher levels, diagnostic codes set by partner DTEs.

4.0 OTHER SYSTEM CONSIDERATIONS

4.1 SECURITY

4.1.1 SNA-to-SNA Connections

Called DTEs can implement a rudimentary calling DTE identification check by testing the calling DTE address in INCOMING CALL packets. DTEs can elect to implement as a user option a connection identification capability defined for CALL REQUEST and INCOMING CALL packets.

Care must be exercised in choosing cryptographic techniques. Data link control level cryptographic products defined for SNA products cannot be used at the X.25 link and packet levels. Cryptographic products defined for SNA above, and transparent to, the data link control level can be used.

4.1.2 SNA-to-non SNA Connections

Security techniques are specific to the particular non-SNA remote DTE being supported. In general, techniques used for SNA-to-SNA connections are not applicable.

4.2 RELIABILITY, AVAILABILITY AND SERVICEABILITY (RAS)

Errors at the X.25 DTE/DCE interface, either detected by IBM SNA X.25 DTEs or indicated by their associated DCEs, are reported to the SNA control point or to a local operator, as appropriate. The network-generated Cause and Diagnostic Codes defined in CCITT Recommendation X.25, and a common set of DTE-originated diagnostic codes defined for SNA-to-SNA connections, are used for reporting purposes to aid in problem determination. Session outage notifications are propagated in accordance with general SNA mechanisms pertaining to link/station failures.

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CCITT Recommendation X.25 (Geneva, November 1980) defines an interface between customer data terminal equipment (DTE) and data circuit-terminating equipment (DCE). It is designed to facilitate the attachment of DTEs to packet-switched data networks (PSDNs). The definition includes three independent elements:

1. Physical Level - the mechanical, electrical, functional and procedural characteristics to activate, maintain and deactivate physical communication links between DTEs and DCEs.

2. Link Level - the link access procedure for the interchange of data across communication links between DTEs and DCEs.

3. Packet Level - the packet formats and control procedures for the exchange of control information and user data, or both, between DTEs and DCEs.

   Other international standards explicitly or implicitly referenced in this document include:

   a. CCITT Recommendation X.1 - International User Classes of Service in Public Data Networks.

   b. CCITT Recommendation X.2 - International User Services and Facilities in Public Data Networks.

   c. CCITT Recommendation X.21 - Interface between Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE) for synchronous Operation on Public Data Networks.

   d. CCITT Recommendation X.21_bis - Use on Public Data Networks of Data Terminal Equipment (DTE) which are Designed for Interfacing to Synchronous V-Series Modems.

   e. CCITT Recommendation X.96 - Call Progress Signals in Public Data Networks.

   f. CCITT Recommendation X.110 - Routing Principles for International Public Data Services through Switched Public Data Networks of the Same Type.

   g. CCITT Recommendation X.121 - International Numbering Plan for Public Data Networks.

CCITT Recommendation X.25 focuses on a description of the DTE/DCE Interface functions from the perspective of DCEs. This manual focuses on the same interface from the perspective of DTEs. Thus, several instances occur where the term DTE or DCE is replaced by the word station(s). Other substantive differences between the two interface descriptions are identified by vertical bars (|) in the left margin of this
2 manual. Text in this edition of the manual that has been changed or extended for
2 clarification or to correct errors found in the second edition, as well as that
2 required to accommodate and describe the enhanced logical link control protocol is
2 identified by the figure '2' in the left margin.

Note:

1. The bit/byte numbering used throughout this manual is consistent with the numbering used in CCITT Recommendation X.25 (1980) and may, therefore, differ from that with which the reader may be more familiar.

2. Network specific interface requirements, that deviate from the interpretation of CCITT Recommendation X.25 (Geneva, November 1980) reflected in this document, may be considered by IBM SNA X.25 Product Managers on an individual basis, in making technical and business judgements regarding possible justification for the support of such deviation(s). Network specific interface requirements are not defined in this manual.

This part describes the X.25 DTE/DCE Interface as perceived by IBM SNA X.25 DTEs,
2 based on CCITT Recommendation X.25 as published in the 'Yellow Book' instead of the
2 version adopted by the VIIIth Plenary Assembly in 1984 to be published in the 'Red
2 Book' sometime in 1985, and is composed of nine sections and several appendices as
follows:

Section 1 - DTE/DCE Interface Characteristics - specifies the physical level interface used between IBM SNA X.25 DTEs and their associated DCEs.

Section 2 - Link Access Procedure Across the DTE/DCE Interface - specifies the link level interface used for the interchange of data via communication links between IBM SNA X.25 DTEs and their associated DCEs.

Section 3 - Description of the Packet Level DTE/DCE Interface - describes the packet level procedures used to exchange control information and user data at the X.25 DTE/DCE interface.

Section 4 - Procedures for Virtual Circuit Services - describes the procedures used for virtual call and permanent virtual circuit services.

Section 5 - Procedures for Datagram Services - is not applicable for IBM SNA X.25 DTEs.

Section 6 - Packet Formats - specifies the formats for packets exchanged between IBM SNA X.25 DTEs and their associated DCEs.

Section 7 - Procedures and Formats for Optional User Facilities - specifies the optional user facilities allowed by IBM SNA X.25 DTEs and the procedures and formats for their selection and use.

Section 8 - Logical Link Control (LLC) on SNA-to-SNA Connections - defines the format and use of 'Qualified' data packets to perform adjacent SNA node physical services.

Section 9 - Other System Considerations - describes some other considerations for the use of IBM SNA X.25 DTEs in Packet-Switched Data Network environments.

Appendix A - defines the range of logical channels used for virtual calls and permanent virtual circuits.

Appendix B - defines the states of the packet level at the X.25 DTE/DCE interface.

Appendix C - describes the actions taken by DCEs on receipt of packets in a given state of the packet level X.25 DTE/DCE interface as perceived by DCEs.

Appendix D - defines packet level DCE time-outs and DTE time-limits.

Appendix E - specifies the diagnostic codes generated by DCEs employing CCITT Recommendation X.25 for CLEAR, RESET INDICATION, RESTART INDICATION and DIAGNOSTIC packets.

Appendix F - specifies the diagnostic codes generated by IBM SNA X.25 DTEs for CLEAR REQUEST, RESET REQUEST and RESTART REQUEST packets on SNA-to-SNA connections.

Appendix G - describes the actions taken by IBM SNA X.25 DTEs on receipt of packets in a given state of the packet level of the X.25 DTE/DCE interface as perceived by DTEs.

Appendix H - describes the Physical Services Header (PSH) used on SNA-to-SNA connections to an IBM 5973 Network Interface Adapter (NIA).

Appendix I - describes some architectural considerations for SNA-to-non SNA connections.

Appendix J - describes the actions taken by IBM SNA X.25 DTEs upon occurrence of events in the various states of the link layer interface.

Appendix K - describes the formats, protocols and procedures employed by IBM SNA X.25 DTEs for an enhanced logical link control between adjacent nodes on SNA-to-SNA connections.

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1.0 DTE/DCE INTERFACE CHARACTERISTICS - (PHYSICAL LEVEL)

The DTE/DCE physical interface characteristics defined as the Physical Level element shall be in accordance with CCITT Recommendation X.21. For an interim period, some Common Carriers, Administrations or Recognized Private Operating Agencies (RPOAs) may offer a DTE/DCE interface at this level in accordance with Recommendation X.21 bis. The exact use of the relevant points in these Recommendations is detailed in the following points of this specification.

X.21 and X.21 bis as defined in CCITT Recommendations V.24 and V.35 for leased service only are used.

1.1 DEDICATED ACCESS

The interface characteristics for DTEs connected to packet-switched data transmission services by dedicated circuits are described in "X.21 Interface" through "X.21_bis Interface."

1.1.1 X.21 Interface

1.1.1.1 Elements

The DTE/DCE physical interface elements shall be according to §-2 of CCITT Recommendation X.21.

1.1.1.2 Test Loops

The operation of test loops shall be according to §-7 of CCITT Recommendation X.21.

1.1.1.3 Procedures

The procedures for entering operational phases shall be as follows:

1. when the DTE signals 'c=ON', signals on circuit 'T' shall be according to the higher level procedures described in the following points of this Specification.
2. when the DCE signals 'i=ON', signals on circuit 'R' shall be according to the higher level procedures described in the following points of this Specification.
3. the DTE/DCE interface should normally remain in the operational condition with both 'c=ON' and 'i=ON' to enable proper operation of the higher level procedures described in the following points of this Specification.
4. if a situation necessitates the DTE to signal DTE ready or DTE uncontrolled not ready, or the DCE to signal DCE ready or DCE not ready, the interface should return to the operational condition with both 'c=ON' and 'i=ON' when the situation is appropriate to enable normal operation of the higher level procedures described in the following points of this Specification.

1.1.2 X.21 bis Interface

1.1.2.1 Elements

The DTE/DCE physical interface elements shall be according to §-1 of CCITT Recommendation X.21_bis.

1.1.2.2 Problem Determination

Failure detection and fault isolation shall be according to §-3 of CCITT Recommendation X.21_bis.

Note: - The addition of circuit #142 (Test) is considered a future requirement for IBM SNA X.25 DTEs.

1.1.2.3 Procedures

When circuits 105, 106, 107, 108 and 109 are in the 'ON' condition, signals on circuits 103 and 104 shall be according to the higher level procedures described in the following points of this specification.

1.2 SWITCHED ACCESS

The interface characteristics and procedures for DTEs connected to packet-switched data transmission services through circuit-switched data transmission services are not allowed in SNA environments.

(Text deleted).

1.3 ACCESS SPEEDS

IBM SNA X.25 DTEs support one or more of the following CCITT recommended data transmission speeds:

2.4, 4.8, 9.6 or 48.0 Kbit/s.

Additional data transmission speeds that may be considered by specific IBM SNA X.25 DTEs include:

1.2, 19.2, 56.0 and 64.0 Kbit/s.

2.0 LINK ACCESS PROCEDURE ACROSS THE DTE/DCE INTERFACE

2.1 SCOPE AND FIELD OF APPLICATION

2.1.1 The Link Access Procedure (LAPB)(text deleted)

LAPB is described as the Link Level Element used for the interchange of data between DCEs, operating in user classes of service 8 to 11 as indicated in CCITT Recommendation X.1, and IBM SNA X.25 DTEs.

2.1.2 Principles and Terminology

The procedure uses the principle and terminology of the High Level Data Link Control (HDLC) procedures specified by the International Organization for Standardization (ISO).

2.1.3 The transmission facility is duplex.

2.1.4 ISO Compatibility

Station (DCE and DTE) compatibility of operation with the ISO balanced class of procedure (Class BA, options 2 and 8) is achieved using the provisions found under the headings annotated as (LAPB) in this specification.

(Text deleted.)

Note: Other possible applications being considered by the CCITT include:

- (Text deleted.)
- - two-way alternate, normal response mode.

2.2 FRAME STRUCTURE

2.2.1 Format

All transmissions across the X.25 DTE/DCE interface are in frames conforming to one of the formats shown in Table II-1. The flag preceding the address field is defined as the opening flag. The flag following the Frame Checking Sequence (FCS) is defined as the closing flag.

2.2.2 Flag (F) Sequence

All frames shall start and end with at least one flag sequence consisting of at least one '0' bit followed by six contiguous '1' bits and at least one '0' bit ('01111110'). A single flag sequence may be used as both the closing flag for one frame and the opening flag for the next frame. IBM SNA X.25 DTEs transmit and receive bit configurations '...0111111001111110...' as flag sequences and receive and interpret bit configurations '...011111101111110...' as flag sequences.

2.2.3 Address (A) Field

The A field is a single octet, positioned as shown in Table II-1 and coded as described in "Procedure for Addressing (Text deleted)" on page II-14.

2.2.4 Control (C) Field

The C field is a single octet, positioned as shown in Table II-1 whose content is described in "Control Field Formats and State Variables" on page II-6.

Note: Possible extension of the control field is being considered by the CCITT.

TABLE II-1 - Frame Formats

Order of Bit Transmission: 12345678 12345678 12345678 16 to 1 12345678

Flag	Address	Control	FCS	Flag
F 01111110	A 8-bits	C 8-bits	FCS 16-bits	F 01111110

Order of Bit Transmission: 12345678 12345678 12345678 123.......n 16 to 1 12345678

Flag	Address	Control	Information	FCS	Flag
F 01111110	A 8-bits	C 8-bits	I N-Octets*	FCS 16-bits	F 01111110

FCS = frame checking sequence
* - Octet is an 8-bit byte.

2.2.5 Information (I) Field

The I-field of all frames transmitted and received by IBM SNA X.25 DTEs must contain an integral number of octets and is unrestricted with respect to code or grouping except for the packet formats specified in "PACKET FORMATS" on page II-46, the 'Qualified' data packet formats for SNA-to-SNA connections shown in "Logical Link Control (LLC) on SNA-to-SNA Connections" on page II-83 and the Physical Services Header (PSH) formats for SNA-to-SNA connections described in Appendix H.

Note: Frames containing other than an integral number of octets are ignored by IBM SNA X.25 DTEs at the link level.

See "(Text deleted); Frame Reject (FRMR) Response" on page II-11 and "Maximum Number of Bits in an I-frame, N1" on page II-23 below with regard to the maximum information field length.

2.2.6 Transparency

Transmitting stations examine the frame content between the two flags including the address, control, information and FCS and insert a '0' bit immediately following all sequences of 5 contiguous '1' bits (including the last 5 bits of the FCS) to ensure that a flag is not simulated by data on the line. Receiving stations examine the frame content and discard any '0' bit that immediately follows 5 contiguous '1' bits.

2.2.7 Frame Checking Sequence (FCS)

The FCS is a 16-bit sequence containing the ones complement of the sum (modulo 2) of:

1. The remainder of $Xk(X^{15} + X^{15} + X^{13} + \ldots + X^2 + X + 1)$ divided (modulo 2) by the generator polynomial $X^{16} + X^{12} + X^5 + 1$, where k is the number of bits in the frame existing between, but not including, the final bit of the opening flag and the first bit of the FCS, excluding bits inserted for transparency, and

2. the remainder after multiplication by X^{16} and then division (modulo 2) by the generator polynomial $X^{16} + X^{12} + X^5 + 1$, of the content of the frame, existing between but not including, the final bit of the opening flag and the first bit of the FCS, excluding bits inserted for transparency.

As a typical implementation, at transmitting stations, the initial remainder of the division is preset to all ones and is then modified by division by the generator polynomial (as described above) on the address, control and information fields; the ones complement of the resulting remainder is transmitted as the 16-bit FCS.

At receiving stations, the initial remainder is preset to all ones, and the serial incoming protected bits and the FCS when divided by the generator polynomial will result in a remainder of '0001110100001111' (X^{15} through X^0, respectively) in the absence of transmission errors.

2.2.8 Order of Bit Transmission

| Addresses, commands, responses, sequence numbers and information octets are transmitted with the low order bit first (for example the first bit of the sequence number that is transmitted has the weight 2^0).

| (Text deleted). The FCS shall be transmitted to the line commencing with the coefficient of the highest term.

Note: The low order bit is bit 1, as depicted in Tables II-1 to II-4.

2.2.9 Invalid frames

Frames not properly bounded by two flags, or having fewer than 32 bits between flags, are invalid.

2.2.10 Frame abortion

A frame being transmitted may be aborted by the transmission of an abortion sequence (e.g., at least seven (7) contiguous '1' bits (with no inserted '0's)).

2.2.11 Interframe Time-Fill

The transmission of contiguous flags between frames is defined as interframe time-fill.

2.2.12 Link Channel States

2.2.12.1 Active Channel State

A channel is 'active' when the transmitting station is actively transmitting a frame, an abortion sequence or interframe time-fill.

2.2.12.2 Idle Channel State

A channel is 'idle' when a contiguous '1's condition is detected, by the receiving station, that persists for at least fifteen (15) bit times.

IBM SNA X.25 DTEs detect the idle channel state and may consider it to be either:

- an indication that the DCE is not able to support link set-up;
- a simple indication that the DCE has temporarily suspended transmission; or,
- an indication that the link is in the disconnected phase if a flag sequence is not received within at least time Ti. Ti is defined in "DTE Timer, Ti" on page II-23.

Note:

1. The action to be taken by DCEs upon detection of the idle channel state is a subject for further study by the CCITT.
2. A link channel as defined here is the means of transmission for one direction.

2.3 ELEMENTS OF PROCEDURE

2.3.1 Introduction

The elements of procedure are defined in terms of actions that occur on receipt of commands at receiving stations.

The elements of procedure specified here contain a selection of commands and responses relevant to the link and system configuration described in "Scope and Field of Application" on page II-3.

A procedure is derived from these elements of procedure and is described in "Description of the Procedure" on page II-14. Together "Frame Structure" on page II-3 and "Elements of Procedure" form the general requirements for proper management of the access link connecting DCEs and IBM SNA X.25 DTEs.

2.3.2 Control Field Formats and State Variables

2.3.2.1 Control (C) Field Formats

The C field contains a command or a response, and sequence numbers where applicable.

Three C-field formats (see Table II-2) are used to perform numbered information transfers (I-frames), numbered supervisory functions (S-frames) and unnumbered control functions (U-frames).

TABLE II-2 - Control Field Formats

Control field bits	8	7	6	5	4	3	2	1
I frame	Nr			P/F	Ns			0
S frame	Nr			P/F	S	S	0	1
U frame	M	M	M	P/F	M	M	1	1

Ns = transmitter send sequence number (bit 2 = low order bit).
Nr = transmitter receive sequence number (bit 6 = low order bit).
S = supervisory function bit.
M = modifier function bit.
P/F = poll (P) bit in command frames or final (F) bit in response frames (1 = Poll/Final).

1. Information Transfer Format - I

   The I format is used to perform information transfers. The functions of Ns, Nr and P/F are independent; i.e., each I-frame has an Ns, and an Nr which may or may not acknowledge additional I-frames received by the station transmitting the Nr, and a P/F bit.

2. Supervisory Format - S

   The S format is used to perform link supervisory control functions such as acknowledging I-frames, requesting retransmission of I-frames, and requesting temporary suspension of transmission of I-frames.

3. Unnumbered Format - U

   The U format is used to provide additional link control functions. This format contains no sequence numbers.

(Text deleted.)

2.3.2.2 Control Field Parameters

The various parameters associated with the control field formats include a modulus and frame variables and sequence numbers.

2.3.2.3 Modulus

Each I-frame is sequentially numbered and may have the value 'Ns=0' through 'Ns=modulus minus one' (where "modulus" is the modulus of the sequence numbers). The modulus equals '8' and the sequence numbers cycle through the entire range '0' to '7', inclusive.

2.3.2.4 Frame Variables and Sequence Numbers

1. Send State Variable

   The send state variable (Vs) denotes the sequence number of the next in-sequence I-frame to be transmitted. Vs can take on the value '0' through 'modulus minus one'. The value of Vs is incremented by one with each successive I-frame transmission, but at transmitting stations cannot exceed Nr of the last received I or S-frame by more than the maximum permissible number of outstanding I-frames (K). The value of 'K' is defined in "Maximum Number of Outstanding I-frames, K" on page II-23.

2. Send Sequence Number

Only I-frames contain Ns, the send sequence number of transmitted frames. Prior to transmitting an in-sequence I-frame, the value of Ns is set equal to the value of Vs at the transmitting station.

3. Receive State Variable

   The receive state variable (Vr) denotes the sequence number of the next in-sequence I-frame to be received at receiving stations. Vr can take on the values '0' through 'modulus minus one'. The value of Vr is incremented by one upon receipt of each error free, in-sequence (with an Ns that is equal to the current value of Vr at the receiving station) I-frame.

4. Receive Sequence Number

   All I frames and S-frames contain Nr, the expected sequence number of the next received I-frame. Prior to transmitting an I or S-frame, Nr is set equal to the current value of Vr at the transmitting station. Nr indicates that the station transmitting the Nr has correctly received all I-frames numbered up to and including 'Nr-1'.

2.3.3 Functions of the Poll/Final Bit

The poll/final (P/F) bit serves a function in both command frames and response frames. In command frames the 'P/F' bit is referred to as the Poll (P) bit. In response frames it is referred to as the Final (F) bit.

Procedures for use of the 'P/F' bit are described in "Procedure for Use of the P/F Bit (text deleted)" on page II-14.

2.3.4 Commands and Responses

Commands and responses transmitted and received by DCEs operating in LAPB mode and IBM SNA X.25 DTEs are described in "Information (I) Command" on page II-9 through "(Text deleted); Frame Reject (FRMR) Response" on page II-11 and are depicted in Table II-3.

TABLE II-3 - Commands and Responses

Format	Commands	Responses	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1
			Encoding							
Information transfer	I		Nr			P/F	Ns			0
Supervisory (See Note)	RR	RR	Nr			P/F	0	0	0	1
	RNR	RNR	Nr			P/F	0	1	0	1
	REJ	REJ	Nr			P/F	1	0	0	1
Unnumbered (See Note)		DM	0	0	0	F	1	1	1	1
	SABM		0	0	1	P	1	1	1	1
	DISC		0	1	0	P	0	0	1	1
		UA	0	1	1	F	0	0	1	1
		FRMR	1	0	0	F	0	1	1	1

DISC = Disconnect
DM = Disconnected Mode
FRMR = Frame Reject
I = Information
REJ = Reject
RNR = Receive Not Ready
RR = Receive Ready
SABM = Set Asynchronous Balanced Mode
UA = Unnumbered Acknowledgement

Note: All Supervisory and Unnumbered Commands are transmitted by IBM SNA X.25 DTEs with 'P=1'; Information transfer frames are transmitted by IBM SNA X.25 DTEs with 'P=0'.

(Text deleted.)

2.3.4.1 Information (I) Command

I commands are used to transfer sequentially numbered frames, that contain information fields, across data links connecting X.25 DCEs and IBM SNA X.25 DTEs.

2.3.4.2 Receive Ready (RR) Command and Response

RR supervisory frames are used by transmitting stations to:

1. indicate that they are ready to receive I-frames;
2. acknowledge previously received I-frames numbered up to and including 'Nr-1'.

RR frames may be used to clear busy conditions initiated by the transmission of RNR frames. RR commands with 'P=1' may be used by transmitting stations to solicit the status of remote stations.

2.3.4.3 Reject (REJ) Command and Response

REJ supervisory frames are used by transmitting stations to request retransmission of I-frames starting with the frame numbered Nr. I-frames numbered 'Nr-1' and below are acknowledged. Additional I-frames pending initial transmission may be transmitted following the retransmitted I-frame(s).

Only one REJ exception condition for a given direction of information transfer may be established at any time. REJ exception conditions are cleared (reset) upon receipt of an I-frame with an Ns equal to the Nr contained in the REJ frame. REJ commands with the 'P=1' may be used by transmitting stations to solicit the status of remote stations.

2.3.4.4 Receive Not Ready (RNR) Command and Response

RNR supervisory frames are used by transmitting stations to indicate busy conditions; i.e., temporary inability to accept additional I-frames. I-frames numbered up to and including 'Nr-1' are acknowledged. I-frame Nr and subsequent I-frames received, if any, are not acknowledged; the acceptance status of these I-frames is indicated in subsequent exchanges.

Indication that a busy condition at a transmitting station has cleared is communicated to the remote station by the transmission of a UA, RR, REJ or SABM.

RNR commands with the 'P=1' may be used by transmitting stations to solicit the status of remote stations.

Upon receipt of an RNR command or response IBM SNA X.25 DTEs start timer Tp if it is not running. It timer Tp then expires prior to the receipt of a UA, RR, REJ or SABM, IBM SNA X.25 DTEs perform the retransmission procedure described in "Time-Outs and Time-Limits" on page II-22 before declaring the link (station) to be inoperative and reporting the condition to a higher level.

Note: If unacknowledged frames are purged, by the DTE or DCE, as a result of sending
or receiving an SABM or UA, notification must be signalled to a higher level to protect
2 the integrity of the system unless ELLC is being used.

2.3.4.5 Set Asynchronous Response Mode (SARM) Command

SARM commands are not transmitted, and result in a frame rejection condition when received, by IBM SNA X.25 DTEs.

(Text deleted).

2.3.4.6 Set Asynchronous Balanced Mode (SABM) Command

Unnumbered SABM commands are used by transmitting stations to place the remote station in the asynchronous balanced mode (ABM) information transfer phase.

No information field is permitted with the SABM command. Receiving stations confirm acceptance of SABM commands by transmitting a UA response at the first opportunity. Upon acceptance of a SABM command receiving stations set both Vs and Vr equal to '0'. IBM SNA X.25 DTEs always transmit SABM commands with 'P=1'.

Previously transmitted I-frames that are unacknowledged when a SABM command is executed remain unacknowledged (see "Waiting for Acknowledgement" on page II-19).

Note: If unacknowledged frames are purged, by the DTE or DCE, as a result of sending
2 or receiving an SABM or UA, unless ELLC is being used, notification must be given to a
higher level so that the DTE/DCE packet level interface can be restarted to protect
the integrity of the system.

2.3.4.7 Disconnect (DISC) Command

Unnumbered DISC commands are used by transmitting stations to terminate the operational mode previously set. DISC informs the receiving station that the transmitting station is suspending operation.

No information field is permitted with DISC commands. Prior to executing DISC commands, receiving stations confirm acceptance by transmitting a UA response. Transmitting stations enter the disconnected phase upon receipt of the acknowledging UA response. IBM SNA X.25 DTEs always transmit DISC commands with 'P=1'. Previously transmitted I-frames that are unacknowledged when the DISC command is executed remain unacknowledged (see "Waiting for Acknowledgement" on page II-19).

Note: If unacknowledged frames are purged, by the DTE or DCE, as a result of sending
2 or receiving an SABM or UA, unless ELLC is being used, notification must be given to a higher level so that the DTE/DCE packet level interface can be restarted to protect the integrity of the system.

2.3.4.8 Unnumbered Acknowledgement (UA) Response

Unnumbered UA responses are used by transmitting stations to acknowledge receipt and indicate acceptance of SABM and DISC commands. Receiving stations transmit a UA response before executing the received U command. The UA response is transmitted with 'F=1' when 'P=1' in the received U command. No information field is permitted with UA responses.

2.3.4.9 Disconnected Mode (DM) Response

Unnumbered DM responses are used to report a status where the transmitting station is logically disconnected from the link, and is in the disconnected phase. The DM response may be sent in this phase to request a set mode command, or, if sent in response to the receipt of an SABM command, to inform the remote station that the transmitting station is still in disconnected phase and cannot execute the SABM command. No information field is permitted with the DM response.

Stations in the disconnected phase monitor received commands and:

- react to SABM and DISC commands as described in "Procedures for Link Set-Up and Disconnection (LAPB)" on page II-15; and,
- respond DM with 'F=1' to any other command received with 'P=1'.

2.3.4.10 (Text deleted); Frame Reject (FRMR) Response

(Text deleted)

FRMR responses are used by stations to report error conditions that are not recoverable by retransmission of the identical frame to the remote station; i.e., one of the following conditions, resulting from the receipt of a frame without FCS error:

- a command or response that is invalid or not implemented;
- an information field that exceeds the maximum permissible length;
- an invalid Nr (text deleted); or,
- an information field which is not permitted or an S or U frame of incorrect length.

An invalid Nr is one that points to an I-frame that has been previously transmitted and acknowledged or to an I-frame that has not been transmitted and is not the next sequential I-frame pending transmission.

An information field which immediately follows the control field, and consists of 3 octets, is returned with the (text deleted) FRMR response. This format is shown in Table 4.

TABLE II-4 - FRMR Information Field Format

I-field bits 1 2 ...... 7 8	9	10 11 12	13	14 15 16	17	18	19	20	21	22	23	24
Rejected Frame Control Field	0	V(S)	Note	V(R)	W	X	Y	Z	0	0	0	0

- Rejected frame control field is the control field of the received frame that caused the (text deleted) frame reject.
- Vs is the current value of Vs at the station reporting the rejection condition (bit 10 = low order bit).
- Vr is the current value of Vr at the station reporting the rejection condition (bit 14 = low order bit).
- 'W=1' indicates that the control field received and returned in bits 1 through 8 was considered invalid or not implemented.
- 'X=1' indicates that the control field received and returned in bits 1 through 8 was considered invalid because the frame contained an information field which is not permitted or is an S or U-frame with incorrect length. 'W=1' in required in conjunction with this bit.
- 'Y=1' indicates that the information field received exceeded the maximum established capacity of the station reporting the rejection condition.
- 'Z=1' indicates that the control field received and returned in bits 1 through 8 contained an invalid Nr.

Note: (Text deleted) Bit 13 is set to:

'1' if the frame rejected was a response; or,
'0' if the frame rejected was a command.

2.3.5 Exception Condition Reporting and Recovery

Procedures to effect recovery following the detection/occurrence of exception conditions at the link level are described in "Busy Condition" through "Rejection Condition" on page II-13. Exception conditions described include situations that may occur as the result of transmission errors, station malfunctions or abnormal operational situations.

2.3.5.1 Busy Condition

A busy condition results when a station is temporarily unable to continue receiving I-frames due to internal constraints (e.g., receive buffering limitations). Notification of the busy condition is conveyed to the remote station by transmitting an RNR frame across the DTE/DCE interface. I-frames pending transmission may be transmitted by stations experiencing a busy condition, either prior to, or following, transmission of the RNR frame. Recovery from a busy condition is indicated by stations as described in "Receive Not Ready (RNR) Command and Response" on page II-10.

2.3.5.2 Ns Sequence Error

A sequence exception condition results when an error-free (no FCS error) I-frame with an Ns that is not equal to the current value of Vr at the receiving station is received. Receiving stations do not acknowledge (increment their Vr) I-frames that result in sequence exception conditions.

The information field of all I-frames received with an Ns that is not equal the current value of Vr at the receiving station is discarded.

Stations that receive one or more I-frames having sequence errors but otherwise error-free accept the control information contained in the Nr field and the 'P' bit to perform link control functions (e.g., to receive acknowledgement of previously transmitted I-frames and to cause the station to respond ('P=1')). Therefore, retransmitted I-frames may contain an Nr field and 'P' bit that are updated, and therefore different from, those contained in the originally transmitted I-frame(s).

2.3.5.3 REJ Recovery

REJ frames are transmitted by stations to initiate exception recovery (retransmission) following detection of sequence errors.

Only one "sent REJ" exception condition for a station is established at a time. A "sent REJ" exception condition is cleared when the requested I-frame is received; or, when a link set-up or disconnection procedure as described in "Link Set-up" on page II-15 or "Link Disconnection" on page II-16 is performed.

Stations receiving REJ initiate sequential (re-)transmission of I-frames starting with the one indicated by the Nr contained in the received REJ frame.

2.3.5.4 Reply Time-out Recovery

If, due to a transmission error, a station does not receive (or receives and discards) a single I-frame or the last I-frame in a sequence of I-frames, it cannot detect an out-of-sequence exception condition and will, therefore, fail to transmit REJ. DCEs shall, following the completion of a system specified time-out period (see "Time-Outs and Time-Limits" on page II-22), take appropriate recovery action to determine at which I-frame retransmission must begin.

IBM SNA X.25 DTEs use the lost reply protection mechanism, described in "Deadlock Protection" on page II-14, after a system specified time-out period (see "Time-Outs and Time-Limits" on page II-22), to determine at which I-frame to begin retransmission.

2.3.5.5 FCS Error, Unknown Address and Invalid Frame

Any frame received with an FCS error, an unknown address (i.e.,other than 'A' or 'B') or that is invalid (see "Invalid frames" on page II-5) is discarded and no action is taken by the receiving station as the result of such frame(s).

2.3.5.6 Rejection Condition

A rejection condition is established upon receipt of an error-free frame that contains an invalid command/response in the C field, an invalid frame format, an invalid Nr (text deleted) or an information field that exceeds the maximum information field length that can be accommodated.

Receiving stations report exception conditions to the remote station by transmitting a (text deleted) FRMR response. Stations that receive a FRMR response are responsible for returning the the link to operational mode by transmitting an SABM command. After transmitting a FRMR response, stations maintain the frame rejection condition until reset by the remote station. I-frames received by stations in the frame rejection condition are discarded, except for the 'P' bit indication (Nr is ignored). The (text deleted) FRMR response may be repeated at each opportunity until recovery is effected by the remote station, or until internal recovery is initiated locally.

2.4 DESCRIPTION OF THE PROCEDURE

Tables J-1, -2, -3 and -4 in appendix J formalize the actions taken, frames transmitted and state transitions made by DTEs as a result of events occurring in the various states of the X.25 DTE/DCE Link Level interface.

2.4.1 Procedure to Set the Mode Variable B (Text Deleted)

Mode variable procedures are not required in SNA environments since only balanced mode (LAPB) procedures are allowed.

(Text deleted).

2.4.2 Procedure for Addressing (Text deleted)

Frames containing commands transferred from:

DCEs contain the address 'A'.
DTEs contain the address 'B'.

Frames containing responses transferred from:

DCEs contain the address 'B'.
DTEs contain the address 'A'.

Addresses, A and B, are coded as follows:

Address	8	7	6	5	4	3	2	1
A	0	0	0	0	0	0	1	1
B	0	0	0	0	0	0	0	1

Note: Stations (DCEs and DTEs) discard all frames received with an address other than 'A' or 'B'.

2.4.3 Procedure for Use of the P/F Bit (text deleted)

Upon receipt of any command frame with 'P=1', receiving stations transmit an appropriate response frame with 'F=1' at the first opportunity (e.g., immediately following the frame currently being transmitted, if any). Appropriate responses include:

- a UA or DM response to received SABM and DISC command frames;
- an FRMR, REJ, RNR or RR response to received I-frames; and,
- an FRMR, RNR or RR response to received supervisory command frames.

The 'P' bit is also used in conjunction with timer recovery conditions as described in "Waiting for Acknowledgement" on page II-19. (Text deleted).

2.4.3.1 Deadlock Protection

Transmitting stations provide a time-out function to protect against dead-lock conditions caused by the loss of responses from the remote station due to transmission errors. A timer T1 (or Tp for DTEs) may be started upon transmission of I-frames or supervisory command frames, or both, during the information transfer phase. Timer T1 (and Tp for DTEs) is also used during link set-up and disconnection as described in "Link Set-up" on page II-15 and "Link Disconnection" on page II-16, respectively.

If timer T1 (or Tp for DTEs) expires prior to receipt of an appropriate response frame from the remote station, recovery action is initiated by the local station. Transmitting stations transmit an appropriate supervisory command frame or retransmit the appropriate I-frame with 'P=1' and restart timer T1 (or Tp for DTEs). If timer T1 expires prior to receipt of an appropriate response with 'F=1' from the remote station N2 times, appropriate recovery action is initiated by the DCE.

Upon expiration of timer Tp prior to receipt of an appropriate response with 'F=1', IBM SNA X.25 DTEs perform the retransmission procedure described in "Time-Outs and Time-Limits" on page II-22 before declaring the link (station) to be inoperative and reporting the condition to a higher layer.

2.4.4 Procedure for Link Set-Up and Disconnection (LAP)

Unbalanced Link Access Procedures (LAP) are not allowed in SNA environments. (Text deleted)

2.4.5 Procedures for Link Set-Up and Disconnection (LAPB)

2.4.5.1 Link Set-up

Stations indicate their ability to set up the link by transmitting contiguous flag sequences (active channel state).

Upon receipt of a SABM command, receiving stations prepared to receive I-frames return a UA response and set both Vs and Vr equal to '0'. Stations that for some reason are unable, or do not desire, to enter the information transfer phase return a DM response to received SABM commands.

DTEs wishing to set-up the link transmit a SABM command with 'P=1' and start timer Tp (see "Deadlock Protection" on page II-14). Upon receipt of a UA response with 'F=1' from the DCE, DTEs set both Vs and Vr equal to '0' and stop timer Tp.

IBM SNA X.25 DTEs should always take the initiative in the link level initialization procedure by sending SABM with 'P=1'.

Upon receipt of a DM response with 'F=1' indicating that the DCE cannot accept activation of the link, DTEs must report the condition to a higher layer and take no further action.

Upon expiration of timer Tp prior to receipt of an appropriate response with 'F=1', IBM SNA X.25 DTEs perform the retransmission procedure described in "Time-Outs and Time-Limits" on page II-22 before declaring the link (station) to be inoperative and reporting the condition to a higher layer.

DCEs wishing to set-up the link, transmit a SABM command and start Timer T1 (see "Time-Outs and Time-Limits" on page II-22). Upon reception of a UA response from the DTE, DCEs reset both Vs and Vr to '0' and stop Timer T1.

Should timer T1 expire before reception of the UA response from the DTE, DCEs retransmit the SABM command and restart Timer T1. After transmission of the SABM command N2 times by the DCE, appropriate recovery action is initiated. The value of N2 is defined in "Maximum Number of Retransmissions, N2" on page II-23.

2.4.5.2 Information Transfer Phase

Stations, having transmitted a UA response to an received SABM command or having received a UA response to a transmitted SABM command, accept and transmit I and S-frames according to the procedures described in "Procedures for Information Transfer (Text deleted)" on page II-17.

Upon receipt of an SABM command, a UA response or a DM response with 'F=0', while in the information transfer phase, IBM SNA X.25 DTEs conform to the resetting procedure described in "Procedures for Resetting (LAPB)" on page II-20.

When receiving an SABM command while in the information transfer phase, DCEs will conform to the resetting procedure described in "Procedures for Resetting (LAPB)" on page II-20.

2.4.5.3 Link Disconnection

During the information transfer phase, stations indicate disconnecting of the link by transmitting a DISC command across the DTE/DCE interface.

Upon receipt of a DISC command, receiving stations return a UA response and enter the disconnected phase.

DTEs wishing to disconnect the link transmit a DISC command with 'P=1' and start timer Tp (see "Time-Outs and Time-Limits" on page II-22). Upon receipt of a UA response with 'F=1' from the DCE, DTEs stop timer Tp.

Upon expiration of timer Tp prior to receipt of an appropriate response with 'F=1', IBM SNA X.25 DTEs perform the retransmission procedure described in "Time-Outs and Time-Limits" on page II-22 before declaring the link (station) to be inoperative and reporting the condition to a higher layer.

Should the DCE wish to disconnect the link, it will send the DISC command and start Timer T1 (see "Time-Outs and Time-Limits" on page II-22. Upon receipt of the UA response from the DTE, the DCE will stop Timer T1.

Should Timer T1 expire before reception of the UA response from the DTE, the DCE will retransmit the DISC command and restart Timer T1. After transmission of the DISC command N2 times by the DCE, appropriate recovery action will be initiated. The value of N2 is defined in "Maximum Number of Retransmissions, N2" on page II-23.

2.4.5.4 Disconnected Phase

1. Stations, having received a DISC command and returned a UA response, or having received a UA response to a transmitted DISC command, enter the disconnected phase.

   Stations, in the disconnected phase, may initiate link set-up. While in the disconnected phase, stations react to the receipt of SABM commands as described in "Link Set-up" on page II-15 and respond DM received DISC commands.

   Upon receipt of any command frame (other than SABM) with 'P=1', receiving stations respond DM with 'F=1'.

   Upon receipt of a DM with 'F=0', DTEs may transmit an SABM command with 'P=1'.

   Other frames are ignored by receiving stations while in the disconnected phase.

2. When the DCE enters the disconnected phase after detecting error conditions as listed in "Rejection Conditions (LAPB)" on page II-21, or exceptionally after recovery from a temporary internal malfunction; it may also indicate this by sending a DM response rather than a DISC command. In these cases, the DCE will transmit DM and start timer T1 (see "Time-Outs and Time-Limits" on page II-22).

   If timer T1 runs out before the reception of an SABM or DISC command from the DTE, the DCE will retransmit the DM response and restart timer T1. After transmission of the DM response N2 times, DCEs remain in the disconnected phase and initiate appropriate recovery actions. The value of N2 is defined in "Maximum Number of Retransmissions, N2" on page II-23.

2.4.5.5 Collision of Unnumbered Commands

Collision situations are resolved in the following manner.

1. Like Commands when the sent and received U commands are the same, receiving stations both send a UA response at the earliest possible opportunity. Stations enter the indicated phase upon receipt of the UA response.

2. Unlike Commands when the sent and received U commands are different, receiving stations both enter the disconnected phase and transmit a DM response at the earliest possible opportunity.

2.4.5.6 Collision of a DM Response with a SABM or DISC Command

When a DM response is issued by the DCE as an unsolicited response to request the DTE to issue a mode-setting command, as described in "Disconnected Phase" on page II-16, a collision between the SABM or DISC command issued by the DTE and the unsolicited DM response issued by the DCE may occur. IBM SNA X.25 DTEs always transmit SABM and DISC commands with 'P=1' to avoid misinterpretation of such unsolicited DM responses.

2.4.6 Procedures for Information Transfer (Text deleted)

These procedures apply to the transmission of I-frames in each direction of transmission during the information transfer phase.

In the following text, "number one higher" is in reference to a continuously repeated sequence series, i.e., '7' is one higher than '6' and '0' is one higher than '7' for modulo eight series.

2.4.6.1 Sending I Frames

Stations having I-frames to transmit (i.e., I-frames not already transmitted, or having to be retransmitted as described in "Receiving Reject" on page II-19 or "Waiting for Acknowledgement" on page II-19, transmit them with an Ns equal to the current value of Vs at the transmitting station, and an Nr equal to the current value of Vr at the transmitting station. Upon completion of transmission of each successive I-frame, transmitting stations increment Vs by one (1).

DCEs start timer T1 if it is not running at the instant of transmission of an I-frame.

IBM SNA X.25 DTEs must start timer Tp upon completion of transmission of I-frames if it is not already running.

When the value of Vs at a transmitting station is equal to the last value of Nr received from the remote station plus 'K' (where 'K' is the maximum permissible number of outstanding I-frames allowed - see "Maximum Number of Outstanding I-frames, K" on page II-23), stations do not transmit any new I-frames, but may retransmit I-frames as described in "Receiving Reject" on page II-19 or "Waiting for Acknowledgement" on page II-19.

Note: To ensure integrity of information transfer, stations do not transmit any I-frames when Vs at the transmitting station is equal to the last value of Nr received from the remote station plus '7'.

Stations in the busy condition may continue to transmit I-frames, provided the remote station is not also in a busy condition. (Text deleted). Stations in the frame rejection condition, do not transmit I-frames.

2.4.6.2 Receiving I-Frames

1. Correct Receipt

   Upon receipt of an I-frame with the correct FCS and an Ns equal to the current value of Vr at the receiving station, stations not in the busy condition accept the I-field, increment the value of Vr by one (1) and acknowledge receipt of the I-frame(s) by transmitting:

   a. the next sequential I-frame to be transmitted, if available, or an RR supervisory frame with an Nr equal to the current value of Vr; or,

   b. an RR supervisory frame with an Nr equal to the current value of Vr, if no I-frame is available for transmission.

2. Busy

   DCEs may ignore the information field contained in I-frames received while in a busy condition.

   DTEs ignore the information field contained in I-frames received while in a busy condition.

Note: Zero length information fields shall not be passed to the packet level by the DCE and this situation should be indicated to the packet level.

IBM SNA X.25 DTEs treat I-frames with zero length information fields the same as any other I-frame at the link level.

2.4.6.3 Receipt of Incorrect Frames

Frames with an incorrect FCS, an unknown address and invalid frames (see "Invalid frames" on page II-5) are ignored by receiving stations.

Stations receiving I-frames with the correct FCS, but with an incorrect Ns (i.e., one that is not equal to the current value of Vr at the receiving station) discard the I-field and transmit a REJ response with an Nr one higher than the Ns contained in the last correctly received I-frame. Then they discard the I-field, but use the Nr and 'P' bit indications of all I frames received with an Ns that is not equal to the current value of Vr at the receiving station. Upon receipt of the expected I-frame (i.e., one with an Ns equal to the current value of Vr), receiving stations acknowledge the frame as described in "Receiving I-Frames."

2.4.6.4 Receiving Acknowledgement

DTEs, even in a busy condition (text deleted), consider the Nr contained in correctly received I or S (RR, RNR and REJ) frames to be an acknowledgement for all I-frames transmitted with an Ns up to and including 'Nr-1'.

IBM SNA X.25 DTEs reset timer Tp upon correct receipt of an I or S-frame that actually acknowledges some previously transmitted I-frame(s) (i.e., a frame with an Nr higher than the value of the last Nr received); or, upon receipt of an I or S-frame with 'F=1'.

If timer Tp has been reset with I-frame(s) still unacknowledged, DTEs restart timer Tp. If timer Tp expires prior to receipt of an acknowledgment, DTEs follow the retransmission procedure described in "Receiving Reject" on page II-19 and "Waiting for Acknowledgement" on page II-19 with respect to the unacknowledged I-frame(s).

When correctly receiving an I or S-frame (RR, RNR or REJ), even in the busy (text deleted) condition, DCEs consider the Nr contained in this frame as an acknowledgment for all the I-frames they have transmitted with an Ns up to and including the received Nr minus one. The DCE will reset timer T1 when it correctly receives an I or S-frame with the Nr higher than the last received Nr (actually acknowledging some I-frame(s)).

If timer T1 has been reset, and if there are outstanding I-frames still unacknowledged, the DCE will restart timer T1. If timer T1 then runs out, the DCE will follow the retransmission procedure (in "Receiving Reject" on page II-19 and "Waiting for Acknowledgement" on page II-19) with respect to the unacknowledged I-frames.

2.4.6.5 Receiving Reject

Upon receipt of a REJ frame, receiving stations set Vs equal to the Nr contained in the received REJ frame, then transmit the corresponding I-frame when it is available or retransmit it.

Stations conform to the following with respect to the re-transmission of I-frames:

1. A station that is transmitting a supervisory or unnumbered command or response when it receives a REJ, will complete the transmission in progress before commencing transmission of the requested I-frame.
2. A station that is transmitting an I-frame when a REJ is received, may abort transmission of the I frame and commence transmission of the requested I-frame immediately after abortion.
3. A station that is not transmitting any frame when a REJ is received, commence transmission of the requested I-frame immediately.

Other unacknowledged I-frames already transmitted, following the one indicated in the REJ are retransmitted following retransmission of the requested I-frame.

If the REJ frame was received from the remote station as a command with 'P=1', receiving stations transmit an RR or RNR response with 'F=1' prior to transmitting or retransmitting the corresponding I-frame.

2.4.6.6 Receiving RNR

After receiving an RNR, stations may transmit or retransmit the I-frame with Ns equal to the Nr indicated in the RNR frame received. If timer T1 (or Tp for DTEs) runs out after the reception of RNR, stations follow the procedure described in "Waiting for Acknowledgement." Stations do not transmit any other I-frames after receipt of an RNR frame until an RR or REJ frame is received from the remote station.

2.4.6.7 Station Busy Condition

Stations experiencing a busy condition transmit an RNR command or response at the earliest opportunity. While in the busy condition, stations accept and process S-frames and respond RNR with 'F=1' to I and S command frames received with 'P=1'. To clear a busy condition, stations transmit either REJ commands or responses or RR commands or response with Nr set to the current value of Vr, depending on whether or not information fields of correctly received I-frames were discarded.

Note: DTEs encountering DCE busy conditions, may transmit supervisory command frames with 'P=1' to solicit the status of the DCE. DTEs that do not implement supervisory commands, may use the procedures (applicable to LAPB) for DCEs described in "Receiving RNR."

2.4.6.8 Waiting for Acknowledgement

Transmitting stations maintain an internal retransmission count (Y) which is set to '0' upon receipt of a UA or RNR, or upon correct receipt of an I or S-frame with an Nr higher than the last Nr received from the remote station (actually acknowledging some I-frame(s)).

If Timer T1 (or Tp for DTEs) expires, stations enter or (re-)enter the timer recovery condition, increment 'Y' by one (1) and set an internal variable (X) to the current value of Vs.

Stations restart timer T1 (or Tp for DTEs), set Vs equal to the value of the last Nr received from the remote station and retransmit the corresponding I-frame with 'P=1' or transmit an appropriate S-frame with 'P=1'.

Timer recovery conditions are cleared upon receipt of a valid S-frame with 'F=1'.

Upon correct receipt of a supervisory frame with 'F=1' and an Nr within the range from the current value of Vs to 'X' included, stations clear the timer recovery condition and set Vs equal to the value of Nr received.

Upon correct receipt of a supervisory frame with 'F=0' and with an Nr within the range from the current value of Vs to 'X' included, stations do not clear the timer recovery condition. The received Nr may be used to update Vs. However, stations may retransmit the last retransmitted I-frame (even if it is acknowledged) with 'P=1' in the event that timer T1 (or Tp for DTEs) expires at a later time.

When 'Y' is equal to N2 (or Np for DTEs), stations initiate a resetting procedure as described in (text deleted) "Procedure" or "Alternative #1" on page II-21. The values of N2 (and Np for DTEs) are system parameter (see "Maximum Number of Retransmissions, N2" on page II-23).

Note: Although DCEs implement the internal variable 'X', other mechanisms exist that achieve the identical functions. Therefore, internal variable (X) is not necessarily implemented in all DTEs.

2.4.7 Procedures for Resetting (LAP)

(Text deleted).

Unbalanced Link Access Procedures (LAP) are not allowed in SNA environments.

2.4.8 Rejection Conditions (LAP)

(Text deleted).

Unbalanced Link Access Procedures (LAP) are not allowed in SNA environments.

2.4.9 Procedures for Resetting (LAPB)

2.4.9.1 Introduction

The resetting procedures described here are used, only during the information transfer phase, to initialize/reinitialize both directions of information transmission.

2.4.9.2 Procedure

Stations indicate a resetting by transmitting a SABM command. Upon receipt of a SABM command, receiving stations prepared to resume normal link level operation return a UA response, at the earliest opportunity, and set Vs and Vr equal to '0'. This also clears station busy conditions, if present. DTEs not prepared to resume normal link level operations upon receipt of a SABM command transmit a DM response and enter the disconnected phase. Prior to initiating this link resetting procedure, stations may initiate a disconnect procedure as described in "Link Disconnection" on page II-16.

2.4.9.3 Alternative #1

Under certain rejection conditions listed in "Waiting for Acknowledgement" on page II-19 and "Unsolicited DM or FRMR" on page II-22, DCEs may ask the DTE to reset the link by transmitting a DM response.

After transmitting a DM response, DCEs enter the disconnected phase as described in
2 item #2 under "Disconnected Phase" on page II-16.

Upon receipt of a DM response with 'F=0', DTEs prepared to resume normal link layer operations may transmit a SABM command with 'P=1' and start timer Tp.

(Text deleted).

2.4.9.4 Alternative #2

Under certain rejection conditions listed in "Erroneous Frame," stations may request the remote station to reset the link by transmitting a FRMR response.

After transmitting a FRMR response, transmitting stations enter the frame rejection condition. The frame rejection condition is cleared when the station receives a SABM or DISC command or a DM response. Other commands received while in the frame rejection condition cause receiving stations to retransmit the FRMR response with the same information field originally transmitted.

Upon receipt of a FRMR response, DTEs prepared to resume normal link layer operations transmit an SABM command with 'P=1' and start timer Tp. Otherwise, DTEs initiate the disconnect procedure described in "Link Disconnection" on page II-16.

Note: If unacknowledged frames are purged, by the DTE or DCE, as a result of resetting the link layer, notification must be given to a higher layer to protect the integrity of the system.

DCEs may start timer T1 on transmission of the FRMR response. If timer T1 then expires prior to the receipt of an SABM or DISC command from the DTE, DCEs may retransmit the FRMR response and restart timer T1. After transmission of the FRMR response N2 times DCEs may reset the link as described in "Procedure" on page II-20. The value of N2 is defined in "Maximum Number of Retransmissions, N2" on page II-23.

2.4.10 Rejection Conditions (LAPB)

2.4.10.1 Erroneous Frame

Stations initiate a resetting procedure as described in "Alternative #2," upon receipt, during the information transfer phase, of a frame with the correct FCS, with the address 'A' or 'B', and with one of the following conditions:

- the frame is unknown as a command or as a response;
- the information field is invalid; or,
- the frame contains an invalid Nr as defined in "(Text deleted); Frame Reject (FRMR) Response" on page II-11.

Coding of the information field of FRMR responses transmitted is given in "(Text deleted); Frame Reject (FRMR) Response" on page II-11. Bit 13 of this information field is set to:

'0' if the rejected frame was a command; or,
'1' if the rejected frame was a response.

2.4.10.2 Unsolicited DM or FRMR

Stations initiate a resetting procedure as described in "Procedure" on page II-20 (or "Alternative #1" for DCEs) upon receipt, during the information transfer phase, of a DM response or a FRMR response.

2.4.10.3 Unsolicited UA or 'F=1'

Stations may initiate a resetting procedure as described in "Procedure" on page II-20 (or "Alternative #1" on page II-21 for DCEs) upon receipt, during the information transfer phase a UA response or an unsolicited response with 'F=1'.

2.4.11 List of System Parameters

The system parameters are as follows:

2.4.11.1 Time-Outs and Time-Limits

1. DCE Timer, T1

   The period of timer T1 takes into account whether the timer is started at the beginning or at the end of transmission of the frame at the DCE.

   The period of timer T1, at the expiration of which retransmission of a frame may be initiated according to the procedures described in "Procedure for Link Set-Up and Disconnection (LAP)" on page II-15 to "Procedures for Information Transfer (Text deleted)" on page II-17, is a system parameter agreed upon for a period of time with the network Administration.

   Proper operation of the procedure requires that timer T1 be greater than the maximum time between transmission of frames (SABM, DM, DISC, FRMR, I-frames or supervisory command frames) and receipt of the corresponding response frame returned as an answer to this frame (UA, DM or acknowledging frame). Therefore, DTEs should not delay the response or acknowledging frame returned to the above frames by more than a value T2 less than T1, where T2 is a system parameter.

   DCEs will not delay response or acknowledging frames by more than T2.

2. DTE Time-Out Function, (Ft)

   The duration of the time-out function (Ft) is:

$$Ft = (Tp \bullet Np + Td) \bullet Nd$$

   where:

   Tp is a function of the time allowed by DTEs between the transmission of command frames and receipt of the corresponding acknowledging frame. Upon expiration of timer Tp, DTEs retransmit the command with 'P=1' and restart timer Tp.

   Np ≥'1' is the maximum number of transmissions and retransmissions of a frame following the expiration of time Tp.

   Td is typically many time greater than time Tp and is the time to be delayed between consecutive repetitions of Tp•Np.

   Nd ≥'1' is the maximum number of repetitions of Tp•Np+Td to be performed before declaring the link/station to be inoperative.

Note: Although Td may be defined as zero, experience has shown that when Td='0' and Nd='1' are used, links are often declared inoperative prematurely, causing unnecessary session outages and user dissatisfaction.

It is, therefore, recommended that Tp, Np, Td and Nd have default values that can be overridden by customers as experience indicates.

IBM SNA X.25 DTEs start timer Tp upon completion of transmission of supervisory command frames or I-frames with 'P=1'.

3. Time-Limit, T2

   Time-limit T2 is the maximum time allowed between receipt of command frames from remote stations and transmission of the appropriate response frames. This value is product and configuration specific. T2 must never exceed the time needed to transmit one maximum length frame plus fifty (50) milliseconds.

2.4.11.2 Maximum Number of Retransmissions, N2

The value of the maximum number of transmissions and retransmissions of a frame following the expiration of timer T1 is a system parameter (N2) agreed upon for a period of time with the network Administration.

2.4.11.3 Maximum Number of Bits in an I-frame, N1

The maximum permissible number of bits in an I-frame, exclusive of bits inserted for transparency, is a system parameter (N1) which depends upon the maximum length of the information fields transferred across the DTE/DCE interface (i.e., 48+(8 times the maximum number of octets allowed in the information field of I-frames)).

2.4.11.4 Maximum Number of Outstanding I-frames, K

The maximum permissible number (K) of sequentially numbered I-frames that stations may have outstanding (i.e., unacknowledged) at any given time is a system parameter which can never exceed seven (7). The value of 'K' is agreed upon for a period of time with
2 the network Administration. It is essential that 'K' be a parameter whose default value can be overridden.

Note: As a result of the further study proposed in "Control (C) Field" on page II-4, the permissible maximum number of outstanding I-frames may be increased by the CCITT.

2.4.11.5 DTE Timer, Ti

The period of time that the DTE may allow the link to be in the idle channel state before considering it to be in the disconnected phase (out-of-order) state. Ti is much larger Tp.

2.5 MULTI-LINK PROCEDURE

2 CCITT Recommendation X.25 (1984) defines formats and procedures for the operation of
2 multiple parallel data links between DTEs and DCEs for a given DTE/DCE interface
2 appearance. However, this and other additional capabilities defined in CCITT
2 Recommendation X.25 (1984) are being evaluated to ascertain their applicability in SNA
2 environments and decisions regarding support in IBM SNA X.25 DTEs will be based on
2 future technical and business considerations.

It is, therefore, recommended that LAPB be implemented in such a manner that compatibility with the multi-link procedure described in CCITT Recommendation X.25 (1984) can be maintained.

3.0 DESCRIPTION OF THE PACKET LEVEL DTE/DCE INTERFACE

This and subsequent points relate to the transfer of packets at the DTE/DCE interface for both SNA-to-SNA connections and for SNA-to-non SNA connections. The procedures apply to packets that are successfully transferred across the DTE/DCE interface.

Packets transferred across the DTE/DCE interface are contained within the link level information field which delimit their length, and only one packet is contained within the information field.

Note:

1. (Text deleted).
2. At present, some networks require the data fields of packets to contain an integral number of octets. The transmission by the DTE of data fields not containing an integral number of octets to networks may cause a loss of data integrity.

DTEs wishing universal operation on all networks should transmit packets with data fields containing only an integral number of octets. Full data integrity can only be assured by exchange of octet-oriented data fields in both directions of transmission.

IBM SNA X.25 DTEs transmit and receive packets with User Data fields that contain an integral number of octets only.

This point covers a description of the packet level interface for virtual call and permanent virtual circuit services (text deleted). As designated in Recommendation X.2 [2], virtual call and permanent virtual circuit services are essential (E) services to be provided by all networks. (Text deleted).

Note: Under study by the CCITT are considerations regarding the amount of duplication between datagram, fast select and possible additional virtual call enhancements with the objective to minimize the variety of interfaces.

For SNA-to-SNA connections, virtual circuits (virtual calls or permanent virtual circuits) are treated, by SNA DTEs, as real links that can accommodate multiple SNA sessions. Permanent virtual circuits are managed like non-switched links while virtual calls are managed either like switched links or like non-switched links depending upon the implementation at the IBM SNA X.25 DTE. Except for the IBM-5973 Network Interface Adapter (NIA), IBM SNA X.25 DTEs must use 'Qualified' data packets for Logical Link Control (QLLC) or the Enhanced Logical Link Control (ELLC) to perform adjacent SNA node physical services (see "Logical Link Control (LLC) on SNA-to-SNA Connections" on page II-83). Adjacent SNA node physical services, segmentation and sequence numbering may be performed with an optional Physical Services Header (PSH) as described in Appendix H only for compatibility with the IBM-5973 NIA.

For SNA-to-non SNA connections, transformation between X.25 and SNA protocols may be performed at SNA boundary network nodes. In this environment several implementation approaches can be used as described in Appendix I.

SNA-to-SNA connections and SNA-to-non SNA connections differ only at the packet level. Thus, the previous points ("DTE/DCE Interface Characteristics - (physical level)" on page II-1 and "Link Access Procedure across the DTE/DCE Interface" on page II-3) apply equally to both types of connection. Functions, facilities, formats and procedures in "DESCRIPTION OF THE PACKET LEVEL DTE/DCE INTERFACE," "PROCEDURES FOR VIRTUAL CIRCUIT SERVICES" on page II-29, "Procedures for Datagram Service" on page II-45, "PACKET FORMATS" on page II-46 and "PROCEDURES AND FORMATS FOR OPTIONAL USER FACILITIES" on page II-69 that apply only to SNA-to-non SNA connections are enclosed in brackets (e.g., [text]).

(Text deleted).

Procedures for virtual circuit service (i.e., virtual call and permanent virtual circuit services) are specified in "PROCEDURES FOR VIRTUAL CIRCUIT SERVICES" on page II-29. (Text deleted). Packet formats for virtual circuit services are specified in "PACKET FORMATS" on page II-46. Procedures and formats for optional user facilities are specified in "PROCEDURES AND FORMATS FOR OPTIONAL USER FACILITIES" on page II-69.

3.1 LOGICAL CHANNELS

To enable simultaneous virtual calls and/or permanent virtual circuits (text deleted), logical channels are used. Each virtual call and permanent virtual circuit is assigned a Logical Channel Group Number (less than or equal to 15) and a Logical Channel Number (less than or equal to 255). For virtual calls, a Logical Channel Group Number and a Logical Channel Number are assigned during the call set-up phase. The range of logical channels used for virtual calls is agreed upon with the network Administration at the time of subscription to the service (see Appendix A). For permanent virtual circuits (text deleted), Logical Channel Group Numbers and Logical Channel Numbers are assigned in agreement with the Administration at the time of subscription to the service (see Appendix A).

The Logical Channel Group Number and the Logical Channel Number may be managed as a single twelve-bit entity (Logical Channel Identifier - LCI).

3.2 BASIC STRUCTURE OF PACKETS

Packets transferred across the DTE/DCE interface consist of at least three octets. These three octets contain a general format identifier (GFI), logical channel identifier (LCI) and a packet type identifier (PTI). Other fields are appended to packets as required (see "PACKET FORMATS" on page II-46).

Packet types and their use in association with various services are given in Table II-5.

TABLE II-5 — Packet Types and Their Uses in Various Services

PACKET TYPE		SERVICE			Mnemonic	
DCE to DTE	DTE to DCE	VC	PVC	ITF	DCE	DTE
CALL SET-UP AND CLEARING						
INCOMING CALL	CALL REQUEST	X			INC	CRQ
CALL CONNECTED	CALL ACCEPTED	X			CCN	CAC
CLEAR INDICATION	CLEAR REQUEST	X			CLI	CLR
DCE CLEAR CONFIRMATION	DTE CLEAR CONFIRMATION	X			NCC	TCC
DATA [AND INTERRUPT]						
DCE DATA	DTE DATA	X	X		NDT	TDT
[DCE INTERRUPT]	[DTE INTERRUPT]	[X]	[X]		NIN	TIN
[DCE INTERRUPT CONFIRMATION]	[DTE INTERRUPT CONFIRMATION]	[X]	[X]		NIC	TIC
FLOW CONTROL AND RESET						
DCE RR	DTE RR	X	X		NRR	TRR
DCE RNR	DTE RNR	X	X		NNR	TNR
RESET INDICATION		X	X		RSI	
	RESET REQUEST		X			RSR
DCE RESET CONFIRMATION	DTE RESET CONFIRMATION		X		NRC	TRC
RESTART						
RESTART INDICATION	RESTART REQUEST			X	IRI	IRR
DCE RESTART CONFIRMATION	DTE RESTART CONFIRMATION			X	NSC	TSC
DIAGNOSTIC*				X	DGN	

VC = Virtual Call
PVC = Permanent Virtual Circuit
ITF = Entire DTE/DCE Interface

* — Not necessarily available on all networks.

Note: DTE REJ and DATAGRAM packets are not used.

Text deleted.

3.3 PROCEDURE FOR RESTART

The restart procedure is used to initialize or reinitialize the packet level DTE/DCE interface. The DTE restart procedure must be executed after link level initialization is complete. The DTE/DCE interface becomes operational only upon successful completion of the restart procedure. The restart procedure simultaneously clears all virtual calls and resets all permanent virtual circuits (text deleted) at the DTE/DCE interface (see "Effects of Clear, Reset and Restart Procedures on the Transfer of Packets" on page II-43(text deleted)).

Figure B-1, in Appendix B, gives the state diagram which defines the logical relationships of events related to the restart procedure.

Table C-2, in Appendix C, specifies actions taken by DCEs upon receipt of packets from DTEs for the restart procedure. (Text deleted).

Table G-2, in Appendix G, specifies the actions taken by DTEs on receipt of packets from DCEs for the restart procedure.

3.3.1 Restart by DTEs

At any time, after link level initialization is complete, DTEs may initiate a restart by transferring a RESTART REQUEST packet across the DTE/DCE interface. The Diagnostic

Code field in RESTART REQUEST packets is coded x'00' to indicate initial restart (see Appendix F for SNA-to-SNA connections). The interface for each logical channel is then in the DTE RESTART REQUEST state (r2).

DCEs confirm restart by transferring a DCE RESTART CONFIRMATION packet placing logical channels used for virtual calls in the READY state (p1), and logical channels used for permanent virtual circuits (text deleted) in the FLOW CONTROL READY state (d1).

Note: States p1 and d1 are specified in "PROCEDURES FOR VIRTUAL CIRCUIT SERVICES" on page II-29 (text deleted).

DCE RESTART CONFIRMATION packets can only be interpreted universally as having local significance. The time spent in the DTE RESTART REQUEST state (r2) will not exceed time-limit T20 (see Appendix D). In this state, DTEs ignore all packets, except RESTART INDICATION and DCE RESTART CONFIRMATION. If the DCE does not confirm this restart within 200 seconds, the RESTART REQUEST packet can be retransmitted after the 200 second timer is reinitialized. If the total time spent in state (r2) exceeds 'n' times 200 seconds, where 'n≥1', notification of failure of the DTE/DCE interface must be reported to a higher level by IBM SNA X.25 DTEs using the Diagnostic code x'34'. The DTE/DCE interface must be placed in an inoperative state.

Note: [For SNA-to-non SNA connections the coding of the diagnostic field is a matter to be negotiated by the specific non-SNA DTE(s).]

3.3.2 Restart by DCEs

DCEs may indicate a restart by transferring a RESTART INDICATION packet across the DTE/DCE interface. The interface for each logical channel is then in the DCE RESTART INDICATION state (r3). In this state of the DTE/DCE interface, DCEs ignore all packets except RESTART REQUEST and DTE RESTART CONFIRMATION. IBM SNA X.25 DTEs must report the contents of the restart cause and diagnostic fields contained in RESTART INDICATION packets to a higher layer.

DTEs confirm the restart by transmitting a DTE RESTART CONFIRMATION packet across the DTE/DCE interface, before timer T10 elapses, placing all logical channels used for virtual calls in the READY state (p1) and all logical channels used for permanent virtual circuits (text deleted) in the FLOW CONTROL READY state (d1).

Actions taken by DCEs when DTEs do not confirm the restart within time-out T10 are given in Appendix D.

3.3.3 Restart Collision

Restart collision occurs when a DTE and a DCE simultaneously transfer a RESTART REQUEST and a RESTART INDICATION packet. When this occurs, DCEs consider the restart to be complete. DCEs do not expect a DTE RESTART CONFIRMATION packet and do not transfer a DCE RESTART CONFIRMATION packet. DTEs do not expect a DCE RESTART CONFIRMATION packet and do not transfer a DTE RESTART CONFIRMATION packet when a restart collision occurs. This places all logical channels used for virtual calls in the READY state (p1), and all logical channels used for permanent virtual circuits (text deleted) in the FLOW CONTROL READY state (d1).

3.4 ERROR HANDLING

Table C-1, in Appendix C, specifies the reaction of DCEs when special error conditions are encountered. Other error conditions are discussed in §-4. (Text deleted). Table G-1, in Appendix G, specifies the reaction of DTEs when special error situations are encountered.

3.4.1 Diagnostic Packet

DIAGNOSTIC packets are used by some networks to indicate error conditions in circumstances where the usual methods of indication (i.e., reset, clear and restart with cause and diagnostic) are not appropriate (see Tables C-1 and D-1). DIAGNOSTIC packets from DCEs supply information on error situations that are considered to be unrecoverable at the packet level of X.25; the information provided in the diagnostic code and explanation fields of DIAGNOSTIC packets must be reported to a higher level for error analysis and recovery by IBM SNA X.25 DTEs. No state transition takes place on the logical channel to which the DIAGNOSTIC packet is related.

A DIAGNOSTIC packet is issued only once per particular instance of an error condition. DTEs do not confirm receipt of DIAGNOSTIC packets. After issuing a DIAGNOSTIC packet, DCEs maintain the logical channel(s) to which the DIAGNOSTIC packet is related in the same state as that when the DIAGNOSTIC packet was generated.

3.5 EFFECTS OF THE PHYSICAL LEVEL AND THE LINK LEVEL ON THE PACKET LEVEL

Changes in operational states at the physical level and the link level of the DTE/DCE interface do not implicitly change the state of logical channels at the packet level. When such changes occur, they are explicitly indicated at the packet level by the use of appropriate clear, reset or restart procedures.

Failures at the physical and/or link level are conditions in which stations cannot transmit and receive any frames because of abnormal conditions caused by, for instance, a line fault between the DTE and the DCE.

When failures at the physical level or the link level are detected, virtual calls are cleared and permanent virtual circuits are declared out of order (text deleted) by DCEs. Further actions are specified in "Effects of Physical and Link Level Failures" on page II-44 for virtual circuit services (text deleted).

When DTEs detect such a failure, or when the link goes into disconnected mode, and link level queues are purged by the DTE or the DCE, inoperative notifications must be given to higher levels. In this event, inoperative notification are required for the LAPB link and for all virtual circuits to cause all using SNA half-sessions to be notified of the outage.

When physical and/or link level failures are recovered, DCEs transmit RESTART INDICATION packets with the cause "Network Operational" to local DTEs. Further actions are specified in "Effects of Physical and Link Level Failures" on page II-44 for virtual circuit services (text deleted).

(Text deleted).

In other out-of-order conditions at the physical and/or link level, including transmission of a DISC command by the DTE, the behavior of the DCE is being studied by the CCITT.

IBM SNA X.25 DTEs assume that DCEs clear virtual calls and reset permanent virtual circuits when other out of order conditions occur at the physical and/or link level.

Note: An out-of-order condition on the link level includes receipt of a DISC commands by DCEs in the case of a single link procedure.

(Text deleted).

4.0 PROCEDURES FOR VIRTUAL CIRCUIT SERVICES

4.1 PROCEDURES FOR VIRTUAL CALL SERVICE

Figures B-1, B-2 and B-3, in Appendix B, contain state diagrams which define the state transitions that occur at the packet level DTE/DCE interface for logical channels used for virtual calls.

Appendix C gives details of the actions taken by DCEs on receipt of packets in each state shown in Appendix B.

Text deleted.

Appendix G gives details of the actions taken by DTEs on receipt of packets in each state shown in Appendix B.

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

4.1.1 Ready State

A logical channel is in the READY state (p1) when no call exists.

4.1.2 Call Request Packet

Calling DTEs indicate call requests by transferring CALL REQUEST packets across the DTE/DCE interface. The logical channel, selected for the call by the DTE, is then in the DTE WAITING state (p2). If the time spent in the DTE WAITING state (p2) exceeds 200 seconds, the CALL REQUEST packet can be retransmitted after the 200 second timer is reinitialized. If the total time spent in state (p2) exceeds 'n' times 200 seconds, where 'n≥1', a CLEAR REQUEST is transmitted and notification of the CALL REQUEST failure must be reported to a higher level using the Diagnostic code #49; the logical channel is placed in an inoperative state. CALL REQUEST packets include the called DTE address. The calling DTE address field may also be used.

Note:

1. A DTE address may be a network address, an abbreviated address or any other DTE identification agreed upon for a period of time between the DTE and the DCE.
2. CALL REQUEST packets use the logical channel in the READY state (r1) with the highest number in the range that has been agreed upon with the network Administration (see Appendix A). Thus, the risk of call collision is minimized.

4.1.3 Incoming Call Packet

DCEs indicate incoming calls by transferring INCOMING CALL packets across the DTE/DCE interface. This places the logical channel, selected by the DCE for the call, in the DCE WAITING state (p3).

DCEs assign the logical channel in the READY state (r1) with the lowest number (see Appendix A) to INCOMING CALL packets. INCOMING CALL packets include the calling DTE address. The called DTE address field may also be used. The contents of the called DTE address field are ignored by IBM SNA X.25 DTEs.

Note: A DTE address may be a DTE network address, an abbreviated address or any other DTE identification agreed upon for a period of time between the DTE and the DCE.

4.1.4 Call Accepted Packet

Called DTEs accept calls by transferring CALL ACCEPTED packets, specifying the logical channel indicated in INCOMING CALL packets across the DTE/DCE interface, before timer T11 elapses. This places the specified logical channel in the DATA TRANSFER state (p4).

If the called DTE does not accept a call by transmitting a CALL ACCEPTED packet, or does not reject it by transmitting a CLEAR REQUEST packet as described in "Clearing by DTEs," within time-out T11 (see Appendix D), DCEs consider this to be a procedure error on the part of the called DTE and clear the virtual call according to the procedure described in "Clearing by DCEs" on page II-31.

4.1.5 Call Connected Packet

Receipt of a CALL CONNECTED packet specifying the logical channel assigned to a previous CALL REQUEST packet by a calling DTE indicates that the call has been accepted by the called DTE. This places the specified logical channel in the DATA TRANSFER state (p4).

The time spent in the DTE WAITING state (p2) will not exceed time-limit T21 (see Appendix D).

4.1.6 Call Collision

Call collision occurs when a DTE and DCE simultaneously transfer a CALL REQUEST packet and an INCOMING CALL packet specifying the same logical channel. When this occurs, DCEs proceed with the call request and cancel the incoming call. DTEs discard the INCOMING CALL packet in the event of call collision.

4.1.7 Clearing by DTEs

DTEs may indicate call clearing, at any time, by transferring a CLEAR REQUEST packet across the DTE/DCE interface (see "Effects of Clear, Reset and Restart Procedures on the Transfer of Packets" on page II-43). The specified logical channel is then in the DTE CLEAR REQUEST state (p6). DCEs transfer a DCE CLEAR CONFIRMATION packet specifying the same logical channel across the DTE/DCE interface when prepared to free the logical channel. The logical channel is then in the READY state (p1).

DCE CLEAR CONFIRMATION packets can only be interpreted universally as having local significance; however, they may have end to end significance in some networks. In any event the time spent in the DTE CLEAR REQUEST state (p6) will not exceed time-limit T23 (see Appendix D). If a DCE CLEAR CONFIRMATION packet is not received within 200 seconds, the CLEAR REQUEST packet can be retransmitted after the 200 second timer is reinitialized. If the total time spent in state (p6) exceeds 'n' times 200 seconds, where 'n≥1', notification of the clear failure must be given to a higher level by IBM SNA X.25 DTEs using the Diagnostic code #50; the logical channel is placed in an inoperative state.

Depending upon the state of the logical channel, it is possible for DTEs to receive other types of packets between the transfer of a CLEAR REQUEST packet and the receipt of the DCE CLEAR CONFIRMATION packet. Any such packets are discarded by IBM SNA X.25 DTEs.

Note: Calling DTEs may abort a call by clearing the call prior to receipt of a CALL CONNECTED or CLEAR INDICATION packet.

Called DTEs may refuse an incoming call by clearing it as described in this point rather than transmitting a CALL ACCEPTED packet as described in "Call Accepted Packet" on page II-30. Called DTEs must provide the reason for refusing incoming calls by placing an appropriate diagnostic code (see Appendix F) in the Diagnostic Code field of CLEAR REQUEST packets.

4.1.8 Clearing by DCEs

DCEs indicate call clearing by transferring CLEAR INDICATION packets across the DTE/DCE interface (see "Effects of Clear, Reset and Restart Procedures on the Transfer of Packets" on page II-43). The specified logical channel is then in the DCE CLEAR INDICATION state (p7). DTEs respond by transferring a DTE CLEAR CONFIRMATION packet across the DTE/DCE interface, before time-out T13 elapses. The specified logical channel is then in the READY state (p1). DTEs must report the contents of network generated call clearing cause and diagnostic fields to a higher layer.

Actions taken by DCEs when DTEs do not confirm call clearing within time-out T13 are given in Appendix D.

4.1.9 Clear Collision

Clear collision occurs when a DTE and a DCE simultaneously transfer a CLEAR REQUEST packet and a CLEAR INDICATION packet specifying the same logical channel. In this event, DCEs consider call clearing to be complete. DCEs do not expect a DTE CLEAR CONFIRMATION packet and do not transfer a DCE CLEAR CONFIRMATION packet. DTEs do not expect a DCE CLEAR CONFIRMATION packet and do not transfer a DTE CLEAR CONFIRMATION packet when a clear collision occurs. This places the specified logical channel in the READY state (p1).

4.1.10 Unsuccessful Call

When a call cannot be established, DCEs transfer a CLEAR INDICATION packet specifying the logical channel indicated in the CALL REQUEST packet. IBM SNA X.25 DTEs must report the contents of network generated call clearing cause and diagnostic code fields to a higher level.

4.1.11 Call Progress Signals

DCEs are capable of transferring the clearing call progress signals specified in CCITT Recommendation X.96 [4], as clearing cause and/or diagnostic codes, to DTEs.

Clearing call progress signals are carried in CLEAR INDICATION packets that terminate the call to which the packet refers. The method of coding CLEAR INDICATION packets containing call progress signals is detailed in "Clear Request and Clear Indication Packets" on page II-54. IBM SNA X.25 DTEs must report all clearing call progress signals to a higher level.

4.1.12 Data Transfer State

Procedures for the control of packets transferred between DTEs and DCEs in the DATA TRANSFER state (p4) are described in "Procedures for Data [and Interrupt] Transfer" on page II-32.

4.2 PROCEDURES FOR PERMANENT VIRTUAL CIRCUIT SERVICE

Figures B-1 and B-3, in Appendix B, contain state diagrams defining events that occur at the packet level DTE/DCE interface for logical channels assigned for permanent virtual circuits.

Appendix C gives details of the action taken by DCEs upon receipt of packets in each state shown in Appendix B. (Text deleted).

Appendix G gives details of the action taken by DTEs upon receipt of packets in each state shown in Appendix B.

Call set-up and clearing procedures do not apply to permanent virtual circuits. Procedures for the control of packets transferred between DTEs and DCEs while in the DATA TRANSFER state (p4) are described in "Procedures for Data [and Interrupt] Transfer."

4.3 PROCEDURES FOR DATA [AND INTERRUPT] TRANSFER

The data transfer [and interrupt] procedures described in the following points of "Procedures for Data [and Interrupt] Transfer" apply independently to each logical channel assigned for virtual calls and permanent virtual circuits existing at the DTE/DCE interface.

Normal network operation dictates that user data in data [and interrupt] packets are all passed transparently, unaltered through the network in the case of packet DTE to packet DTE communications. Order of bits in data packets is preserved. Packet sequences are delivered as complete packet sequences. DTE Diagnostic Codes are treated as described in "Clear Request and Clear Indication Packets" on page II-54, "Reset Request and Reset Indication Packets" on page II-60 and "Restart Request and Restart Indication Packets" on page II-62.

4.3.1 States for Data Transfer

A virtual call logical channel is in the DATA TRANSFER state (p4) after completion of call establishment and prior to a clearing or a restart procedure. A permanent virtual circuit logical channel is continually in the DATA TRANSFER state (p4) except during the restart procedure. Data, [interrupt,] flow control and reset packets may be transmitted and received by DTEs in the DATA TRANSFER state (p4) of a logical channel at the DTE/DCE interface. In this state, the flow control and reset procedures described in "Procedures for Flow Control" on page II-37 apply to data transmission on that logical channel to and from DTEs.

When a virtual call is cleared, data [and interrupt] packets may be discarded by the network (see "Effects of Clear, Reset and Restart Procedures on the Transfer of Packets" on page II-43). In addition, data, [interrupt,] flow control and reset packets transmitted by DTEs are ignored by DCEs when the logical channel is in the DCE CLEAR INDICATION state (p7).

(Text deleted.)

4.3.1.1 SNA-to-SNA Connections

Logical Link Control (LLC, see "Logical Link Control (LLC) on SNA-to-SNA Connections" on page II-83) protocols enable IBM SNA X.25 DTE's to cope with the various situations that may possibly occur on SNA-to-SNA connections.

The following actions are taken by IBM SNA X.25 DTEs to protect against possible packet losses:

1. Orderly Clearing

Virtual call clearing is normally initiated only upon requests from SNA control points which are responsible for making sure that data flows have first been quiesced and all sessions using the virtual circuit have been properly deactivated.

2. Accidental Clearing

When call clearing is initiated by the network, following some network detected error condition, the station is placed in an inoperative state, notification of the station outage is given to a higher level causing session outage notifications to be propagated according to SNA mechanisms to all half-sessions that were sharing the virtual circuit. Inoperative stations are returned to an operational state only by stimulus from some higher level SNA protocol. After the station is recontacted and sessions are reestablished the SNA session protocols are responsible for recovery from any packet loss that may have occurred as a result of call clearing.

4.3.2 User Data Field Length of Data Packets

The standard maximum User Data field length is '128' octets.

Other maximum User Data field lengths that may be offered by some network Administrations include:

'16', '32', '64', '256', '512' and '1024' octets.

An optional maximum User Data field length may be selected for a period of time as the default maximum User Data field length common to all virtual calls at the DTE/DCE interface (see "Non-Standard Default Packet Sizes" on page II-73). A value other than the default may be selected for a period of time for each permanent virtual circuit (see "Non-Standard Default Packet Sizes" on page II-73). Negotiation of maximum User Data fields lengths, on a per call basis, may be made with the Flow Control Parameter Negotiation facility (see "Flow Control Parameter Negotiation" on page II-73).

IBM SNA X.25 DTE implementations that allow maximum User Data field lengths other than '128' octets support the flow control parameter negotiation facility (i.e., not all networks provide the selection of a default maximum length other than '128' octets). As a result, a multi-channel interface may be required to simultaneously support multiple maximum packet lengths.

The User Data field of data packets transmitted across the DTE/DCE interface may contain any number of octets up to the agreed maximum.

(Text deleted.)

If the User Data field in a data packet exceeds the locally permitted maximum User Data field length, DCEs reset the virtual call or permanent virtual circuit with the resetting cause "Local Procedure Error". Upon receipt of a reset on virtual calls, DTEs clear the virtual call and must report the error to a higher level.

When DTEs receive data packets that exceed the locally permitted User Data field length, they clear the virtual call or reset the permanent virtual circuit with the diagnostic code #167, "Packet Too Long" (see Appendix F) and must report the error to a higher level.

4.3.3 Delivery Confirmation (D) Bit

4.3.3.1 SNA-to-SNA Connections

The 'D' bit in packets on SNA-to-SNA connections should always be '0'. When DTEs receive a data packet that contains 'D=1', they clear the virtual call or reset the permanent virtual circuit with the Diagnostic Code #174, "Invalid 'D' Bit Received" (see Appendix F) and must report the error to a higher level.

Upon receipt of an INCOMING CALL or CALL CONNECTED packet with 'D=1', IBM SNA X.25 DTEs clear the virtual call with the Diagnostic Code 'E9' (Invalid 'D' Bit Request) and must report the error to a higher level.

4.3.3.2 SNA-to-non_SNA Connections

The setting of the Delivery Confirmation (D) bit is used to indicate whether or not the DTE wishes to receive an end-to-end acknowledgement of delivery, for data it is transmitting, by means of the packet receive sequence number (Pr) (see "Procedures for Flow Control" on page II-37).

Note:

1. Use of the 'D' bit procedure does not obviate the need for a higher level protocol agreed upon between participating DTEs which may be used with or without the 'D' bit procedure to recover from user or network generated resets and clearings.

2. After January 1982, the 'D' bit procedure should be considered an integral part of the X.25 DTE/DCE interface. In the interim period, the 'D' bit procedure will be available on some Public Data Networks and between some pairs of Public Data Networks on a bilateral basis.

During the interim period, Administrations of networks that do not provide the 'D' bit procedure should be consulted to determine whether the significance of Pr is a local updating of the window across the packet level DTE/DCE interface or conveys an end-to-end acknowledgement of delivery of data.

To facilitate the orderly introduction of the 'D' bit procedures in DTEs and DCEs, the following mechanisms are provided.

Calling DTEs can ascertain during call establishment that the 'D' bit procedure can be used for the call by setting bit 7 in the General Format Identifier of the CALL REQUEST packet equal to '1' (see "General Format Identifier" on page II-47). Every network or part of international network where the 'D' bit procedure is available passes this bit transparently. Remote DTEs able to handle the 'D' bit procedure should not regard this bit being set to '1' in INCOMING CALL packets as invalid.

Likewise, called DTEs can set bit 7 in the General Format Identifier of the CALL ACCEPTED packet equal to '1'. Every network or part of international network where the 'D' bit is available passes this bit transparently. Calling DTEs able to handle the 'D' bit procedure should not regard this bit being set to '1' in CALL CONNECTED packets as invalid.

If any network along the path does not support the 'D' bit procedure, this would be indicated by call clearing by the DCE with a cause indicating "Incompatible Destination" and the diagnostic "Invalid General Format Identifier" or by any other means to indicate an invalid general format identifier at the DTE/DCE interface (see Table C-1).

Use by DTEs of the above mechanism in CALL REQUEST and CALL ACCEPTED packets is recommended but is not mandatory for using the 'D' bit procedure on virtual calls.

When 'D'='1' in a data packet on a virtual call or permanent virtual circuit where the 'D' bit procedure is not available, this will be indicated to both participating DTEs by a RESET INDICATION packet with the cause "Incompatible destination" and the diagnostic "Invalid general format identifier"; or, by some other means to indicate an invalid general format identifier at the DTE/DCE interface (see Table C-1).

DTEs may request either local or remote significance and IBM SNA X.25 DTEs permit partner DTEs to operate with end-to-end significance. Thus, bit 7 of the first octet (GFI) in CALL REQUEST and CALL ACCEPTED packets may be set to '0' or '1' according to the parameters that, in the SNA "BIND" command opening the SNA session corresponding to the virtual circuit, indicate whether definite responses are supported for that SNA session (see Approach 1 in Appendix I).

Similarly, the state of bit 7 of the first octet (GFI) in INCOMING CALL packets may be used to determine the proper "BIND" protocol. The state of bit 7 of the first octet in CALL CONNECTED packets may be compared to the established SNA session and a decision made as to whether compatibility of operation on the virtual circuit and the SNA session is guaranteed.

4.3.4 More Data Mark

Stations wishing to indicate a sequence of more than one packet use a More Data mark ('M' bit) as defined below.

4.3.4.1 SNA-to-SNA Connections

'M' bit segmenting is required for IBM SNA X.25 DTEs, but if compatibility with the IBM-5973 NIA is required, the PSH segmenting procedure described in Appendix H must be implemented as well.

When PSH segmenting is implemented, the maximum packet size must be the same at the local and remote X.25 DTE/DCE interfaces.

'M=1' is only used in full data packets to indicate that more data follows. Recombination with the following data packet may only be performed within the network when 'M=1'.

Two categories of data packets, 'A' and 'B', are defined as shown in Table II-6. Table II-6 also illustrates the network's treatment of the 'M' bit at both ends of virtual calls or permanent virtual circuits.

Upon receipt of a partially filled data packet with 'M'='1', IBM SNA X.25 DTEs on SNA-to-SNA connections clear the virtual call or reset the permanent virtual circuit with the Diagnostic Code 'A1' (Invalid 'M' Bit Packet Sequence).

4.3.4.2 SNA-to-non_SNA Connections

The 'M' bit can be set equal to '1' in any data packet. 'M=1' in a full data packet or in a partially full data packet that also has 'D=1', indicates that more data follows. Recombination with the following data packet may only be performed within the network when 'M=1' in a full data packet that also has 'D=0'.

A sequence of data packets with 'M=1' in every packet except for the last one will be delivered as a sequence of data packets with 'M=1' in every packet except for the last one when the original packets having 'M=1' are either full (irrespective of the setting of the 'D' bit) or partially full but have 'D=1'.

Two categories of data packets, 'A' and 'B', are defined as shown in TABLE II-6. TABLE II-6 also illustrates the network's treatment of the 'M' and 'D' bits at both ends of virtual calls or permanent virtual circuits.

Table II-6 – Definition of Two Categories of Data Packets and Network Treatment of the 'M' bit and the 'D' bit

Data packet sent by source DTE				Combining with subsequent packet(s) is performed by the network when possible	Data Packet* Received b Destination DTE	
Category	M	D	Full		M	D
B	0 or 1	0	No	No	0	0
B**	0	1	No	No	0	1
B**	1	1	No	No	1	1
B	0	0	Yes	No	0	0
B**	0	1	Yes	No	0	1
A	1	1	Yes	Yes (See Note)	1	0
B**	1	1	Yes	No	1	1

* – Refers to the delivered data packet whose last bit of user data corresponds to the last bit of user data, if any, that was present in the data packet sent by the source DTE.
** – Valid on SNA-to-non-SNA connections only.

Note: If the data packet sent by the source DTE is combined with other packets, up to and including a category 'B' packet, the 'M' and 'D' bit settings in the data packet received by the destination DTE will be according to that given in the right hand columns for the last data packet sent by the source DTE that was part of the combination.

4.3.5 Complete Packet Sequence

A complete packet sequence is composed of a single category 'B' packet and all contiguous preceding category 'A' packets (if any). Category 'A' packets have the exact maximum User Data field length with 'M=1' and 'D=0'. All other data packets are category 'B' packets.

Complete packet sequences, transmitted by source DTEs, are always delivered to the destination DTE as single complete packet sequences.

Thus, when the maximum user data field length at the receiving end is larger than that at the transmitting end, packets of complete packet sequences are combined within the network. They will be delivered as complete packet sequences where each packet, except the last one, has the exact maximum user data field length, 'M=1' and 'D=0'. The User Data field of the last packet of a sequence may have less than the maximum length with the 'M' and 'D' bits set as described in Table II-6.

When the maximum user data field length is the same at both ends, data fields of data packets are delivered to the receiving DTE exactly as received by the network, except as follows. If a full packet with 'M=1' and 'D=0' is followed by an empty packet, the two packets may be merged so as to become a single category 'B' full packet. If the last packet of a complete packet sequence transmitted by the source DTE has a User Data field less than the maximum length with 'M=1' and 'D=0', the last packet of the complete packet sequence is delivered to the destination DTE with 'M=0'.

When the maximum user data field length at the receiving end is smaller than that at the transmitting end, packets will be segmented within the network, and the 'M' and 'D' bits set by the network as described to maintain complete packet sequences.

4.3.5.1 SNA-to-SNA Connections Only

When PSH segmenting is used, the maximum packet length at the local and remote DTE/DCE interfaces is the same. Therefore, no 'M' bit packet sequences occur at either DTE/DCE interface.

4.3.6 Qualifier Bit

Complete packet sequences may be transmitted on one of two levels. DTEs wishing to transmit data on more than one level use an indicator called the Qualifier ('Q') bit.

When only one level of data is being transmitted on a logical channel, the Qualifier bit is always set to 'Q=0'. When two levels of data are being transmitted, transmitting DTEs should set the 'Q' bit in all data packets of complete packet sequences to the same value, either '0' or '1'. Complete packet sequences, transmitted with the 'Q' bit set to the same value in all packets, are delivered by the network as complete packet sequences with the 'Q' bit in all packets set to the value assigned by the transmitting DTE.

Other sequences of 'Q' bit settings received cause DTEs to reset the permanent virtual circuit or clear the virtual call with the Diagnostic Code #175, "Invalid 'Q' Bit Received". IBM SNA X.25 DTEs must report the contents of the resetting/clearing cause and diagnostic code fields to a higher level.

Actions taken by networks when the 'Q' bit is not set to the same value in all data packets of a complete packet sequence by the transmitting DTE is under consideration by the CCITT.

Packets are numbered consecutively (see "Numbering of Data Packets" on page II-38) regardless of their data level.

4.3.6.1 SNA-to-SNA Connections

The 'Q' bit is used by IBM SNA X.25 DTEs on SNA-to-SNA connections to identify data packets associated with the QLLC Logical Link Control procedure described in "Logical Link Control (LLC) on SNA-to-SNA Connections" on page II-83.

4.3.6.2 SNA-to-non_SNA Connections

CCITT Recommendation X.29 provides one example of the procedures to be used when the 'Q' bit is set to '1'. IBM SNA X.25 DTEs that support CCITT Recommendation X.29 and other packet assembly/disassembly (PAD) control procedures implement the 'Q' bit procedure, accordingly.

4.3.7 Interrupt Procedure

4.3.7.1 SNA-to-SNA Connections

The interrupt procedure is not allowed on SNA-to-SNA connections.

4.3.7.2 SNA-to-non_SNA Connection

Interrupt procedures allow DTEs to transmit data to remote DTEs, without following the flow control procedures applying to data packets (see "Procedures for Flow Control"). The interrupt procedure applies only during the FLOW CONTROL READY state (d1) within the DATA TRANSFER state (p4).

Interrupt procedures have no effect on the transfer and flow control procedures applying to data packets on virtual calls or permanent virtual circuits.

To transmit an interrupt, DTEs transfer a DTE INTERRUPT packet across the DTE/DCE interface. DTEs do not transmit a second DTE INTERRUPT packet before a DCE INTERRUPT CONFIRMATION packet (see Note 2 to Table C-4) has been received. DCEs, after the interrupt procedure is completed at the remote end, confirm receipt of interrupts by transferring DCE INTERRUPT CONFIRMATION packets. Receipt of DCE INTERRUPT CONFIRMATION packets indicate that interrupts have been confirmed by remote DTEs by means of DTE INTERRUPT CONFIRMATION packets.

DCEs indicate interrupts from remote DTEs by transferring DCE INTERRUPT packets containing the same data field as in the DTE INTERRUPT packet transmitted across the DTE/DCE interface by the remote DTE. DCE INTERRUPT packets are delivered at or before the point in the stream of data packets at which DTE INTERRUPT packets were generated. DTEs confirm receipt of DCE INTERRUPT packets by transferring DTE INTERRUPT CONFIRMATION packets across the DTE/DCE interface.

4.4 PROCEDURES FOR FLOW CONTROL

"Procedures for Flow Control" on page II-37 only applies to the DATA TRANSFER state (p4) and specifies the procedures for controlling the flow of data and reset packets on logical channels used for virtual calls or permanent virtual circuits.

4.4.1 Flow Control

At the DTE/DCE interface of logical channels used for virtual calls or permanent virtual circuits, the transmission of data packets is controlled separately for each direction of transmission and is based on authorizations from the receiving station.

On virtual calls or permanent virtual circuits, flow control also allows receiving DTEs to limit the rate at which remote DTEs transmit data packets. This is achieved by the receiving station controlling the rate at which it accepts packets across the DTE/DCE interface, noting that there is a network-dependent limit on the number of data packets that can be in the network on a virtual call or permanent virtual circuit.

4.4.1.1 Numbering of Data Packets

Data packets transmitted across the DTE/DCE interface for each direction of transmission on a virtual call or permanent virtual circuit are sequentially numbered.

The sequence numbering scheme of the packets is performed modulo '8'. The packet sequence numbers cycle through the entire range '0' to '7', inclusively. Some Administrations provide the Extended Packet Sequence Numbering facility (see "Extended Packet Sequence Numbering" on page II-69) which, if selected, provides a sequence numbering scheme for packets being performed modulo '128'. In this case, packet sequence numbers cycle through the entire range '0' to '127', inclusively. The packet sequence numbering scheme, modulo '8' or '128', is the same for both directions of transmission and applies to all logical channels at the DTE/DCE interface.

Note: IBM SNA X.25 DTEs must implement Modulo '8' packet sequence numbering. Implementation of modulo '128' packet sequence numbering is optional.

Only data packets contain this sequence number called the packet send sequence number, Ps.

The first data packet transmitted across the DTE/DCE interface for a given direction of data transmission, when the logical channel has just entered the FLOW CONTROL READY state (d1), has 'Ps=0'.

4.4.1.2 Window Description

At the DTE/DCE interface of each logical channel used for virtual calls or permanent virtual circuits, and for each direction of data transmission, a window is defined as the ordered set of 'W' consecutive packet send sequence numbers of data packets authorized to cross the interface.

The lowest sequence number in the window is referred to as the lower window edge. When a virtual call or permanent virtual circuit at the DTE/DCE interface has just entered the FLOW CONTROL READY state (d1), the window related to each direction of data transmission has a lower window edge equal to '0'.

The Ps of the first data packet not authorized to cross the DTE/DCE interface is the value of the lower window edge plus 'W' modulo '8' (or '128' when extended).

The standard window size, 'W', is two (2) for each direction of data transmission at the DTE/DCE interface. Other window sizes may be offered by some network Administrations. An optional window size may be selected for a period of time as the default window size common to all virtual calls at the DTE/DCE interface (see "Non-Standard Default Window Sizes" on page II-69). A value other than the standard default may be selected for a period of time for each permanent virtual circuit (see "Non-Standard Default Window Sizes" on page II-69. Negotiation of window sizes, on a per call basis, may be made with the Flow Control Parameter Negotiation facility (see "Flow Control Parameter Negotiation" on page II-73).

IBM SNA X.25 DTEs must implement 'W=2' and also allow values other than 'W=2', namely, 'W' < 'modulus' to be set as determined at subscription time. When the access link to the network exhibits long delay characteristics and the packets used are short, IBM SNA X.25 DTEs may implement the optional Flow Control Parameter Negotiation facility as not all networks permit selection of default values other than 'W=2'.

4.4.1.3 Flow Control Principles

When the Ps of the next packet to be transmitted is within the window, transmitting stations are authorized to transmit that data packet to the receiving station. When the Ps of the next data packet to be transmitted is outside of the window, transmitting stations do not transmit data packets. (Text deleted).

When the Ps of the data packet received is the next in-sequence (text deleted) receiving stations may accept the data packet. A received data packet containing a Ps that is out of sequence (i.e., there is a duplicate or a gap in the Ps numbering), outside the window or not equal to '0' for the first data packet received after entering the FLOW CONTROL READY state (d1) is considered by DCEs to be a local procedure error. In this event DCEs reset the virtual call or permanent virtual circuit (see "Procedure for Reset" on page II-42). DTEs consider the receipt of a data packet containing a Ps that is out of sequence (i.e., there is a duplicate or a gap in the Ps numbering), (text deleted) or not equal to '0' for the first data packet received after entering the FLOW CONTROL READY state (d1) to be a hard DCE failure and either clear the virtual call or reset the permanent virtual circuit, or restart the DTE/DCE interface. The contents of clearing/resetting Cause and Diagnostic Code fields must be reported to a higher level.

Some networks do not invoke the error procedure on receipt of data packets containing a Ps that is out of sequence but is within the window. These networks may pass on such packets to remote DTEs to make it possible for local DTEs to retransmit packets on virtual calls or permanent virtual circuits (within the national network).

Because packets should never get out of order on SNA-to-SNA connections (packet level retransmission does not occur), an out-of-sequence Ps should be treated as an error. DTEs clear the virtual call or reset the permanent virtual circuit (on SNA-to-SNA connections with the diagnostic code #171', "Invalid PS", see Appendix F) and must report the error to a higher level.

A number modulo '8' (or '128' when extended) referred to as a packet receive sequence number (Pr), conveys information from the receiver across the DTE/DCE interface for the transmission of data packets. Pr's become the lower window edge when transmitted across the DTE/DCE interface. In this way, additional data packets are authorized to cross the DTE/DCE interface by the receiving station.

Pr's are conveyed in data, receive ready (RR) and receive not ready (RNR) packets.

The value of a Pr received must be within the range from the last Pr received up to and including the Ps of the next data packet to be transmitted. Otherwise, DCEs consider the receipt of this Pr to be a procedure error and reset the virtual call or permanent virtual circuit. DTEs consider the receipt of a Pr value that is not within the range from the last Pr received up to and including the Ps of the next data packet to be transmitted as a DCE hard failure and either reset the permanent virtual circuit or clear the virtual call, or restart the DTE/DCE interface. Such failures must be reported to a higher level. On SNA-to-SNA connections the Diagnostic Code #172', "Invalid Pr", (see Appendix F) is used.

Pr's are less than or equal to the sequence number of the next expected data packet and imply that the transmitting station has accepted at least all data packets numbered up to and including 'Pr-1'.

4.4.1.4 Delivery Confirmation

When 'D=0' in a data packet having 'Ps=p', significance of the returned Pr corresponding to that data packet (i.e., 'Pr≥p+1') is a local updating of the window across the packet level DTE/DCE interface so that the achievable throughput is not constrained by the DTE-to-DTE round trip delay across the network(s).

1. SNA-to-SNA Connections

   'D=1' is not allowed on SNA-to-SNA connections. If a packet with 'D=1' is received on an SNA-to-SNA connection, IBM SNA X.25 DTEs clear the virtual call or reset the permanent virtual circuit with the Diagnostic Code #173, "Invalid 'D' Bit Received in Data Packet" (see Appendix F).

   If an INCOMING CALL or CALL CONNECTED packet is received with bit 7='1', IBM SNA X.25 DTEs clear the call with the Diagnostic Code #233, "Invalid 'D' Bit Request" (see Appendix F). In all cases, the error condition and Cause and Diagnostic codes must be reported to a higher level.

2. SNA-to-non_SNA Connections

   When 'D=1' in a data packet having 'Ps=p', the significance of the returned Pr corresponding to that data packet (i.e., 'Pr≥p+1') is an indication that a Pr has been received from the remote DTE for all data bits in the data packet which originally had 'D=1'.

Note:

1. DTEs, upon receipt of a data packet with 'D=1', transmit the corresponding Pr as soon as receipt of the packet at its destination within the SNA network has been acknowledged by the appropriate response. Data, RR or RNR packet may be used to convey the Pr (see note to "DTE and DCE Receive Not Ready (RNR) Packets." Likewise, DCEs are required to send Pr to the DTE as soon as possible after the Pr is received from the remote DTE. DTEs should not defer updating the window for previous packets with 'D=0' while waiting for acknowledgement of a packet with 'D=1'.

2. In the case where a Pr for a data packet with 'D=1' is outstanding, local updating of the window is deferred for subsequent data packets with 'D=0'. Some networks may also defer updating the window for previous data packets (within the window) with 'D=0' until the corresponding Pr for the packet with the outstanding 'D=1' is transmitted to the DTE.

3. Pr values corresponding to the data contained in data packets with the 'D=1' need not be the same at the DTE/DCE interfaces at each end of a virtual call or permanent virtual circuit.

4. If the virtual call has not been established indicating support of the 'D' bit procedure, IBM SNA X.25 DTEs do not send data packets with 'D=1'. If they receive a packet with 'D=1' from a non-SNA DTE they accept the packet by returning the corresponding Pr as soon as possible, without waiting for any SNA acknowledgement.

4.4.1.5 DTE and DCE Receive Ready (RR) Packets

RR packets are used by transmitting stations to indicate that they are ready to receive the 'W' data packets within the window starting with Pr, where Pr is indicated in the RR packet.

4.4.1.6 DTE and DCE Receive Not Ready (RNR) Packets

RNR packets are used by transmitting stations to indicate a temporary inability to accept additional data packets for a given virtual call or permanent virtual circuit. Stations receiving an RNR packet stop transmitting data packets on the indicated logical channel, but the window is updated by the Pr value of the RNR packet. The receive not ready situation indicated by the transmission of an RNR packet is cleared by the transmission in the same direction of an RR packet or by initiation of a reset procedure.

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

Note: RNR packets may be used to convey the Pr value corresponding to the data packet which had 'D=1' across the DTE/DCE interface when additional data packets cannot be accepted on SNA-to-non_SNA connections.

4.4.2 Throughput Characteristics and Classes

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

- the access line characteristics, local window size and traffic characteristics of other logical channels at the local DTE/DCE interface;
- the access line characteristics, local window size and traffic characteristics of other logical channels at the remote DTE/DCE interface; and,
- the throughput achievable on the virtual call or permanent virtual circuit through the network(s) independent of interface characteristics including number of active logical channels. This throughput may be dependent on network service characteristics such as window rotation mechanisms and/or optional user facilities requested on national/international calls.

The attainable throughput will also be affected by:

- the receiving DTE flow controlling the DCE;
- the transmitting DTE not sending data packets which have the maximum data field length;
- the local DTE/DCE window and/or packet sizes; and,
- [the use of the 'D' bit.]

A throughput class for one direction of transmission is an inherent characteristic of the virtual call or permanent virtual circuit related to the amount of resources allocated to this virtual call or permanent virtual circuit. This characteristic is meaningful when 'D=0' in data packets. It is a measure of the throughput that is not normally exceeded on the virtual call or permanent virtual circuit. However, due to the statistical sharing of transmission and switching resources, it is not guaranteed that the throughput class can be reached 100% of the time.

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

Text deleted.

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

1. the access data links at both ends of a virtual call or permanent virtual circuit are engineered for the throughput class;

2. the receiving DTE is not flow controlling the DCE such that the throughput class is not reachable;

3. the transmitting DTE is sending data packets which have the maximum data field length; and,

4. all data packets transmitted on the virtual call or permanent virtual circuit have 'D=0'

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

In the absence of the Default Throughput Class Assignment facility (see "Default Throughput Classes Assignment" on page II-69), the default throughput classes for both directions of transmission correspond to the user class of service of the DTE (see "Coding of Throughput Class Negotiation Facility" on page II-81) but do not exceed the maximum throughput class supported by the network. Negotiation of throughput classes on a per call basis may be made with the Throughput Class Negotiation facility (see "Throughput Class Negotiation" on page II-74).

Note: The summation of throughput classes of all virtual calls and permanent virtual circuits (text deleted) supported at a DTE/DCE interface may be greater than the data transmission rate of the access line.

4.4.3 Procedure for Reset

The reset procedure is used to re-initialize virtual calls or permanent virtual circuits and in so doing removes in each direction of transmission all data [and interrupt] packets which may be in the network (see "Effects of Clear, Reset and Restart Procedures on the Transfer of Packets" on page II-43). When a virtual call or permanent virtual circuit at the DTE/DCE interface has just been reset, the window related to each direction of data transmission has a lower window edge equal to '0', and the numbering of subsequent data packets to cross the DTE/DCE interface for each direction of data transmission starts from '0'.

The reset procedure can only apply in the DATA TRANSFER state (p4) of the DTE/DCE interface. In any other state of the DTE/DCE interface, the reset procedure is abandoned. For example, when a clearing or restarting procedure is initiated, RESET REQUEST and RESET INDICATION packets can be left unconfirmed.

For flow control, there are three states d1, d2, and d3 within the DATA TRANSFER state (p4). They are FLOW CONTROL READY (d1), DTE RESET REQUEST (d2), and DCE RESET INDICATION (d3) as shown in the state diagram in Figure B-3 of Appendix B. When entering state p4, the logical channel is placed in state d1. Table C-4 specifies
2 actions taken by DCEs upon receipt of packets from DTEs. Table G-4, in Appendix G, specifies actions taken by DTEs upon receipt of packets from DCEs.

4.4.3.1 Reset Request Packet

DTEs indicate requests for resetting of permanent virtual circuits by transmitting a RESET REQUEST packet, specifying the logical channel, across the DTE/DCE interface.

This places the specified logical channel in the DTE RESET REQUEST state (d2). DTEs discard data, [interrupt,] RR, and RNR packets received on logical channels in the DTE RESET REQUEST state. Packets of incomplete packet sequences received in this state, are also discarded.

A diagnostic code as defined in Appendix F must be included. Error conditions that cause a reset must be reported, with associated diagnostic codes, to a higher level. If the time spent in state (d2) exceeds 200 seconds, the RESET REQUEST packet can be restransmitted after the 200 second timer is reinitialized. If the total time spent in state (d2) exceeds 'n' times 200 seconds, where 'n≥1', notification of the RESET REQUEST failure must be reported to a higher level using the diagnostic code #51; the logical channel is placed in an inoperative state.

4.4.3.2 Reset Indication Packet

DCEs indicate a reset by transmitting a RESET INDICATION packet, specifying the logical channel and the reason for the resetting, across the DTE/DCE interface. This places the specified logical channel in the DCE RESET INDICATION state (d3). DCEs ignore data, [interrupt,] DTE RNR and DTE RR packets received on logical channels in the DCE RESET INDICATION state. DTEs discard untransmitted packets of send packet sequences and must notify a higher layer of the inoperative condition, reporting the contents of the resetting cause and diagnostic fields.

IBM SNA X.25 DTEs that receive RESET INDICATION packets on logical channels assigned for virtual calls clear the virtual call with the diagnostic code #234, "Reset Indication on Virtual Call".

RESET INDICATION packets are used as a normal sequence for packet level initialization, e.g.:

- A RESET INDICATION packet with Cause "Out-of-Order (#1)" is returned by the X.25-based network to indicate that the remote DTE/DCE interface has not, as yet, been initialized.

- A RESET INDICATION packet with Cause "DTE Originated '0'" and Diagnostic Code "PU Not Available #236" is returned by an SNA NIA to indicate that the SNA SDLC link has not, as yet, been initialized.

- RESET INDICATION packets are propagated by X.25-based networks for each permanent virtual circuit as a result of a restarting procedure at the remote DTE/DCE
2 interface. Such RESET_INDICATION packets may contain either:
2
2 – the network generated Cause '9' (Remote DTE Operational) with an appropriate
2 Diagnostic code; or,
2
2 – the DTE Originated Cause '0' with the Diagnostic code passed through from the
2 associated RESTART_REQUEST packet.
2

4.4.3.3 Reset Collision

Reset collision occurs when a DTE and a DCE simultaneously transmit a RESET REQUEST packet and a RESET INDICATION packet specifying the same logical channel. In this event DCEs consider the reset to be complete. DCEs do not expect a DTE RESET CONFIRMATION packet and do not transfer a DCE RESET CONFIRMATION packet. DTEs do not expect a DCE RESET CONFIRMATION packet and do not transfer a DTE RESET CONFIRMATION packet when a reset collision occurs. This places the specified logical channel in the FLOW CONTROL READY state (d1).

4.4.3.4 Reset Confirmation Packets

When a logical channel is in the DTE RESET REQUEST state (d2), DCEs confirm the reset by transmitting a DCE RESET CONFIRMATION packet across the DTE/DCE interface. This places the specified logical channel in the FLOW CONTROL READY state (d1).

DCE RESET CONFIRMATION packets can only be interpreted universally as having local significance, however, within some Administration's networks, reset confirmation may have end-to-end significance. In any event the time spent in the DTE RESET REQUEST state (d2) will not exceed time-limit T22 (see Appendix D).

When logical channels are in the DCE RESET INDICATION state (d3), DTEs confirm the reset by transmitting a DTE RESET CONFIRMATION packet before time T12 elapses. This places the specified logical channel in the FLOW CONTROL READY state (d1). Actions taken by DCEs when DTEs do not confirm the reset within time-out T12 are given in Appendix D.

4.5 EFFECTS OF CLEAR, RESET AND RESTART PROCEDURES ON THE TRANSFER OF PACKETS

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

Data [or interrupt] packets generated by a DTE (or the network) after the completion of a reset (or for permanent virtual circuits also a restart) procedure at the local interface are not delivered to the remote DTE before completion of the corresponding reset procedure at the remote interface.

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

Note: The maximum number of packets that may be discarded is a function of network end-to-end delay and throughput characteristics and, in general, has no relation to the local window size. (Text deleted.)

(Text deleted.)

4.5.1 SNA-to-non SNA Connections

[For virtual calls on which all data packets are transferred with the 'D=1', the maximum number of packets that may be discarded in one direction of transmission is never larger than the window size for the direction of transmission].

4.6 EFFECTS OF PHYSICAL AND LINK LEVEL FAILURES

When a failure at the physical and/or link level is detected, DCEs transmit to the remote end:

1. a reset with the cause "Out of Order" for each permanent virtual circuit; and,

2. a clear with the cause "Out of Order" for each existing virtual call.

DCEs clear incoming virtual calls received until the failure is recovered.

When physical and link level failures are recovered, a restart procedure is executed (see "Effects of the Physical Level and the Link Level on the Packet Level" on page II-28) and a reset with the cause "Remote DTE Operational" is transmitted to the remote end of each permanent virtual circuit. DTEs must report "Out of Order" cause and diagnostic codes to a higher level.

5.0 PROCEDURES FOR DATAGRAM SERVICE

Datagram services are not used by IBM SNA X.25 DTEs. In the event that a DATAGRAM or DATAGRAM SERVICE SIGNAL packet is received, IBM SNA X.25 DTEs clear the virtual call or reset the permanent virtual circuit with the Diagnostic Code #170 'Not Supported'.

(Text deleted).

6.0 PACKET FORMATS

6.1 GENERAL

The possible extension of X.25 packet formats by the addition of new fields is being considered by the CCITT.

Note: Any such field:

1. would only be provided as additions following all previously defined fields, and not as insertions between any previously defined fields;
2. would be transmitted to a DTE only when either the DCE has been informed that the DTE is able to interpret this field and act upon it, or when the DTE can ignore the field without adversely affecting the operation of the DCE; and,
3. would not contain any information pertaining to a user facility to which the DTE has not subscribed.

Bits of an octet are numbered 8 to 1 where bit 1 is the low order bit and is transmitted first. Octets of a packet are consecutively numbered starting from '1' and are transmitted in this order. Octets of sub-fields within a packet are consecutively numbered starting from '0'.

For example a packet:

Octet	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	
1	General format identifier (GFI)				Logical channel group number				
	0	0	0	1	0	0	1	0	
2	Logical channel number								
	0	0	0	0	0	0	0	1	
3	Packet type identifier								
	0	0	0	0	1	0	1	1	
4	Calling DTE address length				Called DTE address length				
	0	1	0	0	0	1	0	1	
5	0	0	0	1	0	0	1	0	Called DTE Address
6	0	0	1	1	0	1	0	0	Called DTE Address
7	0	1	0	1	0	1	1	0	Called DTE Address (bits 8–5); Calling DTE Address (bits 4–1)
8	0	1	1	1	1	0	0	0	Calling DTE Address
9	1	0	0	1	0	0	0	0	Calling DTE Address (bits 8–5)
10	0	0	Facility Length						
			0	0	0	0	0	0	
Call User Data Field	Protocol Identifier								
	1	1	0	0	0	0	1	1	
	Up to 15 Octets								

would appear on the transmission link as a string of:

- binary bits in the order:

  'xxx...xxx1100001100000000.....0000000100010010'>>;

- hexadecimal digits in the order:

  'x,x,...,x,x,C,3,0,0.....,0,1,1,2'>>; or,

- octets containing hexadecimal values in the order:

  'xx,...,xx,C3,00,.....,01,12'>>,

where the first bit(s) transmitted are immediately to the left of '>>.

Figure 1. Octet Numbering: Call Set-up/Clearing Packet

6.1.1 General Format Identifier

The General Format Identifier (GFI) field is a four bit binary coded field that indicates the general format of the rest of the packet header. The General Format Identifier field occupies bit positions 8, 7, 6 and 5 of octet 1, and bit 5 is the low order bit (see Table II-7).

Table II-7 — General Format Identifier		
General format identifier		Octet 1 bits 8 7 6 5
Call set-up packets	Sequence Numbering Scheme modulo 8	0 X 0 1
	Sequence Numbering Scheme modulo 128	0 X 1 0
Clearing, datagram, flow control, interrupt, reset, restart and diagnostic packets	Sequence Numbering Scheme modulo 8	0 0 0 1
	Sequence Numbering Scheme modulo 128	0 0 1 0
Data packets	Sequence Numbering Scheme modulo 8	X X 0 1
	Sequence Numbering Scheme modulo 128	X X 1 0
Datagram service signal packets	Sequence numbering Scheme modulo 8	1 0 0 1
	Sequence Numbering Scheme modulo 128	1 0 1 0
General Format Identifier extension		* * 1 1
* Undefined		

Note: A bit which is indicated as "X" may be set to either '0' or '1' as indicated in the text.

Bit 8 of the General Format Identifier is the Qualifier 'Q' bit in data packets. (Text deleted).

Bit 7 of the General Format Identifier is used for the delivery confirmation procedure in data and call set-up packets and is set to '0' in all other packets. It must be '0' in all packets on SNA-to-SNA connections.

Bits 6 and 5 are encoded for four possible indications. Two of the codes are used to distinguish packets using modulo '8' packet sequence numbering from packets using modulo '128' packet sequence numbering. The third code is used to indicate an extension to an expanded format for a family of General Format Identifier codes which are being considered by the CCITT. The fourth code is unassigned.

Note:

1. In the absence of the extended packet sequence numbering facility (see "Extended Packet Sequence Numbering" on page II-69), the sequence numbering scheme is performed modulo 8.
2. It is envisaged that other general format identifier codes could identify alternative packet formats.

6.1.2 Logical Channel Group Number

The Logical Channel Group Number appears in every packet except restart packets and diagnostic packets in bit positions 4, 3, 2 and 1 of octet 1. For each logical channel, this number has local significance at the DTE/DCE interface.

This field is binary coded and bit 1 is the low order bit of the Logical Channel Group Number. In restart and diagnostic packets, this field is coded x'0'.

6.1.3 Logical Channel Number

The Logical Channel Number appears in every packet except restart packets and diagnostic packets in all bit positions of octet 2. For each logical channel, this number has local significance at the DTE/DCE interface.

This field is binary coded and bit 1 is the low order bit of the Logical Channel Number. In restart and diagnostic packets, this field is coded x'00'.

6.1.4 Packet Type Identifier

Each packet is identified in octet 3 as shown in Table II-8.

Table II-8 - Packet Type Identifier

PACKET TYPE From DCE to DTE	 From DTE to DCE	OCTET 3 BITS 8 7 6 5 4 3 2 1
CALL SET-UP AND CLEARING		
INCOMING CALL - INC	CALL REQUEST - CRQ	0 0 0 0 1 0 1 1
CALL CONNECTED - CCN	CALL ACCEPTED -CAC	0 0 0 0 1 1 1 1
CLEAR INDICATION - CLI	CLEAR REQUEST - CLR	0 0 0 1 0 0 1 1
DCE CLEAR CONFIRMATION - NCC	DTE CLEAR CONFIRMATION - TCC	0 0 0 1 0 1 1 1
DATA AND [INTERRUPT]		
DCE DATA - NDT	DTE DATA - TDT	X X X X X X X 0
DCE [INTERRUPT] - NIN	DTE [INTERRUPT] - TIN	0 0 1 0 0 0 1 1
DCE [INTERRUPT] CONFIRMATION - NIC	DTE [INTERRUPT] CONFIRMATION - TIC	0 0 1 0 0 1 1 1
DATAGRAM*		
DCE DATAGRAM	DTE DATAGRAM	X X X X X X X 0
DATAGRAM SERVICE SIGNAL		X X X X X X X 0
FLOW CONTROL AND RESET		
DCE RR (MOD 8) - NRR	DTE RR (MOD 8) - TRR	X X X 0 0 0 0 1
DCE RR (MOD 128)* "	DTE RR (MOD 128)* "	0 0 0 0 0 0 0 1
DCE RNR (MOD 8) - NNR	DTE RNR (MOD 8) - TNR	X X X 0 0 1 0 1
DCE RNR (MOD 128)* "	DTE RNR (MOD 128)* "	0 0 0 0 0 1 0 1
	DTE REJ (MOD 8)*	X X X 0 1 0 0 1
	DTE REJ (MOD 128)*	0 0 0 0 1 0 0 1
RESET INDICATION - RSI	RESET REQUEST - RSR	0 0 0 1 1 0 1 1
DCE RESET CONFIRMATION - NRC	DTE RESET CONFIRMATION - TRC	0 0 0 1 1 1 1 1
RESTART		
RESTART INDICATION - IRI	RESTART REQUEST - IRR	1 1 1 1 1 0 1 1
DCE RESTART CONFIRMATION - NSC	DTE RESTART CONFIRMATION - TSC	1 1 1 1 1 1 1 1
DIAGNOSTIC		
DIAGNOSTIC* - DGN		1 1 1 1 0 0 0 1

* = Not necessarily available on every network.

Note: A bit which is indicated as "X" may be set to either '0' or '1' as indicated in the text.

6.2 CALL SET-UP AND CLEARING PACKETS

6.2.1 Call Request and Incoming Call Packets

Figure 2 illustrates the format of CALL REQUEST and INCOMING CALL packets.

Octet	Bits 8	7	6	5	4	3	2	1
1	General Format Identifier (GFI)				Logical Channel Group Number			
2	Logical Channel Number							
3	Packet Type Identifier							
	0	0	0	0	1	0	1	1
4	Calling DTE Address Length				Called DTE Address Length			
.	DTE Address (see Note 2)							
.					0	0	0	0
.	0	0	Facility Length					
.	Facilities							
n	Call User Data (see Notes 3 and 4)							

Figure 2. CALL REQUEST and INCOMING CALL: Packet Format

Notes to Figure 2:

1. GFI - Coded 0X01 (modulo 8) or 0X10 (modulo 128).

   Where: 'X = 0' on SNA-to-SNA Connections.

   'X = 0 or 1' on SNA-to-non SNA Connections.

2. The figure is drawn assuming a single address, consisting of an odd number of octets, is present.

3. The first octet of the Call User Data field is required and bits 8, 7 and 2 have particular significance (see Protocol Identifier (PI)).

4. Maximum length of the call user data field is 16 Octets.

5. The Calling DTE Address in CALL REQUEST packets is optional.

6. Facilities in CALL REQUEST and INCOMING CALL packets are optional.

6.2.1.1 General Format Identifier

On SNA-to-non SNA connections, bit 7 of octet 1 is set to '0' unless the 'D' bit mechanism defined in "Delivery Confirmation (D) Bit" on page II-33 is used. CALL REQUEST and INCOMING CALL packets must have bit 7 of octet 1 set to '0' on SNA-to-SNA connections.

6.2.1.2 Address Lengths Field

Octet 4 consists of field length indicators for the called and calling DTE addresses. Bits 4, 3, 2 and 1 indicate the length of the called DTE address in semi-octets. Bits

8, 7, 6 and 5 indicate the length of the calling DTE address in semi-octets. Each address length indicator is binary coded and bit 1 or bit 5 is the low order bit of the indicator.

6.2.1.3 Address Field

Octet 5 and the following octets consist of the called DTE address, when present, then the calling DTE address, when present.

Each digit of an address is coded in a semi-octet in binary coded decimal with bit 5 or bit 1 being the low-order bit of the digit.

Starting from the high order digit, the address is coded in octet 5 and consecutive octets with two digits per octet. In each octet, the higher order digit is coded in bits 8, 7, 6 and 5.

The Address field is rounded up to an integral number of octets by inserting zeros in bits 4, 3, 2 and 1 of the last octet of the field when necessary.

(Text deleted.)

6.2.1.4 Facility Length Field

Bits 6, 5, 4, 3, 2 and 1 of the octet following the Address field indicate the length of the Facility field in octets. The facility length indicator is binary coded and bit 1 is the low order bit of the indicator.

Bits 8 and 7 of this octet are unassigned and set to '0's.

6.2.1.5 Facility Field

The Facility field is present only when the DTE is using an optional user facility requiring some indication in CALL REQUEST and INCOMING CALL packets.

The coding of the Facility field is defined in "PROCEDURES AND FORMATS FOR OPTIONAL USER FACILITIES" on page II-69.

The Facility field contains an integral number of octets. The actual maximum length of this field depends on the facilities that are offered by the network. However, this maximum does not exceed 63 octets.

6.2.1.6 Call User Data Field

Octets following the Facility field are the Call User Data field, which must be an integral number of octets and has a maximum length of 16 octets.

Protocol Identifier (PI)

The first octet of the Call User Data field is the Protocol Identifier which is mandatory in SNA environments.

(Text deleted).

The use and format of the Call User Data field is determined by the setting of bits 8 and 7 of the first octet of this field (Protocol Identifier). If bits 8 and 7 of the first octet of the Call User Data field are:

- '00' a portion of the Call User Data field is used for protocol identification in accordance with CCITT Recommendation X.29. This setting is not considered for IBM SNA X.25 DTEs in this version of the specification.

- '01' a portion of the Call User Data field may be used for protocol identification in accordance with the specifications of network Administrations. This setting is not considered for IBM SNA X.25 DTEs in this version of the specification.

- '10' a portion of the Call User Data field may be used for protocol identification in accordance with specifications of international user bodies. This setting is not considered for IBM SNA X.25 DTEs in this version of the specification.

- '11' the Call User Data belongs to a higher level.

Users are cautioned that if bits 8 and 7 of the first octet of the Call User Data field are set to any value other than '11', a protocol may be identified that is implemented within some public data networks.

Receipt of an incorrect setting of bits 8 or 7 (other than '11'), by IBM SNA X.25 DTEs results in call clearing with the diagnostic code #234, "Invalid Protocol Identifier".

Bit 2 of the Protocol Identifier also has particular significance in SNA environments:

- '0' for SNA-to-non_SNA connections; or,
- '1' for SNA-to-SNA connections.

All Protocol Identifier code points are reserved except:

- x'C0' and x'C1' for SNA-to-non SNA connections; and,
2 - x'C2', x'C3' and x'C6' for SNA-to-SNA connections (see "Logical Link Control (LLC) on SNA-to-SNA Connections" on page II-83).

Note: When a virtual call is being established between two packet mode DTEs, the network does not act on any part of the Call User Data field. (text deleted.)

6.2.2 Call Accepted and Call Connected Packets

Figure 3 illustrates the format of CALL ACCEPTED and CALL CONNECTED packets.

Octet	Bit 8	7	6	5	4	3	2	1
1	General format identifier (GFI)				Logical channel group number			
2	Logical channel number							
3	Packet type identifier							
	0	0	0	0	1	1	1	1
4	Calling DTE address length*				Called DTE address length*			
.	DTE address (see Note 2)*							
.					0	0	0	0
.	0	0	Facility length*					
n	Facilities*							

*—These fields are not mandatory in CALL ACCEPTED packets (see §—6.2.2).

Figure 3. CALL ACCEPTED and CALL CONNECTED: Packet Format

Notes to Figure 3:

1. GFI - Coded 0X01 (modulo 8) or 0X10 (modulo 128).

   Where X = '0' on SNA-to-SNA connections; and,

   '0' or '1' on SNA-to-non SNA connections.

2. The figure is drawn assuming that a single address is present consisting of an odd number of digits.

6.2.2.1 General Format Identifier

On SNA-to-non SNA connections, bit 7 of octet 1 is equal to '0' unless the 'D' bit mechanism defined in "Delivery Confirmation (D) Bit" on page II-33 is used.

CALL ACCEPTED packets and CALL CONNECTED packets must have bit 7 of octet 1 set to '0' on SNA-to-SNA connections.

6.2.2.2 Address Lengths Field

Octet 4 contains field length indicators for called and calling DTE addresses. Bits 4, 3, 2 and 1 indicate the length of the called DTE address in semi-octets. Bits 8, 7, 6 and 5 indicate the length of the calling DTE address in semi-octets. Each address length indicator is binary coded and bit 1 or 5 is the low order bit of the indicator.

The use of the Address Lengths field in CALL ACCEPTED packets is only mandatory when the Address field or the Facility Length field is present.

6.2.2.3 Address Field

Octet 5 and the following octets consist of the called DTE address when present, then the calling DTE address when present.

Each digit of an address is coded in a semi-octet in binary coded decimal with bit 5 or 1 being the low-order bit of the digit.

Starting from the high order digit, the address is coded in octet 5 and consecutive octets with two digits per octet. In each octet, the higher order digit is coded in bits 8, 7, 6 and 5.

The Address field is rounded up to an integral number of octets by inserting zeros in bits 4, 3, 2 and 1 of the last octet of the field when necessary.

(Text deleted.)

6.2.2.4 Facility Length Field

Bits 6, 5, 4, 3, 2, and 1 of the octet following the Address field indicate the length of the Facility field in octets. The facility length indicator is binary coded and bit 1 is the low order bit of the indicator.

Bits 8 and 7 of this octet are unassigned and set to '00'.

The use of the Facility Length field in CALL ACCEPTED packets is only mandatory when the Facility field is present.

6.2.2.5 Facility Field

The Facility field is present only when the DTE is using an optional user facility requiring some indication in the CALL ACCEPTED and CALL CONNECTED packets.

The coding of the Facility field is defined in "PROCEDURES AND FORMATS FOR OPTIONAL USER FACILITIES" on page II-69.

The Facility field contains an integral number of octets. The actual maximum length of this field depends on the facilities which are offered by the network. However, this maximum does not exceed 63 octets.

6.2.3 Clear Request and Clear Indication Packets

Figure 4 illustrates the format of CLEAR REQUEST and CLEAR INDICATION packets.

Octet	Bits 8	7	6	5	4	3	2	1
1	General format identifier (GFI)				Logical channel group number			
2	Logical channel number							
3	Packet type identifier							
	0	0	0	1	0	0	1	1
4	Clearing cause							
5	Diagnostic code (This field is mandatory on SNA-to-SNA Connections (see Appendix F))							

Note: GFI – Coded 0001 (modulo 8) or 0010 (modulo 128).

Figure 4. CLEAR REQUEST and CLEAR INDICATION: Packet Format

6.2.3.1 Clearing Cause Field

Octet 4 is the Clearing Cause field and contains the reason for clearing the call.

The bits of the Clearing Cause field in CLEAR REQUEST packets are set to '0' by DTEs.

(Text deleted).

The coding of the Clearing Cause field in CLEAR INDICATION packets is given in Table II-9.

Table II-9 – Coding of the Clearing Cause Field in CLEAR INDICATION packets — Bits	8 7 6 5	4 3 2 1	DEC
DTE Originated	0 0 0 0	0 0 0 0	00
Number busy	0 0 0 0	0 0 0 1	01
Out of order	0 0 0 0	1 0 0 1	09
Remote procedure error	0 0 0 1	0 0 0 1	17
Reverse charging acceptance not subscribed*	0 0 0 1	1 0 0 1	25
Incompatible destination	0 0 1 0	0 0 0 1	33
Fast select acceptance not subscribed*	0 0 1 0	1 0 0 1	41
Invalid facility request	0 0 0 0	0 0 1 1	03
Access barred	0 0 0 0	1 0 1 1	11
Local procedure error	0 0 0 1	0 0 1 1	19
Network congestion	0 0 0 0	0 1 0 1	05
Not obtainable	0 0 0 0	1 1 0 1	13
RPOA out of order*	0 0 0 1	0 1 0 1	21

* May be received only if the corresponding optional user facility is used.
DEC – decimal

6.2.3.2 Diagnostic Code

Octet 5 contains the Diagnostic Code and provides additional information on the reason for clearing the call.

Diagnostic Codes generated by IBM SNA X.25 DTEs for CLEAR REQUEST packets on SNA-to-SNA connections are specified in Table F-1.

In a CLEAR INDICATION packet, if the Clearing Cause field indicates "DTE Originated", the Diagnostic Code is passed unchanged from the clearing DTE. If the clearing DTE has not provided a Diagnostic Code in its CLEAR REQUEST packet, the bits of the Diagnostic Code in the resulting CLEAR INDICATION packet are '0'.

When a CLEAR INDICATION packet results from a RESTART REQUEST packet, the value of the Diagnostic Code will be that specified in the RESTART REQUEST packet or '0' when no Diagnostic Code has been specified in RESTART REQUEST packets

When the Clearing Cause field does not indicate "DTE Originated," the Diagnostic Code in a CLEAR INDICATION packet is network generated. Appendix E lists the codings for network generated diagnostics. The Diagnostic Code field is set to '0' when no specific additional information on the reason for clearing the call is supplied.

Note: The contents of the Diagnostic Code field do not alter the meaning of the Cause field. IBM SNA X.25 DTEs must report the contents of the Diagnostic Code and Clearing Cause fields to a higher level. DTEs shall not refuse to accept the Cause field because the Diagnostic Code field contains an unspecified code combination.

6.2.4 DTE and DCE Clear Confirmation Packets

Figure 5 illustrates the format of DTE and DCE CLEAR CONFIRMATION packets.

Octet	Bits 8	7	6	5	4	3	2	1
1	General format identifier (GFI)				Logical channel group number			
2	Logical channel number							
3	Packet type identifier 0	0	0	1	0	1	1	1

Note: GFI — Coded 0001 (modulo 8) or 0010 (modulo 128).

Figure 5. DTE and DCE CLEAR CONFIRMATION: Packet Format

6.3 DATA [AND INTERRUPT] PACKETS

6.3.1 DTE and DCE Data Packets

Figure 6 illustrates the format of DTE and DCE DATA packets.

Octet	Bits 8	7	6	5	4	3	2	1
1	General format identifier (GFI) Q	D	0	1	Logical channel group number			
2	Logical channel number							
3	P(R)			M	P(S)			0
. n	Call user data							

(Modulo 8)

Octet	Bits 8	7	6	5	4	3	2	1
1	General format identifier (GFI) Q	D	1	0	Logical channel group number			
2	Logical channel number							
3	P(R)							0
4	P(S)							M
. n	User data							

(Modulo 128)

'D' = Delivery confirmation bit (= '0' on SNA—to—SNA Connections).

'M' = More Data bit

'Q' = Qualifier bit

Figure 6. DTE and DCE DATA: Packet Format

6.3.1.1 Qualifier Bit

Bit 8 of octet 1 is the Qualifier ('Q') bit. It is used on SNA-to-SNA connections to identify 'Qualified' data packets as described in "Logical Link Control (LLC) on

SNA-to-SNA Connections" on page II-83.

6.3.1.2 Delivery Confirmation Bit

Bit 7 of octet 1 is the Delivery Confirmation bit.

6.3.1.3 Packet Receive Sequence Number, Pr

Bits 8, 7 and 6 of octet 3, or bits 8 through 2 of octet 4 when extended, are the Packet Receive Sequence Number (Pr). Pr is binary coded and bit 6, or bit 2 when extended, is the low order bit.

6.3.1.4 More Data Bit

Bit 5 in octet 3, or bit 1 in octet 4 when extended, is the More Data mark ('M' bit) which:

- ='0' for no more data; and,
- ='1' for more data.

6.3.1.5 Packet Send Sequence Number, Ps

Bits 4, 3 and 2 of octet 3, or bits 8 through 2 of octet 3 when extended, are the Packet Send Sequence Number (Ps). Ps is binary coded and bit 2 is the low order bit.

6.3.1.6 User Data Field

Bits following octet 3, or octet 4 when extended, contain user data.

Note: The User Data field field must contain an integral number of octets.

6.3.2 DTE and DCE Interrupt Packets

6.3.2.1 SNA-to-SNA Connections

INTERRUPT packets are not allowed on SNA-to-SNA connections.

6.3.2.2 SNA-to-non SNA Connections

Figure 7 illustrates the format of DTE and DCE INTERRUPT packets.

Octet	8	7	6	5	4	3	2	1
1	General format identifier (GFI)				Logical channel group number			
2	Logical channel number							
3	Packet type identifier							
	0	0	1	0	0	0	1	1
4	Interrupt user data							

Note: GFI — Coded 0X01 (modulo 8) or 0X10 (modulo 128).

Figure 7. DTE and DCE INTERRUPT: Packet Format

6.3.2.3 Interrupt User Data Field

Octet 4 contains user data.

6.3.3 DTE and DCE Interrupt Confirmation Packets

6.3.3.1 SNA-to-SNA Connections

INTERRUPT CONFIRMATION packets are not allowed on SNA-to-SNA connections.

6.3.3.2 SNA-to-non SNA Connections

Figure 8 illustrates the format of DTE and DCE INTERRUPT CONFIRMATION packets.

Octet	8	7	6	5	4	3	2	1
1	General format identifier (GFI)				Logical channel group number			
2	Logical channel number							
3	Packet type identifier							
	0	0	1	0	0	1	1	1

Note: GFI — Coded 0001 (modulo 8) or 0010 (modulo 128).

Figure 8. DTE and DCE INTERRUPT CONFIRMATION: Packet Format

6.4 DATAGRAM AND DATAGRAM SERVICE SIGNAL PACKETS

DATAGRAM and DATAGRAM SERVICE SIGNAL packets are not allowed in IBM SNA X.25 DTEs. (Text deleted).

6.5 FLOW CONTROL AND RESET PACKETS

6.5.1 DTE and DCE Receive Ready (RR) Packets

Figure 9 illustrates the format of DTE and DCE RECEIVE READY packets.

Octet	Bits 8	7	6	5	4	3	2	1
1	General format identifier (GFI) 0	0	0	1	Logical channel group number			
2	Logical channel number							
3	P(R)			Packet type identifier 0	0	0	0	1

(Modulo 8)

Octet	Bits 8	7	6	5	4	3	2	1
1	General format identifier (GFI) 0	0	1	0	Logical channel group number			
2	Logical channel number							
3	Packet type identifier 0	0	0	0	0	0	0	1
4	P(R)							0

(Modulo 128)

Figure 9. DTE and DCE RECEIVE READY: Packet Format

6.5.1.1 Packet Receive Sequence Number, Pr

Bits 8, 7 and 6 of octet 3, or bits 8 through 2 of octet 4 when extended, are the Packet Receive Sequence Number (Pr). Pr is binary coded and bit 6, or bit 2 when extended, is the low order bit.

6.5.2 DTE and DCE Receive Not Ready (RNR) Packet

Figure 10 on page II-60 illustrates the format of DTE and DCE RECEIVE NOT READY packets.

Octet	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1
1	General format identifier (GFI) 0	0	0	1	Logical channel group number			
2	Logical channel number							
3	P(R)			Packet type identifier 0	0	1	0	1

(Modulo 8)

Octet	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1
1	General format identifier (GFI) 0	0	1	0	Logical channel group number			
2	Logical channel number							
3	Packet type identifier 0	0	0	0	0	1	0	1
4	P(R)							0

(Modulo 128)

Figure 10. DTE and DCE RECEIVE NOT READY: Packet Format

6.5.2.1 Packet Receive Sequence Number, Pr

Bits 8, 7 and 6 of octet 3, or bits 8 through 2 of octet 4 when extended, are the Packet Receive Sequence Number (Pr). Pr is binary coded and bit 6, or bit 2 when extended, is the low order bit.

6.5.3 Reset Request and Reset Indication Packets

Figure 11 illustrates the format of RESET REQUEST and RESET INDICATION packets.

Octet	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1
1	General format identifier (GFI)				Logical channel group number			
2	Logical channel number							
3	Packet type identifier 0	0	0	1	1	0	1	1
4	Resetting cause							
5	Diagnostic code (This field is mandatory on SNA-to-SNA Connections (see Attachemt F))							

(Text deleted.)

Note: GFI — Coded 0001 (modulo 8) or 0010 (modulo 128).

Figure 11. RESET REQUEST and RESET INDICATION: Packet Format

6.5.3.1 Resetting Cause Field

Octet 4 is the Resetting Cause field and contains the reason for the reset.

The bits of the Resetting Cause field in RESET REQUEST packets must be set to '0' by DTEs.

(Text deleted.)

The coding of the Resetting Cause field in RESET INDICATION packets is given in Table II-11.

Table II-11 — Coding of the Clearing Cause field in RESET INDICATION packets

Bits	8 7 6 5	4 3 2 1	DEC
DTE Originated	0 0 0 0	0 0 0 0	00
Out of order*	0 0 0 0	0 0 0 1	01
Remote procedure error	0 0 0 0	0 0 1 1	03
Local procedure error	0 0 0 0	0 1 0 1	05
Network congestion	0 0 0 0	0 1 1 1	07
Remote DTE operational*	0 0 0 0	1 0 0 1	09
Network operational*	0 0 0 0	1 1 1 1	15
Incompatible destination*	0 0 0 1	0 0 0 1	17

* Applicable to permanent virtual circuits only.
DEC — decimal

6.5.3.2 Diagnostic Code

Octet 5 is the Diagnostic Code field (mandatory on SNA-to-SNA connections) and contains additional information on the reason for the reset.

Diagnostic Codes generated by IBM SNA X.25 DTEs for RESET REQUEST packets on SNA-to-SNA connections are shown in Table F-1.

In a RESET INDICATION packet, if the Resetting Cause field indicates "DTE Originated", the Diagnostic Code has been passed unchanged from the remote DTE. If the DTE requesting a reset has not provided a Diagnostic Code in its RESET REQUEST packet, the bits of the Diagnostic Code in the resulting RESET INDICATION packet are '0'.

If a RESET INDICATION packet results from a RESTART REQUEST packet, the value of the Diagnostic Code will be that specified in the RESTART REQUEST, or '0' in the case where no Diagnostic Code has been specified in RESTART REQUEST packets.

If the Resetting Cause field does not indicate "DTE Originated", the Diagnostic Code in RESET INDICATION packets is network generated. Appendix E lists the codings for network generated diagnostics. The Diagnostic Code field is set to '0' when no specific additional information on the reason for the reset is supplied.

Note: The contents of the Diagnostic Code field do not alter the meaning of the Cause field. IBM SNA X.25 DTEs must report the contents of the Diagnostic Code and Resetting Cause fields to a higher layer. DTEs shall not refuse to accept the Cause field because the Diagnostic Code field contains an unspecified code combination.

6.5.4 DTE and DCE Reset Confirmation Packets

Figure 12 on page II-62 illustrates the format of DTE and DCE RESET CONFIRMATION packets.

Octet	Bit 8	7	6	5	4	3	2	1
1	General format identifier (GFI)				Logical channel group number			
2	Logical channel number							
3	Packet type identifier							
	0	0	0	1	1	1	1	1

Note: GFI — Coded 0001 (modulo 8) or 0010 (modulo 128).

Figure 12. DTE and DCE RESET CONFIRMATION: Packet Format

6.6 RESTART PACKETS

6.6.1 Restart Request and Restart Indication Packets

Figure 13 illustrates the format of RESTART REQUEST and RESTART INDICATION packets.

Octet	Bit 8	7	6	5	4	3	2	1
1	General format identifier (GFI)				Logical channel group number			
					0	0	0	0
2	Logical channel number							
	0	0	0	0	0	0	0	0
3	Packet type identifier							
	1	1	1	1	1	0	1	1
4	Restarting cause							
5	Diagnostic code (This field is mandatory on SNA-to-SNA Connections (see Appendix F))							

(Text deleted.)

Note: GFI — Coded 0001 (modulo 8) or 0010 (modulo 128).

Figure 13. RESTART REQUEST and RESTART INDICATION: Packet Format

6.6.1.1 Restarting Cause Field

Octet 4 is the Restarting Cause field and contains the reason for the restart.

The bits of the Restarting Cause field in RESTART REQUEST packets are set to '0' by IBM SNA X.25 DTEs. (Text deleted).

The coding of the Restarting Cause field in RESTART INDICATION packets is given in Table II-12.

Table II-12 – Coding of the Restarting Cause field in RESTART INDICATION packets Bits	8 7 6 5	4 3 2 1	DEC
Local Procedure Error	0 0 0 0	0 0 0 1	01
Network congestion	0 0 0 0	0 0 1 1	03
Network operational	0 0 0 0	0 1 1 1	07
DEC – decimal			

6.6.1.2 Diagnostic Code

Octet 5 contains the Diagnostic Code which provides additional information on the reason for the restart.

Diagnostic Codes generated by IBM SNA X.25 DTEs for RESTART REQUEST packets on SNA-to-SNA connections are given in Table F-1. The Diagnostic Code is passed to the corresponding DTEs as the Diagnostic Code of a RESET INDICATION packet on permanent virtual circuits or a CLEAR INDICATION packet on virtual calls.

The coding of the Diagnostic Code field in a RESTART INDICATION packet is given in Appendix E. The contents of the Diagnostic Code field is set to '0' when no specific additional information on the reason for the restart is supplied.

Note: The contents of the Diagnostic Code field do not alter the meaning of the Cause field. IBM SNA X.25 DTEs must report the contents of the Diagnostic Code field to a higher layer. DTEs shall not refuse to accept the Cause field because the Diagnostic Code field contains an unspecified code combination.

6.6.2 DTE and DCE Restart Confirmation Packets

Figure 14 illustrates the format of DTE and DCE RESTART CONFIRMATION packets.

Octet	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1
1	General format identifier (GFI)				Logical channel group number			
					0	0	0	0
2	Logical channel number							
	0	0	0	0	0	0	0	0
3	Packet type identifier							
	1	1	1	1	1	1	1	1

Note: GFI – Coded 0001 (modulo 8) or 0010 (modulo 128).

Figure 14. DTE and DCE RESTART CONFIRMATION: Packet Format

6.7 DIAGNOSTIC PACKETS

Figure 15 on page II-64 illustrates the format of DIAGNOSTIC packets.

Octet	Bit 8	7	6	5	4	3	2	1
1	General format identifier (GFI)				Logical channel group number			
					0	0	0	0
2	Logical channel number							
	0	0	0	0	0	0	0	0
3	Packet type identifier							
	1	1	1	1	0	0	0	1
4	Diagnostic code							
5 . n	Diagnostic explanation (see Note 2)							

Figure 15. DIAGNOSTIC: Packet Format

Notes to Figure 15:

1. GFI - Coded 0001 (modulo 8) or 0010 (modulo 128).
2. The diagnostic explanation field is required to be an integral number of octets in length.

6.7.1 Diagnostic Code Field

Octet 4 contains the diagnostic code and provides information on the error condition that resulted in the transmission of the DIAGNOSTIC packet. Diagnostic Codes are given in Appendix E.

6.7.2 Diagnostic Explanation Field

When the DIAGNOSTIC packet is issued, by DCEs, as a result of receiving an erroneous packet from the DTE (see Table C-1), this field contains the first three octets of header information from the erroneous DTE packet. If the packet contains less than 3 octets, this field contains whatever bits were received.

When the DIAGNOSTIC packet is issued as a result of a DCE time-out (see Table D-1), the Diagnostic Explanation field contains 2 octets coded as follows:

- Bits 8, 7, 6 and 5 of the first octet contain the General Format Identifier for the DTE/DCE interface.
- Bits 4 to 1 of the first octet and bits 8 to 1 of the second octet are x'000' for expiration of time-out T10; and, give the identifier of the logical channel on which the time-out occurred for expiration of time-out T12 or T13.

6.8 PACKETS REQUIRED FOR OPTIONAL USER FACILITIES

6.8.1 DTE Reject (REJ) Packet for the Packet Retransmission Facility

The packet retransmission facility is not used in SNA environments. Therefore, DTE REJECT packets are not generated by IBM SNA X.25 DTEs.

(Text deleted).

6.8.2 Call Set-up and Clearing Packets for the Fast Select Facilities

6.8.2.1 SNA-to-SNA Connections

The possible use of Fast Select facilities on SNA-to-SNA connections is a subject for further study.

6.8.2.2 SNA-to-non_SNA Connections

Figure 16 illustrates the format of CALL REQUEST and INCOMING CALL packets used in conjunction with the Fast Select facility and Fast Select Acceptance facility described in "Fast Select" on page II-75 and "Fast Select Acceptance" on page II-76.

The description in "Call Request and Incoming Call Packets" on page II-50 applies here, except that the call user data field has a maximum length of 128 octets.

Note: At present, some networks require the call user data field to contain an integral number of octets (see "DESCRIPTION OF THE PACKET LEVEL DTE/DCE INTERFACE" on page II-24, Note 2).

Octet	Bits 8	7	6	5	4	3	2	1
1	General format identifier (GFI)				Logical channel group number			
2	Logical channel number							
3	Packet type identifier							
	0	0	0	0	1	0	1	1
4	Calling DTE address length				Called DTE address length			
.	DTE address (see Note 2)							
.					0	0	0	0
.	0	0	Facility length					
.	Facilities							
n	Call user data (see Notes 3 and 4)							

Figure 16. CALL REQUEST and INCOMING CALL: Packet Format for the Fast Select facility

Notes to Figure 16:

1. GFI - Coded 0X01 (modulo 8) or 0X10 (modulo 128).
2. The figure is drawn assuming a single address is present consisting of an odd number of digits.
3. Bits 8 and 7 of the first octet of the call user data field may have particular significance (see "Call Request and Incoming Call Packets" on page II-50).
4. Maximum length of the call user data field is 128 Octets.

Figure 17 on page II-66 illustrates the format of CALL ACCEPTED and CALL CONNECTED packets used in conjunction with the Fast Select facility and Fast Select Acceptance facility described in "Fast Select" on page II-75 and "Fast Select Acceptance" on page II-76.

Octet	Bits 8	7	6	5	4	3	2	1
1	General format identifier (GFI)				Logical channel group number			
2	Logical channel number							
3	Packet type identifier							
	0	0	0	0	1	1	1	1
4	Calling DTE address length				Called DTE address length			
.	DTE address (see Note 2)							
.					0	0	0	0
.	0	0	Facility length					
.	Facilities							
n	Call user data (see Notes 3 and 4)							

Figure 17. CALL ACCEPTED and CALL CONNECTED: Packet Format for the Fast Select facility

Notes to Figure 17:

1. GFI - Coded 0X01 (modulo 8) or 0X10 (modulo 128).
2. The figure is drawn assuming a single address is present consisting of an odd number of digits.
3. Bits 8 and 7 of the first octet of the call user data field may have particular significance (see "Call Request and Incoming Call Packets" on page II-50).
4. Maximum length of the call user data field is 128 Octets.

The description in "Call Accepted and Call Connected Packets" on page II-52 applies here and, in addition, the called user data field may be present and has a maximum length of 128 octets. The address lengths field and facility Length field are mandatory.

Note: At present, some networks require the called user data field to contain an integral number of octets (see "DESCRIPTION OF THE PACKET LEVEL DTE/DCE INTERFACE" on page II-24, Note 2).

If the called user data field is present, the use and format of this field is determined by bits 8 and 7 of the first octet of this field (see Note below).

If bits 8 and 7 of the first octet of the called user data field are '00', a portion of the called user data field is used for protocol identification in accordance with other Recommendations.

If bits 8 and 7 of the first octet of the called user data field are '01', a portion of the called user data field is used for protocol identification in accordance with specifications of Administrations.

If bits 8 and 7 of the first octet of the called user data field are '10', a portion of the called user data field may be used for protocol identification in accordance with specifications of international user bodies.

If bits 8 and 7 of the first octet of the called user data field are '11', no constraints are placed on the use by the DTE of the remainder of the called user data field.

Users are cautioned that if bits 8 and 7 of the first octet of the called user data field have any value other than '11', a protocol may be identified that is implemented within public data networks.

Note: When a virtual call is being established between two packet mode DTEs, the network does not act on any part of the called user data field.

Figure 18 illustrates the format of CLEAR REQUEST and CLEAR INDICATION packets used in conjunction with the Fast Select facility and Fast Select Acceptance facility described in "Fast Select" on page II-75 and "Fast Select Acceptance" on page II-76.

Octet	Bits 8	7	6	5	4	3	2	1
1	General format identifier (GFI)				Logical channel group number			
2	Logical channel number							
3	Packet type identifier							
	0	0	0	1	0	0	1	1
4	Clearing cause							
5	Diagnostic code							
6	Calling DTE address length				Called DTE address length			
.	DTE address (see Note 2)							
.					0	0	0	0
.	0	0	Facility length					
.	Facilities							
n	Call user data (see Notes 3)							

Figure 18. CLEAR REQUEST and CLEAR INDICATION: Packet Format for the Fast Select facility

Notes to Figure 18:

1. GFI - Coded 0X01 (modulo 8) or 0X10 (modulo 128).
2. The figure is drawn assuming a single address is present consisting of an odd number of digits.
3. Maximum length of the call user data field is 128 octets.

Description of the clearing cause field and the diagnostic code field in "Clear Request and Clear Indication Packets" on page II-54 apply here. In addition the following fields may follow the diagnostic code field and in such cases the use of the diagnostic code field is mandatory.

1. Address lengths field

   Octet 6 consists of field length indicators for the called and calling DTE addresses. Bits 4, 3, 2 and 1 indicate the length of the called DTE address in semi-octets. Bits 8, 7, 6 and 5 indicate the length of the calling DTE address in semi-octets. Each address length indicator is binary coded and bit 1 or 5 is the low order bit of the indicator.

   Note: This field is coded with all '0's. Other codings are for further study.

2. Address field

   Note: Pending the further study indicated above, this field is not present.

3. Facility length field

Bits 6, 5, 4, 3, 2 and 1 of the octet following the address field indicate the length of the facility field in octets. The facility length indicator is binary coded and bit 1 is the low order bit of the indicator.

Bits 8 and 7 of this octet are unassigned and set to 0.

Note: This field is coded with all '0's. Other codings are for further study.

4. Facility field

Note: Pending the further study indicted above, this field is not present.

5. Clear user data field

Following the facility field, the clear user data field may be present and has a maximum length of 128 octets.

Note: At present, some networks require the clear user data field to contain an integral number of octets (see "DESCRIPTION OF THE PACKET LEVEL DTE/DCE INTERFACE" on page II-24, Note 2).

7.0 PROCEDURES AND FORMATS FOR OPTIONAL USER FACILITIES

7.1 PROCEDURES FOR OPTIONAL USER FACILITIES ASSOCIATED WITH VC SERVICES

7.1.1 Extended Packet Sequence Numbering

Extended Packet Sequence Numbering is an optional user facility agreed upon for a period of time. It applies in common to all logical channels at the DTE/DCE interface.

This user facility, if subscribed to, provides sequence numbering of packets performed modulo '128'. In the absence of this facility, the sequence numbering of packets is performed modulo '8'.

7.1.2 Non-Standard Default Window Sizes

Non-standard Default Window Sizes is an optional user facility agreed upon for a period of time. The ability to select this facility must be provided by IBM SNA X.25 DTEs. This user facility, if subscribed to, provides for the selection of default window sizes from the list of window sizes supported by the network. Some Administrations may constrain the default window sizes to be the same for each direction of data transmission across the DTE/DCE interface. In the absence of this facility, the default window sizes are two (2).

Values other than the default window sizes may be negotiated for virtual calls, on a per call basis, by means of the Flow Control Parameter Negotiation facility (see "Flow Control Parameter Negotiation" on page II-73), which is recommended for implementation by IBM SNA X.25 DTEs. Values other than the default window sizes may be agreed upon for a period of time for each permanent virtual circuit. (Text deleted).

7.1.3 Default Throughput Classes Assignment

Default Throughput Class Assignment is an optional user facility agreed upon for a period of time. This user facility, if subscribed to, provides for the selection of default throughput classes from the list of throughput classes supported by the network. Some Administrations may constrain the default throughput classes to be the same for each direction of data transmission. In the absence of this facility, the default throughput classes correspond to the user class of service of the DTE (see "Coding of Throughput Class Negotiation Facility" on page II-81) but do not exceed the maximum throughput class supported by the network.

The default throughput classes are the maximum throughput classes which may be associated with any virtual call at the DTE/DCE interface. Values other than the default throughput classes may be negotiated for a virtual call by means of the Throughput Class Negotiation facility (see "Throughput Class Negotiation" on page II-74). Values other than the default throughput classes may be agreed upon for a period of time for each permanent virtual circuit.

7.1.4 Packet Retransmission

The packet retransmission facility is not used in SNA environments.

(Text deleted).

7.1.5 Incoming Calls Barred

Incoming Calls Barred is an optional user facility agreed upon for a period of time. This facility applies to all logical channels at the DTE/DCE interface used for virtual calls (Text deleted). This user facility, if subscribed to, prevents virtual calls (text deleted) from being presented to the DTE. The DTE may originate outgoing virtual calls (text deleted) only.

Note: Logical channels used for virtual calls retain their full duplex capability. (Text deleted).

7.1.6 Outgoing Calls Barred

Outgoing Calls Barred is an optional user facility agreed upon for a period of time. This facility applies to all logical channels at the DTE/DCE interface used for virtual calls (text deleted).

This user facility, if subscribed to, prevents the DCE from accepting outgoing virtual calls (text deleted) from the DTE. DTEs may receive incoming virtual calls (text deleted).

Note: Logical channels used for virtual calls retain their full duplex capability.

7.1.7 One-Way Logical Channel Outgoing

One-way Logical Channels Outgoing is an optional user facility agreed upon for a period of time and is recommended for IBM SNA X.25 DTEs that support multiple virtual circuits. This user facility, if subscribed to, restricts logical channel use to originating outgoing virtual calls (text deleted) only.

Note: A logical channel used for virtual calls retains its full duplex capability. (Text deleted).

The rules according to which logical channel group numbers and logical channel numbers can be assigned to one-way outgoing logical channels for virtual calls are given in Appendix A.

Note: If all the logical channels for virtual calls (text deleted) are one-way outgoing at a DTE/DCE interface, the effect is equivalent to the Incoming Calls Barred facility (see "Incoming Calls Barred" on page II-69).

7.1.8 One-Way Logical Channel Incoming

One-way Logical Channels Incoming is an optional user facility agreed upon for a period of time. This user facility, if subscribed to, restricts logical channel use to receiving incoming virtual calls (text deleted) only. This facility is recommended for IBM SNA X.25 DTEs that support multiple virtual circuits.

Note: A logical channel used for virtual calls retains its full duplex capability.

The rules according to which logical channel group numbers and logical channel numbers can be assigned to one-way logical channels for virtual calls are given in Appendix A.

Note: If all logical channels for virtual calls are one-way incoming at a DTE/DCE interface, the effect is equivalent to the Outgoing Calls Barred facility (see "Outgoing Calls Barred").

7.1.9 Closed User Group

Closed User Group is an optional user facility agreed upon for a period of time for virtual calls (text deleted). This facility, if subscribed to, enables the DTE to belong to one or more closed user groups, and is recommended for IBM SNA X.25 DTEs. A closed user group permits the DTEs belonging to the group to communicate with each other, but precludes communication with all other DTEs.

The calling/source DTE should specify the closed user group selected for a virtual call (text deleted) using the optional user facility parameters (see "Coding of Closed User Group Facility" on page II-79) in the CALL REQUEST (text deleted) packet.

The closed user group selected for a virtual call (text deleted) will be indicated to a called/destination DTE using the optional user facility parameters (see "Coding of Closed User Group Facility" on page II-79) in the INCOMING CALL (text deleted) packet.

When a DTE only belongs to one closed user group or when the virtual call (text deleted) is associated with the DTE's preferential closed user group, this indication may not be present in the CALL REQUEST or INCOMING CALL (text deleted) packet.

IBM SNA X.25 DTEs that support a single CLOSED USER GROUP require no coding in the facilities field when the PSDN supports the assignment of a default user group.

7.1.10 Closed User Group with Outgoing Access

Closed User Group with Outgoing Access is an optional user facility agreed upon for a period of time for virtual calls (text deleted). This facility, if subscribed to, enables the DTE to belong to one or more closed user groups (as in "Closed User Group") and to originate virtual calls (text deleted) to DTEs in the open part of the network and to DTEs having the incoming access capability. This facility is recommended for IBM SNA X.25 DTEs that support multiple virtual circuits.

The procedures for using this facility are the same as those given in "Closed User Group." However, the optional user facility parameters may not be present when originating virtual calls (text deleted) to DTEs in the open part of the network or to DTEs having the incoming access capability.

7.1.11 Closed User Group with Incoming Access

Closed User Group with Incoming Access is an optional user facility agreed upon for a period of time for virtual calls (text deleted). This facility, if subscribed to, enables the DTE to belong to one or more closed user groups (as in "Closed User Group") and to receive incoming calls (text deleted) from DTEs in the open part of the network and from DTEs having the outgoing access capability.

The procedures for using this facility are the same as those given in "Closed User Group." However, the optional user facility parameters may not be present when receiving incoming calls (text deleted) from DTEs in the open part of the network or from DTEs having the outgoing access capability. This facility is recommended for IBM SNA X.25 DTEs that support multiple virtual circuits.

7.1.12 Incoming Calls Barred within a Closed User Group

Incoming Calls Barred within a Closed User Group is an optional user facility agreed upon for a period of time. This user facility, if subscribed to for a given closed user group, permits the DTE to originate virtual calls (text deleted) to DTEs in this closed user group, but precludes the reception of incoming calls (text deleted) from other DTEs in this closed user group.

The procedures for using this facility are the same as those given in "Closed User Group," "Closed User Group with Outgoing Access" and "Closed User Group with Incoming Access."

7.1.13 Outgoing Calls Barred within a Closed User Group

Outgoing Calls Barred within a Closed User Group is an optional facility agreed upon for a period of time. This user facility, if subscribed to for a given closed user group, permits the DTE to receive virtual calls (text deleted) from other DTEs in this closed user group, but prevents the DTE from originating virtual calls (text deleted) to other DTEs in this closed user group.

The procedures for using this facility are the same as those given in "Closed User Group" on page II-71, "Closed User Group with Outgoing Access" on page II-71 and "Closed User Group with Incoming Access" on page II-71.

7.1.14 Bilateral Closed User Group

Bilateral Closed User Groups are not supported in SNA environments.

(Text deleted).

7.1.15 Bilateral Closed User Group With Outgoing Access

Bilateral Closed User Groups with Outgoing Access are not supported in SNA environments.

(Text deleted).

7.1.16 Reverse Charging

Reverse Charging is an optional user facility which can be requested by a DTE for a given virtual call (text deleted) (see "Coding of Reverse Charging Facility" on page II-79). This facility is recommended for IBM SNA X.25 DTEs.

7.1.17 Reverse Charging Acceptance

Reverse Charging Acceptance is an optional user facility agreed upon for a period of time.

This user facility, if subscribed to, authorizes the DCE to transmit to the DTE incoming calls (text deleted) which request the Reverse Charging facility. In the absence of this facility, the DCE will not transmit to the DTE incoming calls (text deleted) which request the Reverse Charging facility. This facility is recommended for IBM SNA X.25 DTEs.

7.1.18 RPOA Selection

RPOA (Recognized Private Operating Agency) selection is an optional user facility which can be requested by a DTE for a given virtual call (text deleted).

This user facility, when requested, provides for the user specification by the calling/source DTE of a particular RPOA transit network through which the call (text deleted) is to be routed internationally, when more that one RPOA transit network exists at an international gateway (see "Coding of RPOA Selection Facility" on page II-80).

7.2 PROCEDURES FOR OPTIONAL USER FACILITIES ONLY AVAILABLE WITH VC SERVICES

7.2.1 Non-Standard Default Packet Sizes

Non-standard Default Packet Sizes is an optional user facility agreed upon for a period of time. The ability to select this facility must be provided by IBM SNA X.25 DTEs. This facility, if subscribed to, provides for the selection of default packet sizes from the list of packet sizes supported by the network. Some network Administrations may constrain packet sizes to be the same for each direction of data transmission across the DTE/DCE interface. In the absence of this facility, default packet sizes are '128' octets.

Note: In "Non-Standard Default Packet Sizes," the term "packet sizes" refers to the maximum User Data field lengths of DCE DATA and DTE DATA packets.

Values other than the default packet sizes may be negotiated for a virtual call, on a per call basis, by means of the flow control parameter negotiation facility (see "Flow Control Parameter Negotiation"), which may be implemented in IBM SNA X.25 DTEs. Values other than the default packet sizes may be agreed upon for a period of time for each permanent virtual circuit.

7.2.2 Flow Control Parameter Negotiation

Flow Control Parameter Negotiation is an optional user facility agreed upon for a period of time which can be used by a DTE for virtual calls. The ability for the DTE to select this facility is recommended for IBM SNA X.25 DTEs. This facility, if subscribed to, permits negotiation, on a per call basis, of flow control parameters. The flow control parameters considered are the packet and window sizes at the DTE/DCE interface for each direction of data transmission.

Note: In "Flow Control Parameter Negotiation," the term "packet sizes" refers to the maximum User Data field lengths of DCE DATA and DTE DATA packets.

In the absence of the Flow Control Parameter Negotiation facility, the flow control parameters to be used at a particular DTE/DCE interface are the default packet sizes (see "Non-Standard Default Packet Sizes") and the default window sizes (see "Non-Standard Default Window Sizes" on page II-69).

When the calling DTE has subscribed to the Flow Control Parameter Negotiation facility, it may separately request packet sizes and window sizes for each direction of data transmission (see "Coding of the Flow Control Parameter Negotiation Facility" on page II-80). If a particular window size is not explicitly requested in a CALL REQUEST packet, the DCE will assume that the default window size was requested. If a particular packet size is not explicitly requested, the DCE will assume that the default packet size was requested.

When a called DTE has subscribed to the Flow Control Parameter Negotiation facility, each INCOMING CALL packet indicates the packet and window sizes from which negotiation starts. No relationship needs to exist between the packet sizes (P) and window sizes (W) requested in the CALL REQUEST packet and those indicated in the INCOMING CALL packet. The called DTE may request window and packet sizes with facilities in the CALL ACCEPTED packet. The only valid facility requests in the CALL ACCEPTED packet, as a function of the facility indications in the INCOMING CALL packet, are given in Table II-13. If the Facility request is not made in the CALL ACCEPTED packet, the DTE is assumed to have accepted the indicated values (regardless of the default values).

TABLE II-13 - Valid facility requests in CALL ACCEPTED packets in response to facility indications in INCOMING CALL packets	
Facility Indication	Valid Facility Request
W (indicated) ≥ 2 W (indicated) = 1	W (indicated) ≥ W (requested) ≥ 2 W (requested) = 1 or 2
P (indicated) ≥ 128 P (indicated) < 128	P (indicated) ≥ P (requested) ≥ 128 128 ≥ P (requested) ≥ P (indicated)

When the calling DTE has subscribed to the Flow Control Parameter Negotiation facility, every CALL CONNECTED packet indicates the packet and window sizes used at the DTE/DCE interface for the call. The only valid facility indications in the CALL CONNECTED packet, as a function of the facility requests in the CALL REQUEST packet, are given in Table II-14.

TABLE II-14 - Valid facility indications in CALL CONNECTED packets in response to facility request in CALL REQUEST packets	
Facility Request	Valid Facility Indication
W (requested) ≥ 2 W (requested) = 1	W (requested) ≥ W (indicated) ≥ 2 W (indicated) = 1 or 2
P (requested) ≥ 128 P (requested) < 128	P (requested) ≥ P (indicated) ≥ 128 128 ≥ P (indicated) ≥ P (requested)

The network may have constraints requiring the flow control parameters used for a call to be modified before indicating them to the DTE in the INCOMING CALL packet or CALL CONNECTED packet; e.g., the ranges of parameter values available on various networks may differ.

Window and packet sizes need not be the same at each end of a virtual call.

The role of the DCE in negotiating the flow control parameters may be network dependent.

7.2.3 Throughput Class Negotiation

Throughput class negotiation is an optional user facility agreed upon for a period of time which can be used by a DTE for virtual calls. This facility, if subscribed to, permits negotiation, on a per call basis, of the throughput classes; and, should be supported by IBM SNA X.25 DTEs that support multiple virtual circuits. The throughput classes are considered independently for each direction of data transmission.

Default values are agreed upon between the DTE and the Administration (see "Default Throughput Classes Assignment" on page II-69). The default values correspond to the maximum throughput classes which may be associated with any virtual call at the DTE/DCE interface.

When the calling DTE has subscribed to the Throughput Class Negotiation facility, it may separately request the throughput classes of the virtual calls in the CALL REQUEST packet (see "Coding of Throughput Class Negotiation Facility" on page II-81). If particular throughput classes are not requested, the DCE will assume the default values.

When a called DTE has subscribed to the Throughput Class Negotiation facility, each INCOMING CALL packet indicates the throughput classes from which negotiation may starts. These throughput classes are lower or equal to the ones selected at the calling DTE/DCE interface, either explicitly, or by default if the calling DTE has not subscribed to the Throughput Class Negotiation facility or has not explicitly requested throughput class values in the CALL REQUEST packet. These throughput classes indicated to the called DTE will also not be higher than the default throughput classes, respectively, for each direction of transmission, at the calling and the called DTE/DCE interfaces. They may be further constrained by internal limitations of the network.

The called DTE may request with a facility in the CALL ACCEPTED packet the throughput classes that should finally apply to the virtual call. The only valid throughput classes in the CALL ACCEPTED packet are lower than or equal to the ones (respectively) indicated in the INCOMING CALL packet. If the called DTE does not make any throughput class facility request in the CALL ACCEPTED packet, the throughput classes finally applying to the virtual call will be the ones indicated in the INCOMING CALL packet.

If the called DTE has not subscribed to the Throughput Class Negotiation facility, the throughput classes finally applying to the virtual call are less than or equal to the ones selected at the calling DTE/DCE interface, and less than or equal to the default values defined at the called DTE/DCE interface.

When the calling DTE has subscribed to the Throughput Class Negotiation facility, every CALL CONNECTED packet will indicate the throughput classes finally applying to the virtual call.

When neither the calling DTE nor the called DTE has subscribed to the Throughput Class Negotiation facility, the throughput classes applying to the virtual call will not be higher than the ones agreed as defaults at the calling and called DTE/DCE interfaces. They may be further constrained to lower values by the network, e.g., for international service.

Note:

1. [Since both Throughput Class Negotiation and Flow Control Parameter Negotiation (see "Flow Control Parameter Negotiation" on page II-73) facilities can be applied to a single call, the achievable throughput will depend on how users manipulate the 'D' bit.]
2. Users are cautioned that the choice of too small a window and packet size at a DTE/DCE interface (made by use of the Flow Control Parameter Negotiation facility) may adversely affect the attainable throughput class for a virtual call. This is likewise true of flow control mechanisms adopted by the DTE to control data transmission from the DCE.

7.2.4 Fast Select

7.2.4.1 SNA-to-SNA Connections

The possible use of the Fast Select facility on SNA-to-SNA connections is a subject for further study.

7.2.4.2 SNA-to-non_SNA Connections

Fast select is an optional user facility which may be requested by a DTE for a given virtual call.

DTEs can request the fast select facility on a per call basis by means of an appropriate request (see "Coding of Fast Select Facility" on page II-82) in a CALL REQUEST packet using any logical channel which has been assigned to virtual calls.

The fast select facility, if requested in the CALL REQUEST packet and if it indicates no restriction on response, allows this packet to contain a call user data field of up to 128 octets and authorizes the DCE to transmit to the DTE, during the DTE waiting state, a CALL CONNECTED packet with a called user data field of up to 128 octets or a CLEAR INDICATION packet with a clear user data field of up to 128 octets.

The fast select facility, is requested in the CALL REQUEST packet and if it indicates restriction on response, allows this packet to contain a call user data field of up to 128 octets and authorizes the DCE to transmit to the DTE, during the DTE waiting state, a CLEAR INDICATION packet with a clear user data field of up to 128 octets; the DCE would not be authorized to transmit a CALL CONNECTED packet.

Where a DTE requests the Fast Select facility in a CALL REQUEST packet, the INCOMING CALL packet should be only delivered to the called DTE if that DTE has subscribed to the fast select acceptance facility (see "Fast Select Acceptance").

If the called DTE has subscribed to the fast select acceptance facility, it will be advised that the fast select facility, and an indication of whether or not there is a restriction on the response, has been requested through the inclusion of the appropriate facility in the INCOMING CALL packet.

If the called DTE has not subscribed to the fast select acceptance facility, an INCOMING CALL packet with the fast select facility requested will not be transmitted and a CLEAR INDICATION packet with the cause "Fast select acceptance not subscribed" will be returned to the calling DTE.

The presence of the fast select facility indicating no restriction on response in an INCOMING CALL packet permits the DTE to issue as a direct response to this packet a CALL ACCEPTED packet with a called user data field of up to 128 octets or a CLEAR REQUEST packet with a clear user data field of up to 128 octets.

The presence of the fast select facility indicating restriction on response in an INCOMING CALL packet permits the DTE to issue as a direct response to this packet a CLEAR REQUEST packet with a clear user data field of up to 128 octets; the DTE would not be authorized to send a CALL ACCEPTED packet.

The possibility to send a CLEAR REQUEST packet with a clear user data field up to 128 octets at any time instead of just in the DCE Waiting state (p3) is for further study.

Note: The call user data field, the called user data field and the clear user data field will not be fragmented for delivery across the DTE/DCE interface.

The significance of the CALL CONNECTED packet and the CLEAR INDICATION packet with the cause "DTE originated" as a direct response to the CALL REQUEST packet with the fast select facility is that the CALL REQUEST packet with the data field has been received by the called DTE.

All other procedures of a call in which the fast select facility has been requested are the same as those of a virtual call.

If a fast select CLEAR REQUEST packet with a non-zero Address Length field or Facility Length field is received, the DCE shall discard the received packet. The DCE shall indicate clearing by transmitting to the DTE a CLEAR INDICATION packet with the cause "Local procedure error" and diagnostic No. 81 or No. 82, as appropriate; the DCE shall consider the clearing procedure complete and enter state p1. The distant DTE is also informed of the clearing by a CLEAR INDICATION packet, with the cause "Remote procedure error" (same diagnostic).

7.2.5 Fast Select Acceptance

7.2.5.1 SNA-to-SNA Connections

The possible use of the Fast Select Acceptance in SNA environments is a subject for further study.

7.2.5.2 SNA-to-non_SNA Connections

Fast select acceptance is an optional user facility agreed for a period of time. This user facility, if subscribed to, authorizes the DCE to transmit to the DTE INCOMING CALL packets which request the fast select facility. In the absence of this facility, the DCE will not transmit to the DTE incoming calls which request the fast select facility.

7.2.6 'D' Bit Modification

Use of the 'D' bit Modification facility is not allowed in SNA environments.

(Text deleted).

7.3 PROCEDURES FOR OPTIONAL USER FACILITIES ONLY AVAILABLE WITH DATAGRAM SERVICES

Datagram services are not used in SNA environments.

(Text deleted).

7.4 FORMATS FOR OPTIONAL USER FACILITIES

7.4.1 General

The Facility field is present only when a DTE is using an optional user facility requiring some indication in CALL REQUEST, INCOMING CALL, CALL ACCEPTED, CALL CONNECTED, CLEAR REQUEST or CLEAR INDICATION (text deleted) packets.

The Facility field contains one or more facility elements. The first octet of each facility element contains a facility code to indicate the facility or facilities requested.

2 **Note:** A facility code must not appear more than once in SNA environments.

The facility codes are divided into four classes, by making use of bits 8 and 7 of the facility field, to specify facility parameters consisting of '1', '2', '3', or a variable number of octets. The general class coding of the facility code field is shown in Table II-15.

Table II-15 — Facility code field class coding

CLASS	Bits 8 7 6 5 4 3 2 1	Parameter Field Characteristics
A	0 0 X X X X X X	single octet
B	0 1 X X X X X X	double octet
C	1 0 X X X X X X	triple octet
D	1 1 X X X X X X	variable length

For class 'D' the octet following the facility code indicates the length, in octets, of the facility parameter field. The facility parameter field length is binary coded and bit 1 is the low order bit of this indicator. Formats for the four classes are shown in Table II-16.

Table II-16 - Facilities Formats

CLASS A

Octet \ Bits	8	7	6	5	4	3	2	1
0	0	0	X	X	X	X	X	X
1	Facility parameter field							

CLASS B

Octet \ Bits	8	7	6	5	4	3	2	1
0	0	1	X	X	X	X	X	X
1	Facility parameter							
2	field							

CLASS C

Octet \ Bits	8	7	6	5	4	3	2	1
0	1	0	X	X	X	X	X	X
1	Facility							
2	parameter							
3	field							

CLASS D

Octet \ Bits	8	7	6	5	4	3	2	1
0	1	1	X	X	X	X	X	X
1	Facility parameter field length							
2	Facility parameter field							

The facility code field is binary coded and, without extension, provides for a maximum of 64 facility codes for classes 'A', 'B' and 'C' and '63' facility codes for class 'D' giving a total of '255' facility codes.

Facility code x'FF' is reserved for extension of the facility code. The octet following this octet indicates an extended facility code having the format 'A', 'B', 'C' or 'D' as defined above. Repetition of facility code x'FF' is permitted and thus additional extensions result.

The coding of the facility parameter field is dependent on the facility being requested.

A facility code may be assigned to identify a number of specific facilities, each having a bit in the parameter field indicating facility requested/facility not requested. In this situation, the parameter field is binary encoded with each bit position relating to a specific facility. A '0' indicates that the facility related to the particular bit is not requested and a '1' indicates that the facility related to the particular bit is requested. Parameter bit positions not assigned to a specific facility are set to zero. If none of the facilities represented by the facility code is requested for a virtual call the facility code and its associated parameter field need not be present.

A Facility Marker, consisting of a single octet pair, is used to separate requests for X.25 facilities, as defined in this section, from requests for non-X.25 facilities that may also be offered by an Administration. The first octet is a facility code and is set to zero and the second octet is the facility parameter field.

The coding of the parameter field will be either all zeros or all ones depending on whether the facility requests following the marker refer to facilities offered by the calling/source or called/destination network, respectively. For intranetwork virtual calls the parameter field should be all zeros.

Requests for non-X.25 facilities offered by the calling/source and called/destination networks may be simultaneously present within the facility field and in such cases two Facility Markers will be required with parameter fields coded as described above.

Within the facility field, requests for X.25 facilities precede all requests for non-X.25 facilities and Facility Markers need only be included when requests for non-X.25 facilities are present.

7.4.2 Coding of Facility Field for Particular Facilities

7.4.2.1 Coding of Closed User Group Facility

The coding of the facility code field and the format of the facility parameter field for Closed User Group are the same in CALL REQUEST and INCOMING CALL (text deleted) packets.

1. Facility Code Field

   The coding of the facility code field for Closed User Groups is:

   bit: 8 7 6 5 4 3 2 1

   code: 0 0 0 0 0 0 1 1

2. Facility Parameter Field

   The index to the Closed User Group selected for the virtual call is in the form of two decimal digits. Each digit is coded in a semi-octet in binary coded decimal with bit 5 being the low order bit of the first digit and bit 1 being the low order bit of the second digit.

   Indexes to the same Closed User Group at different DTE/DCE interfaces may be different.

7.4.2.2 Coding of Bilateral Closed User Group Facility

The Bilateral Closed User Group facility is not used in SNA environments.

(Text deleted).

7.4.2.3 Coding of Reverse Charging Facility

The coding of the facility code and parameter fields for Reverse Charging is the same in CALL REQUEST and INCOMING CALL (text deleted) packets.

1. Facility Code Field

   The coding of the facility code field for Reverse Charging is:

   bit: 8 7 6 5 4 3 2 1

   code: 0 0 0 0 0 0 0 1

2. Facility Parameter Field

   The coding of the facility parameter field is:

   bit 1 = '0' for Reverse Charging not requested

   bit 1 = '1' for Reverse Charging requested

Note: Bits 6, 5, 4, 3, and 2 may be used for other facilities; if not, they are set to '0'. Use of bits 8 and 7 are described in "Coding of Fast Select Facility" on page II-82.

7.4.2.4 Coding of RPOA Selection Facility

The coding of the facility code and parameter fields for RPOA Selection is the same in | CALL REQUEST and INCOMING CALL (text deleted) packets.

1. Facility Code Field

   The coding of the facility code field for RPOA Selection is:

   bit: 8 7 6 5 4 3 2 1

   code: 0 1 0 0 0 1 0 0

2. Facility Parameter Field

   The parameter field contains the Data Network Identification Code for the requested RPOA transit network, and is in the form of 4 decimal digits.

   Each digit is coded in a semi-octet in binary coded decimal with bit 5 of the first octet being the low order bit of the first digit, bit 1 of the first octet being the low order bit of the second digit, bit 5 of the second octet being the low order bit of the third digit, and bit 1 of the second octet being the low order bit of the fourth digit.

7.4.2.5 Coding of the Flow Control Parameter Negotiation Facility

1. Coding for Packet Sizes

   The coding of the facility code field and the format of the facility parameter field for packet sizes are the same in CALL REQUEST, INCOMING CALL, CALL ACCEPTED and CALL CONNECTED packets, where:

   a. Facility Code field

      The coding of the facility code field for packet sizes is:

      bit: 8 7 6 5 4 3 2 1

      code: 0 1 0 0 0 0 1 0

   b. Facility Parameter Field

      The packet size for the direction of transmission from the called DTE is indicated in bits 4, 3, 2, and 1 of the first octet. The packet size for the direction of transmission from the calling DTE is indicated in bits 4, 3, 2, and 1 of the second octet. Bits 5, 6, 7 and 8 of each octet must be x'0'.

      The four bits indicating each packet size are binary coded and express the logarithm base '2' of the number of octets of the maximum packet size.

      Networks may offer values from '4' to '10', corresponding to packet sizes of 16, 32, 64, 128, 256, 512, or 1024, or a subset of these values. All Administrations provide a packet size of '128'.

2. Coding for Window Size

   The coding of the facility code field and the format of the facility parameter field for window sizes are the same in CALL REQUEST, INCOMING CALL, CALL ACCEPTED, and CALL CONNECTED packets, where:

   a. Facility Code Field

      The coding of the facility code field for window size is:

      bit: 8 7 6 5 4 3 2 1

      code: 0 1 0 0 0 0 1 1

b. Facility Parameter Field

The window size for the direction of transmission from the called DTE is indicated in bits 7 to 1 of the first octet. The window size for the direction of transmission from the calling DTE is indicated in bits 7 to 1 of the second octet. Bit 8 of each octet must be '0'.

The bits indicating each window size are binary coded and express the size of the window. A value of b'0000000' is not allowed.

Window sizes of '8' to '127' are only valid if extended sequence numbering is used (see "Extended Packet Sequence Numbering" on page II-69). The ranges of values allowed by a network for calls with normal (modulo '8') packet sequence numbering and extended (modulo '128') packet sequence numbering are network dependent. All Administrations provide a window size of two (2).

7.4.2.6 Coding of Throughput Class Negotiation Facility

The coding of the facility code field and the format of the facility parameter field for Throughput Class Negotiation are the same in CALL REQUEST, INCOMING CALL, CALL ACCEPTED AND CALL CONNECTED packets.

1. Facility Code Field

   The coding of the facility code field for Throughput Class Negotiation is:

   bit: 8 7 6 5 4 3 2 1

   code: 0 0 0 0 0 0 1 0

2. Facility Parameter Field

   The throughput class for transmission from the calling DTE is indicated in bits 4, 3, 2 and 1. The throughput class for transmission from the called DTE is indicated in bits 8, 7, 6 and 5.

   The four bits indicating each throughput class are binary coded and correspond to the throughput classes indicated in Table II-17.

Table II-17 — Throughput Class Codings

bits 4 3 2 1 or bits 8 7 6 5	Throughput Class (bit/s)
0 0 0 0	Reserved
0 0 0 1	Reserved
0 0 1 0	Reserved
0 0 1 1	75
0 1 0 0	150
0 1 0 1	300
0 1 1 0	600
0 1 1 1	1,200
1 0 0 0	2,400
1 0 0 1	4,800
1 0 1 0	9,600
1 0 1 1	19,200
1 1 0 0	48,000
1 1 0 1	Reserved
1 1 1 0	Reserved
1 1 1 1	Reserved

7.4.2.7 Coding of Fast Select Facility

1. SNA-to-SNA Connections

   The possible use of the Fast Select facility on SNA-to-SNA CONNECTIONS is a subject for further study.

2. SNA-to-non_SNA Connections

   The coding of the facility code and parameter field for Fast Select is the same in CALL REQUEST and INCOMING CALL packets, where:

   a. Facility code field

      The coding of the facility code field for fast select is:

      bit: 8 7 6 5 4 3 2 1

      code: 0 0 0 0 0 0 0 1

   b. Facility parameter field

      The coding of the facility parameter field is:

      bit 8 = 0 and bit 7 = 0 or 1 for fast select not requested

      bit 8 = 1 and bit 7 = 0 for fast select requested with no restriction on response

      bit 8 = 1 and bit 7 = 1 for fast select requested with restriction on response

Note: Bits 6, 5, 4, 3 and 2 may be used for other facilities; if not, they are set to 0. Use of bit 1 is described in "Coding of Reverse Charging Facility" on page II-79.

7.4.2.8 Coding of Datagram Non-delivery Indication Facility

The Datagram Non-delivery Indication facility is not used in SNA environments.

(Text deleted).

7.4.2.9 Coding of Datagram Delivery Confirmation Facility

The Datagram Delivery Confirmation facility is not used in SNA environments.

(Text deleted).

8.0 LOGICAL LINK CONTROL (LLC) ON SNA-TO-SNA CONNECTIONS

In SNA-to-SNA environments, virtual circuits are viewed, by SNA Physical Unit (SNA.PU), SNA Path Control (SNA.PC) and the higher layers as communication lines (physical media) with the ability to support multiple sessions. Permanent virtual circuits (PVC)s appear to the higher layers of SNA as dedicated (leased) lines, while virtual calls (VCs), also referred to as switched virtual circuits (SVCs), appear as switched lines.

In this environment a logical link control function is required to enhance the quality of service provided by the underlying service and to accommodate SNA adjacent node physical services equivalent to such SDLC functions as:

- identification information exchange (XID);
- operational mode selection (SNRM, SABM, etc.);
- link test (TEST); and,
- link disconnection (DISC).

Differences between the error detection and recovery characteristics for adjacent SNA nodes in the Public Switched Telephone Network and the Packet-Switched Data Network environments are depicted in Figure 19 on page II-84

Three types of logical link control are defined:

1. Qualified Logical Link Control (QLLC) which employs the Qualified Data Indicator 'Q-bit' in X.25 DATA packets to identify unnumbered and supervisory Receive_Ready QLLC commands and responses; and, designed for use with PSDN virtual circuit services that exhibit quality of service characteristics that are acceptable to the user.

2. Physical Services Header (PSH) LLC which is employed in certain early IBM SNA X.25 DTE implementations and described briefly in appendix H; and,

3. Enhanced Logical Link Control (ELLC) which employs extended formats and the procedures described in appendix K. ELLC provides error detection and optional retransmission recovery capabilities, designed to enhance the quality of service exhibited by underlying virtual circuits. While ELLC may be selected by the user on a virtual circuit basis, the optional retransmission capability applies to the DTE/DCE Interface and may be controlled by the value of LLC parameter LN2 (see §-K.6.5.4).

QLLC and the ELLC procedures described in appendix K are both considered base architecture to be supported by all IBM SNA X.25 DTEs except the:

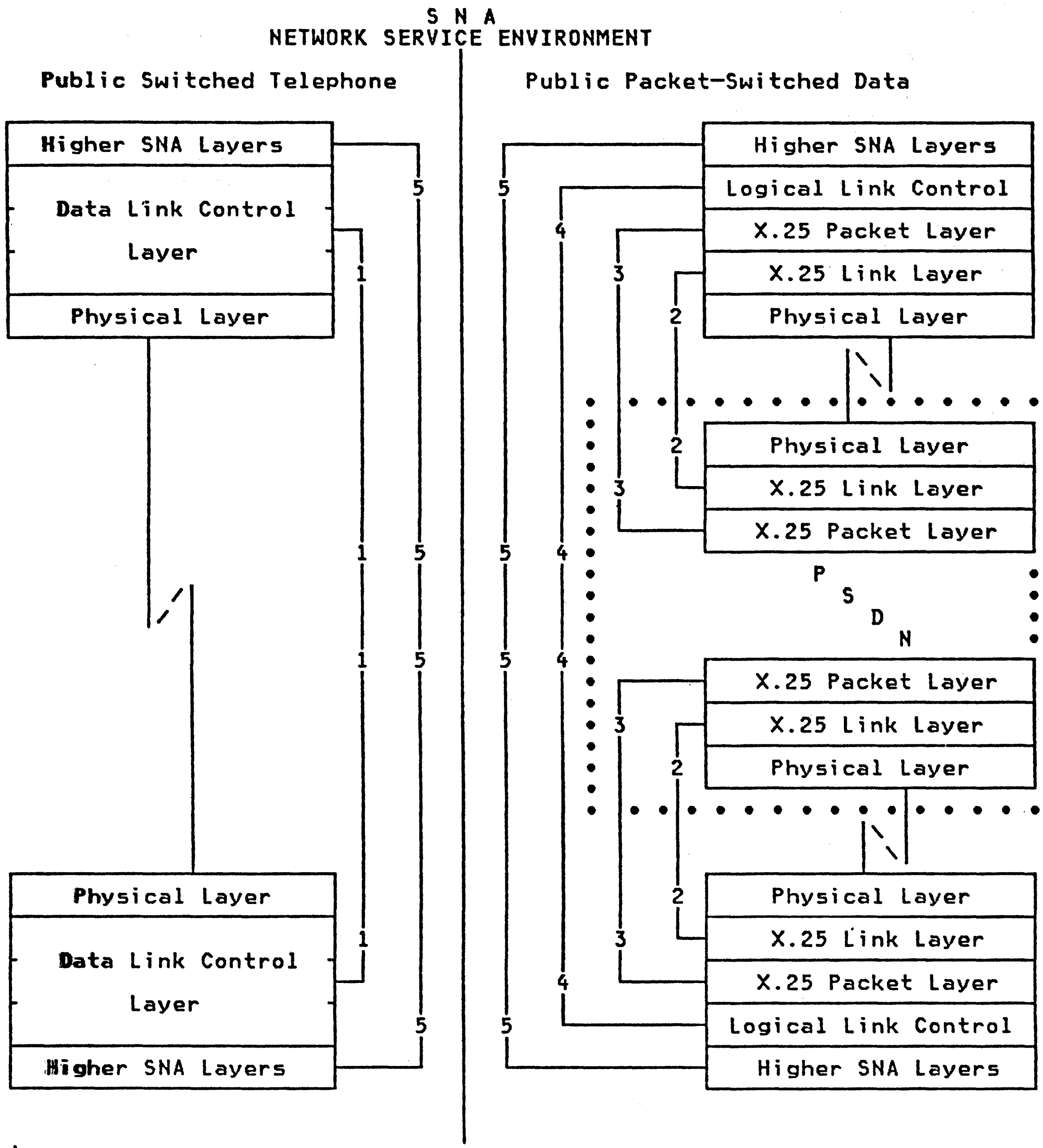
1. IBM-5973 Network Interface Adapter (NIA) which supports only the PSH protocol; and,

2. IBM-5251-M12 which does not support the ELLC protocol.

Consequently, IBM SNA X.25 DTEs that remotely attach to the IBM 5973 NIA must be capable of using PSH_LLC, as well as QLLC and ELLC.

The LLC protocol used for operation on PVCs is established by bilateral agreement between communicating DTEs, while a Protocol_Identifier (PI) carried in the first octet of the Call User Data (CUD) field in X.25 CALL_REQUEST packets is used to negotiate the LLC protocol applicable for operation on VCs. CALL_REQUEST packets for virtual calls desiring to use ELLC procedures have the PI set to x'C6'. DTEs that do not yet support ELLC, and IBM 5973s that support only PSH_LLC, reject such calls by sending a CLEAR_REQUEST packet with the DTE Generated Cause (x'00') and the Diagnostic Code #12, 'Invalid LLC Type'. Calling DTEs may then reinitiate the call by sending a CALL_REQUEST packet with PI set to x'C3' requesting a connection for QLLC operation, or with PI set to x'C2' to request a connection for PSH_LLC operation.

PSH_LLC formats and procedures for their use are outlined briefly in appendix H, while the formats, protocols and procedures for ELLC are described in appendix K.



Legend:
- 1 – SDLC Error Detection and Retransmission Recovery or Reporting
- 2 – LAPB Error Detection and Retransmission Recovery or Reporting
- 3 – Virtual Circuit Error Detection and Reporting
- 4 – QLLC or ELLC Error Detection and Recovery or Reporting
- 5 – SNA Session-Level Error Recovery or Reporting

Figure 19. Error Detection and Recovery: in Different Network Service Environments

Figure 20 on page II-85 shows the correlation between ELLC/QLLC functions and equivalent SDLC functions.

ELLC Function	QLLC Function	SDLC Function	PSH LLC Function	Primary Command	Secondary Response	Peer-to-Peer	
						Command	Response
LI	UDP	I	DATA	X		X	
LSABME	QSM	SNRM/SABM	PSCONTACT	X		X	
LDISC	QDISC	DISC	PSDISC	X		X	
LXID	QXID	XID	PSXID	X	X	X	X
LTEST	QTEST	TEST	PSTEST	X	X	X	X
LUA	QUA	UA	PSCONTACT		X		X
–	QRD	RD	PSDISC		X		
LRR	QRR	RR	–	X	X	X	X
LRNR	–	RNR	–	X	X	X	X
LREJ	–	REJ	–	X	X	X	X
LDM	QDM	DM	–		X		X
LPDUR	QFRMR	FRMR	–		X		X
Note: PSH_LLC is primary/secondary only. ELLC is peer-to-peer only.							

Figure 20. COMMAND/RESPONSE REPERTOIRE: ELLC versus QLLC versus SDLC and PSH_LLC

Peer-to-Peer QLLC, where either link station may initiate actions (i.e., transmit commands), utilizes HDLC asynchronous balanced mode (ABM) functions.

Primary/Secondary QLLC, where only primary link stations initiate actions, utilizes HDLC normal response mode (NRM) functions while secondary link stations respond to NRM functions initiated by primary link stations, and may asynchronously transfer the QRD response.

Procedures for use of the QLLC protocols by Balanced, Primary, and Secondary link stations are described in this section.

8.1 QUALIFIED LOGICAL LINK CONTROL (QLLC)

QLLC is designed to facilitate adjacent SNA node physical services where such nodes are connected through X.25-based packet-switched data network(s). It uses X.25 DATA packets with the Qualifier Bit set equal to '1' ('Q=1', hereafter referred to as 'Q-packets') to transfer HDLC-like commands and responses and is to be provided by all IBM SNA X.25 DTEs, except the 5973 NIA and the 5251-M12, as a base Logical Link Control protocol.

QLLC uses HDLC unnumbered commands and the Receive_Ready supervisory command and response, identical to their SDLC counterparts, carried as user data in Q-packets. QLLC commands and responses are initiated by the same higher level events that initiate their SDLC counterparts and timeout processing, as in SDLC, should be considered for all QLLC commands.

8.1.1 Terminology

QLLC link station configurations include balanced (or peer-to-peer) station configurations, primary station configurations and secondary station configurations that function as described in "Terminology," as well as 'combined stations' that exhibit balanced station characteristics until role negotiation is completed via an

2 exchange of identification information when they assume the role and functions of
2 either primary or secondary link stations depending on the outcome of the role
2 negotiation process.

QLLC is used by two adjacent link stations to exchange elementary units of information over a link connection in either of three environments; peer-to-peer, primary/secondary or indirectly coupled; as depicted in Figure 21. One link station acts as either a PEER or PRIMARY link station, associated with a DTE attached to a PSDN via an X.25 DTE/DCE interface to communicate with another link station associated with a DTE attached to the same or another PSDN, which acts as either a PEER or SECONDARY.

In indirectly coupled configurations, a packet assembly/disassembly (PAD) function, provided either by the PSDN or as a standalone interface adapter, acts as the 'REMOTE DTE' and correlates actions that take place across the link connection to actions that take place across the access link connecting the interface adapter and the secondary link station. In this environment the secondary link station is referred to as the 'Related Secondary Station' (RSS).

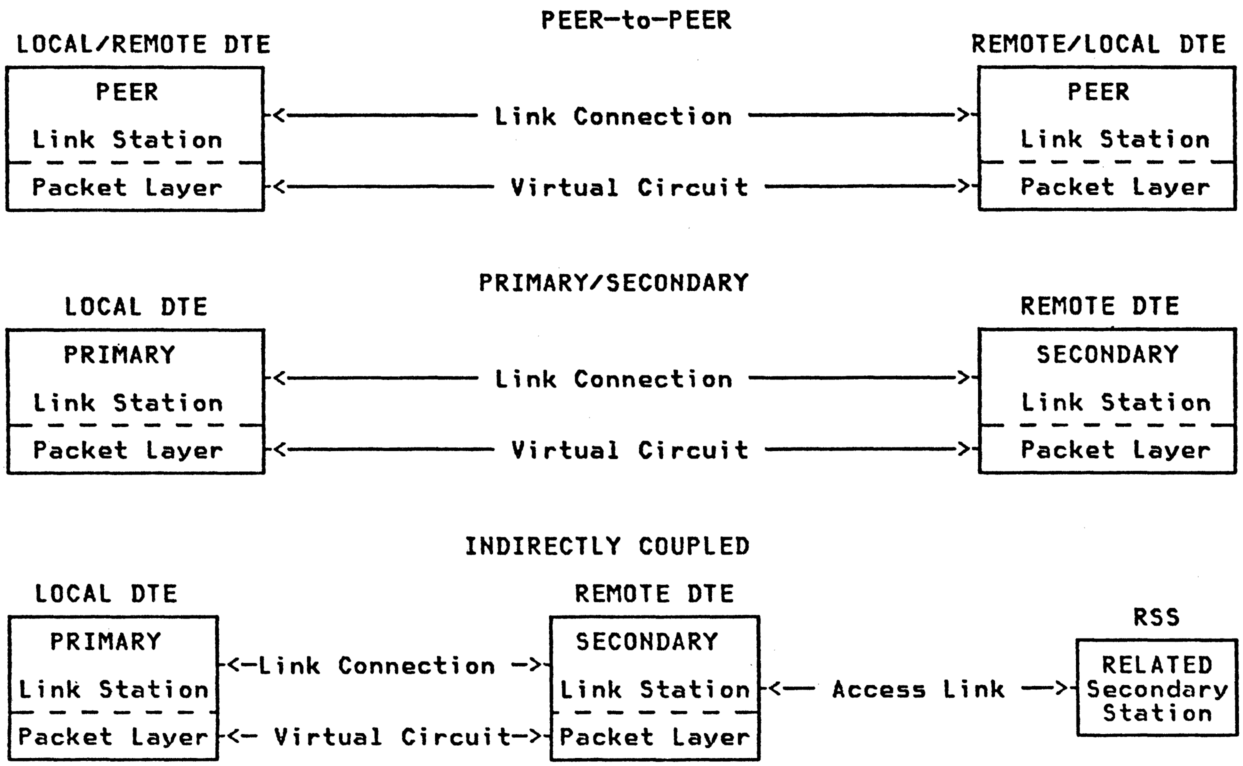


Figure 21. Qualified Logical Link Control: Environments

8.1.2 Objectives

The objective of QLLC is to provide adjacent node physical services equivalent to those used by SDLC in SNA. It must help to keep the 'LOCAL DTE' informed of the situation in the 'REMOTE DTE' and/or the 'Related Secondary Station'. Segmentation/concatenation of data packets is performed by the packet level procedures at both ends of the link connection by means of the More Data Mark 'M-bit' procedures defined in §-4.3.4.

8.1.3 QLLC Elements

The basic elements of information exchanged are called Logical Link Units (LLUs). Two types of LLUs are defined:

QLLUs - composed of commands or responses together with their uses and the resultant actions performed by link stations at both the local and remote DTEs are described in §-8.2 (Elements of Procedure). QLLUs are conveyed between adjacent link stations in Q-packets formatted as shown in Figure 22 on page II-90.

DLLUs - appearing as SNA Basic Transmission Units (BTUs), carried in the user data field of X.25 DATA packets with the 'Q' bit set to zero and the 'M' bit set to either '0' or '1', are used to convey user data between adjacent link stations in local and remote DTEs.

The X.25 Delivery Confirmation 'D-bit' procedures are not used.

8.1.4 Link Connection States

Link connections may be perceived by link stations as being in any one of six basic states at any particular instant in time.

8.1.4.1 INOPERATIVE

A link connection is perceived by the link stations to be in the INOPERATIVE state when the supporting virtual circuit is inoperative. In this state Peer, Primary and Secondary link stations neither transmit nor receive QLLUs or DLLUs.

8.1.4.2 LINK_CLOSED

The LINK_CLOSED state is comparable to the LAPB link layer disconnected phase. Peer and Primary link stations may initiate an exchange of identification information (QXID), or a link test (QTEST) procedure over link connections perceived to be in this state. Some may also initiate the link set-up procedure (transmit a QSM command). Secondary link stations accept and respond to QXID and QTEST commands received over link connections perceived to be in this state. Some may also accept and respond to QSM commands. Some Peer and Secondary link stations respond QDM to QSM commands received across link stations in this state until after a successful exchange of identification information has been completed.

8.1.4.3 LINK_OPENING

The LINK_OPENING state is comparable to the link layer set-up phase. Peer and Primary link stations expect a response (QUA or QDM) to a set mode (QSM) command previously transmitted across link connections perceived to be in this state. Peer link stations also respond (QUA) to set mode (QSM) commands received across link connections perceived to be in this state. Secondary link stations accept and respond (QUA) to set mode (QSM) commands received across link connections perceived to be in this state.

8.1.4.4 LINK_RECOVERY

The LINK_RECOVERY state is comparable to the link layer frame rejection phase. Peer and Secondary link stations retransmit the QFRMR response on link connections perceived to be in this state at each respond opportunity until recovery is effected by the adjacent link station, or until internal recovery is initiated locally.

8.1.4.5 LINK_CLOSING

This state is comparable to the link layer disconnection phase. Peer, Primary and Secondary link stations await satisfactory termination of link connections in this state.

8.1.4.6 LINK_OPENED

The LINK_OPENED state is comparable to the link layer information transfer phase. QLLUs and DLLUs may be transmitted and received by both link stations across link connections perceived to be in this state.

8.1.5 Link Connection Predicate Conditions

Predicate conditions applicable to the various states of the link connection include:

8.1.5.1 Contact Termination Pending - CTp

Represents the Secondary link station condition in which receipt of a Receive Ready (QRR) command QLLU from the Primary link station is required to terminate the SNA_CONTACT phase on link connections perceived to be in the LINK_OPENING state.

8.1.5.2 Other Predicate Conditions - ELSE

Signifies all predicate conditions not otherwise shown for a particular stimulus.

8.1.5.3 Incoming/Outgoing TEST Response Pending - IOTRp

Transmission and receipt of TEST response QLLUs containing test patterns to and from the link station in the adjacent node are pending.

8.1.5.4 Incoming/Outgoing XID Response Pending - IOXRp

Transmission and receipt of XID response QLLUs containing link station identification information to and from the link station in both adjacent nodes are pending.

8.1.5.5 Incoming TEST Response Pending - ITRp

Receipt of a TEST response QLLU containing the test pattern from the link station in the adjacent node is pending.

8.1.5.6 XID/TEST Response Pending - IXOTRp

Receipt of an XID response QLLU containing link station identification information from and transmission of a TEST response QLLU containing the test pattern to the link station in the adjacent node are both pending.

8.1.5.7 Incoming XID Response Pending - IXRp

Receipt of an XID response QLLU containing link station identification information from the link station in the adjacent node is pending.

8.1.5.8 No Predicate Condition - NUL

Signifies that no transient predicate condition exists to alter the action required of the link station.

8.1.5.9 TEST/XID Response Pending - OTIXRp

Receipt of an XID response QLLU containing link station identification information from and transmission of a TEST response QLLU containing the test pattern to the link station in the adjacent node are both pending.

8.1.5.10 Outgoing TEST Response Pending - OTRp

Transmission of a TEST response QLLU containing the test pattern to the link station in the adjacent node is pending.

8.1.5.11 Outgoing XID Response Pending - OXRp

Transmission of an XID response QLLU containing link station identification information to the link station in the adjacent node is pending.

8.1.5.12 Remote RESTART Pending - RRp

A RESTART of the X.25 DTE/DCE Interface providing Called (remote) DTE access to the network is pending.

8.1.5.13 SET_MODE Pending - SMp

Peer and Primary link stations, having completed a successful exchange of identification information across a link connection perceived to be in the LINK_CLOSED state, may transmit a QSM command QLLU when authorized by the higher levels of SNA. Peer and Secondary link stations accept and respond to QSM command QLLUs received on link connections perceived to be in this state.

8.2 QLLC ELEMENTS OF PROCEDURE

8.2.1 Q-Packet Formats

'Q-packets' used by QLLC conform to one of the formats depicted in Figure 22 on page II-90.

Octet	Bits 8	7	6	5	4	3	2	1
1	General format identifier (GFI) 1	0	0	1	Logical channel group number			
2	Logical channel number							
3	Pr			M	Ps			0
4	QLLC Address Field (Coded x'FF' for Commands or ≠ x'FF' for Responses)							
5	QLLC Control Field							
6 • n	QXID/QTEST/QFRMR Information Field (Optional)							

(Modulo 8)

Octet	Bits 8	7	6	5	4	3	2	1
1	General format identifier (GFI) 1	0	1	0	Logical channel group number			
2	Logical channel number							
3	Ps							0
4	Pr							M
5	QLLC Address Field (Coded x'FF' for Commands or ≠ x'FF' for Responses)							
6	QLLC Control Field							
7 • n	QXID/QTEST/QFRMR Information Field (Optional)							

(Modulo 128)

M = More Data Mark

Figure 22. QUALIFIED_DATA: Packet Formats

8.2.1.1 QLLC Address Field

The address field consists of one octet. The contents of the address field is set to x'FF' in 'Q-packets' containing commands and to any value other than x'FF' in 'Q-packets' containing responses.

8.2.1.2 QLLC Control Field

The control field consists of one octet. The control field contains the command/response transmitted by the peer, primary or secondary link station as depicted in Figure 23 on page II-91.

8.2.1.3 QLLC Information Field

The information field consists of a variable number of octets and is used to carry QXID, QTEST or QFRMR data.

8.2.2 QLLC Commands and Responses

Figure 23 shows the code points for the HDLC commands/responses used by peer, primary and secondary QLLC link stations.

QLLC Function	C-Field Hex Octet 1	I-Field Allowed	Primary Command	Secondary Response	Peer-to-Peer	
					Command	Response
QSM	93	NO	X		X	
QDISC	53	NO	X		X	
QXID	BF	YES	X		X	
QTEST	F3	YES	X		X	
QRR	F1	NO	X		X	
QRD	53	NO		X		
QXID	BF	YES		X		X
QTEST	F3	YES		X		X
QUA	73	NO		X		X
QDM	1F	NO		X		X
QFRMR	97	YES		X		X
Note: The Address field as defined for SDLC is octet '0'.						

Figure 23. DTE and DCE DATA Packet: User Data Field Format

8.2.2.1 Q_Set_Mode - QSM

The Set_Mode command QLLU is transmitted by peer and primary link stations to place the link connection, as perceived by the link station in the adjacent node, in the LINK_OPENED state. No information field is permitted with the QSM command.

Upon receipt of the Set_Mode command QLLU peer and secondary QLLC link stations, authorized by the higher layers of SNA, transfer a UA response QLLU confirming acceptance of the QSM command and place the link connection in the LINK_OPENED state. Peer and primary QLLC link stations, having transferred a Set_Mode command QLLU place the link connection in the LINK_OPENED state upon receipt of the UA response QLLU from the peer or secondary QLLC link station in the adjacent node.

8.2.2.2 Q_Disconnect - QDISC

The Disconnect command QLLU is transferred by peer and primary QLLC link stations to place the link connection, as perceived by the peer or secondary QLLC link station in the adjacent node, in the LINK_CLOSED state. No information field is permitted with the QDISC command.

Upon receipt of the DISC command QLLU peer and secondary QLLC link stations, on link connections perceived to be in other than the LINK_CLOSED state, transfer a UA response QLLU confirming acceptance of the QDISC command and place the link connection in the LINK_CLOSED state. Link connections perceived to be in the LINK_CLOSING state, by peer and primary QLLC link stations, are placed in the LINK_CLOSED state upon receipt of a UA response QLLU by that QLLC link station.

8.2.2.3 Q_Exchange_Identification - QXID

The Exchange_Identification command QLLU may be issued by peer and primary QLLC link stations at any time to solicit identification information from the peer or secondary communicating link station in the adjacent node. The information field of the QXID command/response contains the transmitting link station's identification information.

Upon receipt of an XID command QLLU, peer and secondary QLLC link stations transfer the corresponding XID response QLLU as soon as the identification information is available.

8.2.2.4 Q_Test_Link - QTEST

The TEST command QLLU may be issued by peer and primary QLLC link stations at any time to solicit a TEST response QLLU from the peer or secondary QLLC link station in the adjacent node. The information field of the TEST command/response contains the test pattern data.

Upon receipt of a TEST command QLLU, peer and secondary QLLC link stations transfer the corresponding TEST response QLLU with the information field containing the test pattern data received in the QTEST command.

8.2.2.5 Q_Request_Disconnect - QRD

The Request_Disconnect response QLLU may be used by secondary QLLC link stations to request the primary QLLC link station to place the link connection as perceived by the secondary QLLC link station in the LINK_CLOSED state (i.e., initiate the link disconnection procedure by transferring a QDISC command across the link connection). As a result of receiving a DISCONTACT or similar request from a higher SNA level, secondary QLLC link stations may transfer a QRD response, when no other responses (such as acknowledgments for received DLLUs or responses to received Unnumbered commands) are pending and start Query Timer, Tq. Should Query Timer Tq expire prior to receipt of the requested QDISC command, the QRD response may be retransmitted up to Nq times. DLLUs received by the secondary QLLC link station after transmission of the QRD response and prior to receipt of the requested QDISC command are accepted and responded to in the normal way. No information field is permitted with the QRD response.

Upon receipt of a QRD response the primary QLLC link station will transfer a QDISC command when authorized by a higher levels of SNA.

8.2.2.6 Q_Unnumbered_Acknowledgment - QUA

The Unnumbered_Acknowledgment response QLLU is transferred by peer and secondary QLLC link stations in response to QSM or QDISC commands. No information field is permitted with the QUA response.

Upon receipt of the QUA response across a link connection perceived by a peer or primary QLLC link station to be in the LINK_OPENING state the receiving peer or primary QLLC link station places that link connection in the LINK_OPENED state. Upon receipt of the QUA response across a link connection perceived by a peer or primary QLLC link station to be in the LINK_CLOSING state the receiving peer or primary QLLC link station places that link connection in the LINK_CLOSED state.

8.2.2.7 Q_Receive_Ready - QRR

The Receive_Ready command QLLU may be transferred by peer and primary QLLC link stations to indicate that the link connection is in the LINK_OPENED state and the QLLC link stations are prepared to accept and respond to DLLUs.

8.2.2.8 Q_Disconnected_Mode - QDM

The Disconnected_Mode response QLLU may be transferred by peer and secondary QLLC link stations in response to QSM or QDISC commands. No information field is permitted with the QDM response.

Receipt of a QDM response informs the receiving peer or primary QLLC link station that the link connection, as perceived by the communicating QLLC link station in the adjacent node, is in the LINK_CLOSED state.

8.2.2.9 Q_Frame_Reject - QFRMR

The Frame_Reject response QLLU may be used by peer and secondary QLLC link stations to inform the communicating QLLC link station in the adjacent node of an error condition that is considered to be unrecoverable, at the LLC level, by retransmission of the identical LLU.

Upon receipt of a QFRMR response, peer and primary QLLC link stations cause a clearing
of the VC or a resetting of the PVC supporting the link connection and inform a higher
2 SNA level protocol of the failure. The format of the information field of the
2 Frame_Reject response QLLU is depicted in Figure 24.

I-field bits 1 2 ...... 7 8	9	10 11 12	13	14 15 16	17	18	19	20	21	22	23	24
Rejected LPDU Control Field	0	Vs	Note	Vr	W	X	Y	Z	0	0	0	0

2 • Rejected LPDU control field is the control field of the received LPDU that caused the frame reject.

2 • Vs is reserved and set to b'000'.

2 • Vr is reserved and set equal to b'000'.

2 • 'W=1' indicates that the control field received and returned in bits 1 through 8 was considered invalid or not implemented.

2 • 'X=1' indicates that the control field received and returned in bits 1 through 8 was considered invalid because the LPDU contained an information field which is not permitted or is an S or U-frame with incorrect length. 'W=1' in required in conjunction with this bit.

2 • 'Y=1' indicates that the information field received exceeded the maximum established capacity of the link station reporting the rejection condition.

2 • 'Z' is reserved and set equal to b'0'.

2 **Note:** Bit 13 is set to:

2 '1' if the LPDU rejected was a response; or,
2 '0' if the LPDU rejected was a command.

2 Figure 24. QFRMR: Information Field Format

8.2.3 Call User Data (CUD) Field Format

The format of the CUD field for CALL_REQUEST and INCOMING_CALL packets on SNA-to-SNA connections is illustrated in Figure 25.

Bits	8	7	6	5	4	3	2	1
Octet 0	Protocol Identifier							
	1	1	0	0	0	1	1	0
	ELLC							
	or							
	1	1	0	0	0	0	1	1
	QLLC							
	or							
	1	1	0	0	0	0	1	0
	PSH							
1	(Optional) Field Format Identifier (FFI)							
2	ELLC Call Control Indicator							
	x	x	x	x	x	x	x	I/R
3 • 15	Format Specific Field							

I/R = '0' for initial connection.
= '1' for connection recovery.
Note: Bits indicated as 'x' are reserved and should be set to 0's

Figure 25. CALL_USER_DATA Field Format: CALL_REQUEST and INCOMING_CALL Packets

8.2.3.1 Field_Format_Identifier (FFI)

The FFI is optional and when present, defines the format of the remainder of the CUD field. IBM SNA X.25 DTE implementations that use FFIs must make such use optional. IBM SNA X.25 DTEs that do not support FFIs must accept and ignore CUD fields of up to 15 octets in addition to the Protocol Identifier. Figure 26 on page II-95 illustrates the format of the CUD field for the only optional FFI currently defined, b'xxxxxxx1' where the bits denoted by 'x's, bits 8 thru 2, are reserved and set to zeroes.

Octet \ Bits	8	7	6	5	4	3	2	1
0	Protocol_Identifier							
	1	1	0	0	0	1	1	0
	ELLC							
	or							
	1	1	0	0	0	0	1	1
	QLLC							
	or							
	1	1	0	0	0	0	1	0
	PSH							
1	Field_Format_Identifier							
	x	x	x	x	x	x	x	1
2	ELLC_Call_Control_Indicator							
	x	x	x	x	x	x	x	I/R
3	Reserved							
	0	0	0	0	0	0	0	0
4 • 11	Connection_Identifier							

I/R = '0' for initial connection.
= '1' for connection recovery.
Note: Bits indicated as 'x' are reserved and should be set to 0's

Figure 26. CALL_USER_DATA Field Format: CALL_REQUEST and INCOMING_CALL Packets with Connection_Identifiers.

8.2.3.2 ELLC_Call_Control_Indicator - (ELLC_CCI)

The ELLC_CCI (bit 1 of octet 2) is used to distinguish between initial connection requests and connection recovery requests, while the remaining bits, denoted by 'x's in Figure 25 on page II-94 and Figure 26, are reserved and set to zero ('0's).

8.2.3.3 Connection_Identifier - (CI)

The CI is eight octets in length and permits IBM SNA X.25 DTEs to accept or reject incoming calls based on its content. The following rules apply to the use of the optional CI:

1. Some IBM SNA X.25 DTEs may not support the Connection_Identifier.

2. For IBM SNA X.25 DTEs that do support a Connection_Identifier, its use is optional on a per call basis at the discretion of the user.

3. IBM SNA X.25 DTEs that support Connection_Identifiers may reject incoming calls by transferring a CLEAR_REQUEST with the Diagnostic Code #236 (Connection Identifier Mismatch) when the Connection_Identifier does not compare with one that is expected.

8.3 DESCRIPTION OF THE QLLC PROCEDURES

Charts in "Balanced Link Stations" on page II-104, "Primary Link Stations" on page II-116 and "Secondary Link Stations" on page II-123 specify actions taken by balanced (PEER), primary and secondary QLLC link stations, respectively, as a result of events that occur, and LLC command and response LLUs received on link connection perceived to be in the various states.

8.3.1 Link Set-Up

8.3.1.1 Initiation - A1

Peer and primary QLLC link stations authorized by the higher levels of SNA, initiate link setup by transferring a Set_Mode command QLLU placing the link connection in the LINK_OPENING state. Some may also start LLC Query Timer (Tq).

8.3.1.2 Acknowledgment - A2

Upon receipt of a Set_Mode command QLLU, peer and secondary QLLC link stations authorized by the higher levels of SNA to enter the LINK_OPENED state transfer the corresponding UA response QLLU. Secondary QLLC link stations then place the link connection in the LINK_OPENED state.

Alternatively, some secondary QLLC link stations may set the link connection predicate condition to contact termination pending (CTp) and await receipt of a Receive_Ready (RR) command QLLU before placing the link connection in the LINK_OPENED state. Peer QLLC link stations maintain the link connection in the LINK_OPENING state until a UA response QLLU is received from the QLLC link station in the adjacent node.

8.3.1.3 Initiation_Retry - A3

Should Query Timer (Tq) expire prior to receipt of the UA response QLLU or a DM response QLLU to the transmitted Set_Mode command or a CLEAR/RESET, indicating that the peer or secondary QLLC link station in the adjacent node is not operational, peer and primary link stations may retransmit the Set_Mode command QLLU and restart Query Timer (Tq).

8.3.1.4 Failure - A4

After Nq retransmissions of the Set_Mode command QLLU, peer and primary QLLC link stations place the link connection in the INOPERATIVE state and report the condition to the higher levels of SNA.

8.3.1.5 Waiting - A5

Peer and primary QLLC link stations, that do not implement Query Timer, Tq, may wait for a UA response QLLU to the transmitted Set_Mode command, or a packet level reset, indicating remote DTE operational, on the virtual circuit supporting the link connection before taking any further action.

8.3.1.6 Completion - A6

Upon receipt of the UA response QLLU to a transmitted Set_Mode command QLLU, peer and primary QLLC link stations stop Query Timer, Tq, if it is running, place the link connection in the LINK_OPENED state and report the status of the link connection to the higher levels of SNA. Some peer and primary QLLC link stations may also transmit a link Receive_Ready (RR) command QLLU.

8.3.1.7 Alternative - A7

Alternatively, peer and primary QLLC link stations may transfer a Set_Mode command QLLU following receipt of a packet level RESET, indicating remote DTE operational, on the virtual circuit supporting the link connection. Some may also start Query Timer, Tq.

8.3.1.8 Rejection - A8

Peer and secondary QLLC link stations not authorized, by the higher levels of SNA, to set-up the link respond to received Set_Mode command QLLUs by transferring a DM response QLLU and maintain the link connection in the LINK_CLOSED state.

8.3.2 User Data Transfer

8.3.2.1 Data_Transfer - B1

Peer, primary and secondary QLLC link stations on link connections perceived to be in the LINK_OPENED state cooperate in the exchange of X.25 DATA packets with 'Q=0' in accordance with the procedures described in §-4.3.

8.3.2.2 Resetting - B2

QLLC link stations receiving a Set_Mode command QLLU or a DM response QLLU on a link connection perceived to be in the LINK_OPENED state cause a clearing of the VC or a resetting of the PVC supporting the link connection and report the status and reason for the change of status in the link connection to the higher levels of SNA.

8.3.3 Link Disconnection

8.3.3.1 Primary_Initiation - C1

During the LINK_OPENED state (information transfer phase), peer and primary QLLC link stations indicate link disconnection, as dictated by the higher levels of SNA, by transferring a Disconnect command QLLU across the link connection. Some may also start Query Timer, Tq.

8.3.3.2 Secondary_Initiation - C2

Secondary QLLC link stations indicate link disconnection, as dictated by the higher levels of SNA, by transferring a Request_Disconnect response QLLU, across the link connection. Some may also start QLLC Query Timer, Tq.

8.3.3.3 Acknowledgment - C3

Upon receipt of a DISC command QLLU, receiving peer and secondary QLLC link stations return a UA response QLLU, place the link connection in the LINK_CLOSED state and report the status of the link connection to the higher levels of SNA.

8.3.3.4 Primary_Response - C4

Upon receipt of an RD response QLLU, primary QLLC link stations inform the higher levels of SNA and transfer a DISC command QLLU across the link connection. Some may also start Query Timer, Tq.

8.3.3.5 Collision - C5

In the event of a collision of unlike QLLC commands, peer QLLC link stations transfer a DM response QLLU at the earliest opportunity, placing the link connection in the LINK_CLOSED state and report the status of the link connection to the higher levels of SNA.

8.3.4 Link Disconnected Phase

8.3.4.1 Reporting - D1

Peer and secondary QLLC link stations, having received a DISC command QLLU and returned a UA response QLLU; and, peer and primary QLLC link stations having received a QUA response to a transmitted DISC command QLLU, place the link connection in the LINK_CLOSED state and report the status of the link connection to the higher levels of SNA.

8.3.4.2 Activation - D2

Peer and primary QLLC link stations on link connections perceived to be in the LINK_CLOSED state may initiate the link set-up procedure as described in §-8.3.1 when authorized by the higher levels of SNA.

8.3.4.3 Connecting - D3

Peer and secondary QLLC link stations on link connections in the LINK_CLOSED state that are authorized by the higher levels of SNA react to the receipt of Set_Mode command QLLUs as described in §-8.3.1.

8.3.4.4 Response - D4

Peer and secondary QLLC link stations on link connections in the LINK_CLOSED state transfer a DM response QLLU upon receipt of DISC command QLLUs.

8.3.5 Link Identification Exchange

8.3.5.1 Initiate_ID_Exchange - E1

Peer and primary QLLC link stations may initiate the exchange of link identification information, in certain states, by transferring an XID command QLLU and starting Query Timer, Tq.

8.3.5.2 Complete_ID_Exchange - E2

Upon receipt of an XID command QLLU, peer and secondary QLLC link stations transfer an XID response QLLU when authorized by the higher levels of SNA.

8.3.6 Link Test

8.3.6.1 Initiate_Link_Test - F1

Peer and primary QLLC link stations may initiate the link test procedure, in certain states, by transferring a TEST command QLLU and starting Query Timer, Tq.

8.3.6.2 Complete_Link_Test - F2

Upon receipt of a TEST command QLLU, peer and secondary QLLC link stations transfer a TEST response QLLU as soon as authorized by the higher levels of SNA.

8.3.7 External Effects on Logical Link Control Procedures

Certain states and actions are dictated by SNA layers above or below QLLC and are as described as follows.

8.3.7.1 L3_Ready_Signal - G1

QLLC link stations become operational when the Packet Layer (level 3) interface signals the READY state.

8.3.7.2 Set-Up_Link - G2

QLLC link stations perform the link setup only when authorized by the higher levels of SNA.

8.3.7.3 Disconnect_Link - G3

QLLC link stations initiate the link disconnection procedure when authorized by the higher levels of SNA.

8.3.7.4 L3_Inoperative_Signal - G4

QLLC link stations become inoperative and inform the higher levels of SNA when the Packet Layer (level 3) interface signals the inoperative state.

8.3.7.5 XID_Function_Request - G5 — Obsolete

QLLC link stations initiate an exchange of link station identification information at the LLC level only at the request of the higher levels of SNA.

8.3.7.6 TEST_Function_Request - G6 — Obsolete

QLLC link stations initiate a procedure to test the link when authorized by the higher levels of SNA.

8.3.7.7 Exchange_Identification - G7

QLLC link stations transfer link station identification information command or response QLLUs as appropriate when authorized by the higher levels of SNA.

8.3.7.8 TEST_Link Connection - G8

QLLC link stations transfer link test command or response QLLUs as appropriate when authorized by the higher levels of SNA.

8.3.7.9 DATA_Transfer - G9

QLLC link stations cooperate with the higher levels of SNA to exchange BTUs over link connections perceived to be in the LINK_OPENED state.

8.4 STATE/ACTION CHART DESCRIPTION

Operation of the QLLC protocol for balanced, primary and secondary link stations is formalized by the charts contained in "State/Action Charts" on page II-104. Action(s) taken by link station(s) as a result of particular stimuli are shown at the intersection of the various link connection states and the stimulus. LLC stimuli include the events and command and response LLUs defined in §-8.4.1. QLLC link connection states include the predicate conditions defined in §-8.1.5 which are indicated under the heading 'P:' (if any) in the state/action charts.

Information contained at these intersections specify the action(s) taken, (denoted by two uppercase letters 'LL' or by a single uppercase letter concatenated with a number 'L#'), the LLU(s) to be transferred (if any), enclosed in brackets with any required parameters [LLU, parms] and the new state of the link connection to be entered (if any).

The LLU(s) to be transferred, [LLU], may be any of the LLC command or response LLUs depicted in Figure 23 on page II-91. In the event the LLU to be transferred causes a packet level clearing or resetting of the associated virtual circuit, an appropriate diagnostic code must be included (see Appendix F for DTE Generated Diagnostic codes used on SNA-to-SNA connections). When no LLU to be transferred, [LLU], is indicated, nothing is transferred across the link connection.

Applicable QLLC link connection state transitions are specified under the heading New State when the link connection is to be placed in a new state following the specified action and/or transfer of the LLU specified by [LLU]. Link connections remain in the current state when no new state to be entered is specified.

Alternative procedures, denoted by lower case letters 'l' or 'or' under the (ALT) heading, are specified where appropriate.

References to clarifying notes (denoted by '#n' (where 'n' is a decimal digit) under the (ALT) heading) is also provided at certain intersections, where deemed necessary, to explain extenuating circumstances considered essential to proper operation of the protocol, including:

1. An exchange of QLLC link station identification information is not required prior to link set-up.

2. The virtual call (switched virtual circuit) supporting the link connection is cleared (e.g., CLEAR_REQUEST or CLEAR_INDICATION) the underlying virtual circuit is terminated and the QLLC link connection placed in the INOPERATIVE state.

3. Combined QLLC link stations assume the characteristics of either a primary or secondary QLLC link station upon completion of XID role negotiation.

   Sample sequences derived from the QLLC State/Action charts are shown in Figure 27 on page II-134 as an example of how the tables may used.

8.4.1 QLLC Stimuli

QLLC protocol stimuli include the events, commands and responses described in the following paragraphs.

8.4.1.1 Events

L3RDY - Packet Layer (level 3) Ready: Represents a signal from the X.25 Packet Layer (level 3) that the underlying virtual circuit is in the READY (p4 or d1) state.

LSTRT - Link_Start: Represents higher level stimulus to initiate the LLC Set-Up procedure for the link connection.

LSTOP - Link_Stop: Represents higher level stimulus to initiate the LLC disconnection procedure for the link connection.

L3NOP - Level_3_Inoperative: Represents a signal from the Packet Layer (level 3) that the underlying virtual circuit is INOPERATIVE.

ERRPK - Erroneous_Packet: Represents receipt of an erroneous packet (e.g., a Q-packet containing an unidentifiable command/response, etc.) on the link connection.

XCHID - Exchange_Identification: Represents a higher level request for or authorization to transfer link identification information.

LTEST - Link_Test: Represents a higher level request for or authorization to transfer link test data.

SDATA - SEND_Data: Represents a higher level request for the transfer of unqualified user data to the packet layer (level 3) procedures.

CLRST - Virtual Circuit CLEAR/RESET: Represents a packet level clearing of the virtual call, or resetting of the virtual circuit, supporting the link connection.

LLTOX - Link_Timeout_Expiration: Represents expiration of link reply timeout, Timer Tq.

8.4.1.2 Commands Sent or Received

UDP - Unqualified_Data_Packet: Represents a DATA packet with the Qualifier 'Q' bit equal to zero.

QSM - Q_Set_Mode: Represents a Q_Packet containing a Set_Mode command QLLU (QSM) in the user data field.

QDC - Q_Disconnect (QDISC): Represents a Q_Packet containing a Disconnect command QLLU (QDISC) in the the user data field.

QXC - Q_Exchange_Identification (QXID): Represents a Q_Packet containing an Exchange_Identification command (QXID) in the user data field.

QTC - Q_Logical_Link_Test (QTEST): Represents a Q_Packet containing a Test command QLLU (QTEST) in the user data field.

QRR - Q_Receive-Ready: Represents a Q_Packet containing a Receive_Ready command QLLU (QRR) in the user data field.

8.4.1.3 Responses Sent and Received

QDM - Q_Disconnected_Mode: Represents a Q_Packet containing a Disconnected_Mode response QLLU (QDM) in the user data field.

QFR - Q_Frame_Reject (QFRMR): Represents a Q_Packet containing a Frame_Reject response QLLU (QFRMR) in the user data field.

QRD - Q_Request_Disconnect: Represents a Q_Packet containing a Request_Disconnect response QLLU (QRD) in the user data field.

QUA - Q_Unnumbered_Acknowledge: Represents a Q_Packet containing an Unnumbered_Acknowledge response QLLU (QUA) in the user data field.

QXR - Q_Exchange_Identification (QXID): Represents a Q_Packet containing an Exchange_Identification response QLLU (QXID), including link station identification information, in the user data field.

QTR - Q_Test (QTEST): Represents a Q_Packet containing a Link_Test response QLLU (QTEST), including test data, in the user data field.

QRR - Q_Receive-Ready: Represents a Q_Packet containing a Receive_Ready response QLLU (QRR) in the user data field.

C/R - CLEAR or RESET packet: Represents a clearing of the virtual call or a resetting of the permanent virtual circuit supporting the link connection by transmission/receipt of a CLEAR_REQUEST/CLEAR_INDICATION or RESET_REQUEST/RESET_INDICATION packet, respectively.

8.4.2 Actions

Actions taken by QLLC link stations, noted at the intersection of a state/condition/option and a stimulus, include those identified by a capital letter concatenated with a number 'L#' (which refer to the procedures specified in §-8.3) and those identified by two capital letters 'LL' defined as follows:

8.4.2.1 IC - Increment Retransmission Count

Increment the (re)-transmission count and, if the retry limit has not been exceeded, retry the protocol procedure. Otherwise, report the failing procedure to, and await further direction from, the higher levels of SNA.

8.4.2.2 IH - Inform Higher Layers

Inform the higher layer(s) of SNA via internal signalling mechanisms.

8.4.2.3 IP - Ignore Packet

Ignore the received packet.

8.4.2.4 IT - Initiate Query Timer, Tq

Initiate a logical link timeout for the duration of Query Timer, Tq.

8.4.2.5 LE - Local Procedure Error

Representing an internal signalling error or illogical protocol sequence on the part of the QLLC link station that may be either ignored or reported to a higher layer of SNA for future analysis.

8.4.2.6 NA - Not Applicable

Identifies events/actions/responses that cannot occur for a given state/condition/alternative.

8.4.2.7 NS - No Specific Action

No specific action is required by the QLLC link station protocol.

8.4.2.8 RE - Remote Procedure Error

Representing a protocol procedure error on the part of the QLLC link station in the adjacent node that may be either ignored or reported to a higher layer of SNA for future analysis.

8.4.2.9 RS - Report Status

Report the current status of the QLLC link station to a higher level of SNA.

8.4.2.10 TC - Terminate Contact

Terminate the SNA_CONTACT phase and signal CONTACTED to a higher level of SNA.

8.4.2.11 TT - Terminate Timer Tq

Terminate the LLC Query Timer, Tq.

8.5 STATE/ACTION CHARTS

8.5.1 Balanced Link Stations

8.5.1.1 Balanced INOPERATIVE State

CHART B1-E: EVENTS in INOPERATIVE State		
Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
L3RDY	G1, P=NUL	LINK_CLOSED
LSTRT	LE	
LSTOP	LE	
L3NOP	LE	
ERRPK	LE	
XCHID	LE	
LTEST	LE	
SDATA	LE	
CLRST	LE	
LLTOX	LE	

CHART B1-I: DLLUs in INOPERATIVE State		
Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
UDP	LE	

CHART B1-S: S-format QLLUs in INOPERATIVE State		
Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
QRR	LE	

CHART B1-U: U-format QLLUs in INOPERATIVE State		
Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
QSM	LE	
QDC	LE	
QUA	LE	
QRD	LE	
QDM	LE	
QFR	LE	
QXC	LE	
QXR	LE	
QTC	LE	
QTR	LE	

8.5.1.2 Balanced LINK_CLOSED State

CHART B2-E: EVENTS in LINK_CLOSED State

Stimuli	P:	(ALT)	Action(s)	[LLU Transfers]	New State
L3RDY			LE		
LSTRT	NUL	#1	A1, P=NUL	[QSM]	LINK_OPENING
	SMp		A1, P=NUL	[QSM]	LINK_OPENING
	ELSE		LE		
LSTOP			LE		
L3NOP			G4		INOPERATIVE
ERRPK			RE		
XCHID	NUL		G5, P=IXRp	[QXC]	
	OXRp		G7, P=SMp	[QXR]	
	IOXRp		G7, P=IXRp	[QXR]	
	OTRp		G5, P=IXOTRp	[QXC]	
	SMp		G5, P=IXRp	[QXC]	
	ELSE		LE		
LTEST	NUL		G6, P=ITRp	[QTC]	
	OXRp		G6, P=ITOXRp	[QTC]	
	OTRp		G8, P=NUL	[QTR]	
	IOTRp		G8, P=ITRp	[QTR]	
	IXOTRp		G8, P=IXRp	[QTR]	
	SMp		G6, P=ITRp	[QTC]	
	ELSE		LE		
SDATA			LE		
CLRST		#2	RE		
LLTOX	NUL		LE		
	ELSE		RS, P=NUL	[QDM]	

CHART B2-I: DLLUs in LINK_CLOSED State

Stimuli	P:	(ALT)	Action(s)	[LLU Transfers]	New State
UDP	NUL		IP		
	ELSE		RE, P=NUL	[C/R]	

CHART B2-S: S-format QLLUs in LINK_CLOSED State				
Stimuli P:	(ALT)	Action(s)	[LLU Transfers]	New State
QRR		IP		

CHART B2-U: U-format QLLUs in LINK_CLOSED State					
Stimuli	P: (ALT)		Action(s)	[LLU Transfers]	New State
QSM	NUL		A7	[QDM]	
	SMp		A2, P=NUL	(A2 QUA f°)	LINK_OPENED
		or	A2, P=CTp	(A2 QUA f°)	LINK_OPENING
	ELSE		RE, P=NUL	[C/R]	
QDC	NUL		D4	[QDM]	
	ELSE		RE, P=NUL	[C/R]	
QUA	NUL		IP		
	ELSE		RE, P=NUL	[C/R]	
QRD	NUL		RE	[C/R]	
	ELSE		RE, P=NUL	[C/R]	
QDM	NUL		IP		
	ELSE		RS, P=NUL		
QFR	NUL		IP		
	ELSE		RE, P=NUL	[C/R]	

CHART B2-U: U-format QLLUs in LINK_CLOSED State (Continued)					
Stimuli	P:	(ALT)	Action(s)	[LLU Transfers]	New State
QXC	NUL	#3	E2, P=OXRp		
	IXRp		E2, P=IOXRp		
	SMp		E2, P=OXRp		
	ELSE		RE, P=NUL	[C/R]	
QXR	NUL		IP		
	IXRp		RS, P=SMp		
	IOXRp		RE, P=OXRp		
	IXOTRp		IH, P=OTRp		
	ELSE		RE, P=NUL	[C/R]	
QTC	NUL		F2, P=OTRp		
	ITRp		F2, P=OTRp		
	SMp		F2, P=OTRp		
	ELSE		RE, P=NUL	[C/R]	
QTR	NUL		IP		
	ITRp		RS, P=NUL		
	OTRp		IP		
	IOTRp		RS, P=OTRp		
	ITOXRp		IH, P=OXRp		
	ELSE		RE, P=NUL	[C/R]	

8.5.1.3 Balanced LINK_OPENING State

CHART B3-E: EVENTS in LINK_OPENING State

Stimuli	P:	(ALT)	Action(s)	[LLU Transfers]	New State
L3RDY			LE		
	OXRp		RS, P=NUL		LINK_CLOSED
	OTRp		RS, P=NUL		LINK_CLOSED
LSTRT			LE		
	RRp		RS		
LSTOP			G3	[QDC]	LINK_CLOSING
	OXRp		LE		
	OTRp		LE		
L3NOP			G4		INOPERATIVE
ERRPK			RE		
	OXRp		RE, P=NUL	[QFR]	LINK_RECOVERY
		or	RS, P=NUL	[C/R]	LINK_CLOSED
	OTRp		RE, P=NUL	[QFR]	LINK_RECOVERY
		or	RS, P=NUL	[C/R]	LINK_CLOSED
XCHID			LE		
	OXRp		RS, P=NUL	[QXR]	
	OTRp		G5, P=IXOTRp	[QXC]	LINK_CLOSED
LTEST			LE		
	OTRp		RS, P=NUL	[QTR]	
	OXRp		G6, P=ITOXRp	[QTC]	LINK_CLOSED
SDATA			LE		
CLRST		#2	A4, P=RRp		
		or	RS		LINK_CLOSED
	RRp	#2	A6, P=NUL	[QSM]	
	OXRp	#2	RS		
	OTRp	#2	RS		
LLTOX			A3	[QSM]	
	RRp		LE		
	OXRp		LE		
	OTRp		LE		

CHART B3-I: DLLUs in LINK_OPENING State		
Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
UDP	IP	

CHART B3-S: S-format QLLUs in LINK_OPENING State		
Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
QRR	IP	

CHART B3-U: U-format QLLUs in LINK_OPENING State		
Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
QSM	A2 [QUA]	
OXRp	RE, P=NUL [C/R]	LINK_CLOSED
OTRp	RE, P=NUL [C/R]	LINK_CLOSED
QDC	C5 [QDM]	LINK_CLOSED
RRp	C5 [QDM]	
OXRp	RE, P=NUL [C/R]	LINK_CLOSED
OTRp	RE, P=NUL [C/R]	LINK_CLOSED
QUA	A5	LINK_OPENED
OXRp	RE, P=NUL [C/R]	LINK_CLOSED
OTRp	RE, P=NUL [C/R]	LINK_CLOSED
QRD	RE [C/R]	LINK_CLOSED
QDM	RS	LINK_CLOSED
RRp	IP	
OXRp	RS	
OTRp	RS	
QFR	IP	
OXRp	RS, P=NUL [QSM]	
OTRp	RS, P=NUL [QSM]	
QXC	IP	
OXRp	RE, P=NUL [C/R]	LINK_CLOSED
OTRp	RE, P=NUL [C/R]	LINK_CLOSED
QXR	IP	
OTRp	RE, P=NUL [C/R]	LINK_CLOSED
QTC	IP	

8.5.1.4 Balanced LINK_CLOSING State

CHART B4-E: EVENTS in LINK_CLOSING State

Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
L3RDY	LE	LINK_CLOSED
LSTRT	LE	
LSTOP	LE	
L3NOP	G4	INOPERATIVE
ERRPK	RS	
XCHID	LE	
LTEST	LE	
SDATA	LE	
CLRST	RS	INOPERATIVE
LLTOX	LE	

CHART B4-I: DLLUs in LINK_CLOSING State

Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
UDP	IP	

CHART B4-S: S-format QLLUs in LINK_CLOSING State

Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
QRR	IP	

CHART B4-U: U-format QLLUs in LINK_CLOSING State		
Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
QSM	IP	
QDC	IP	
QUA	C3	LINK_CLOSED
QRD	RE [C/R]	LINK_CLOSED
QDM	C3	LINK_CLOSED
QFR	IP	
QXC	IP	
QXR	IP	
QTC	IP	
QTR	IP	
OXRp	RE, P=NUL [C/R]	LINK_CLOSED

8.5.1.5 Balanced LINK_RECOVERY State

CHART B5-E: EVENTS in LINK_RECOVERY State		
Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
L3RDY	RS	LINK_CLOSED
LSTRT	G2 [QSM]	LINK_OPENING
LSTOP	G3 [QDC]	LINK_CLOSING
L3NOP	G4	INOPERATIVE
ERRPK	RE	
or	RS [QFR]	LINK_CLOSED
XCHID	LE	
LTEST	LE	
SDATA	LE	
CLRST	RS	INOPERATIVE
LLTOX	LE	

CHART B5-I: DLLUs in LINK_RECOVERY State		
Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
UDP	RE	LINK_CLOSED

CHART B5-S: S-format QLLUs in LINK_RECOVERY State

Stimuli P: (ALT)	Action(s)	[LLU Transfers]	New State
QRR	IP		

CHART B5-U: U-format QLLUs in LINK_RECOVERY State

Stimuli P: (ALT)	Action(s)	[LLU Transfers]	New State
QSM	RS	[QDM]	LINK_CLOSED
QDC	RS	[QUA]	LINK_CLOSED
QUA	RE	[C/R]	LINK_CLOSED
QRD	RE	[C/R]	LINK_CLOSED
QDM	RE	[C/R]	LINK_CLOSED
QFR	RE	[C/R]	LINK_CLOSED
QXC	RE	[C/R]	LINK_CLOSED
QXR	RE	[C/R]	LINK_CLOSED
QTC	RE		LINK_CLOSED
QTR	RE	[C/R]	LINK_CLOSED

8.5.1.6 Balanced LINK_OPENED State

CHART B6-E: EVENTS in LINK_OPENED State				
Stimuli P: (ALT)		Action(s)	[LLU Transfers]	New State
L3RDY		RS		LINK_CLOSED
LSTRT		LE		
LSTOP		G3	[QDC]	LINK_CLOSING
L3NOP		G4		INOPERATIVE
ERRPK		RE	[QFR]	LINK_RECOVERY
XCHID	NUL	G5, P=IXRp	[QXC]	
	OXRp	G7, P=NUL	[QXR]	
	OTRp	G5, P=IXOTRp	[QXC]	
	ITOXRp	G7, P=ITRp	[QXR]	
	ELSE	LE		
LTEST	NUL	G6, P=ITRp	[QTC]	
	OXRp	G6, P=ITOXRp	[QTC]	
	OTRp	G8, P=NUL	[QTR]	
	IXOTRp	G8, P=IXRp	[QTR]	
	ELSE	LE		
SDATA		G9	[UDP]	
	P≠NUL	LE		
	or	G9	[UDP]	
CLRST		RS		INOPERATIVE
LLTOX		IC		

CHART B6-I: DLLUs in LINK_OPENED State			
Stimuli P: (ALT)	Action(s)	[LLU Transfers]	New State
UDP	B1		

CHART B6-S: S-format QLLUs in LINK_OPENED State			
Stimuli P: (ALT)	Action(s)	[LLU Transfers]	New State
QRR	IP		

CHART B6-U: U-format QLLUs in LINK_OPENED State

Stimuli	P: (ALT)	Action(s)	[LLU Transfers]	New State
QSM		RE	[C/R]	
QDC		C3	[QUA]	LINK_CLOSED
QUA		RE, P=NUL	[C/R]	LINK_CLOSED
QRD		NA		
QDM		RE	[C/R]	LINK_CLOSED
QFR		RE, P=NUL	[C/R]	LINK_CLOSED
QXC	NUL	E2, P=OXRp		
	IXRp	E2, P=IOXRp		
	OXRp	RE, P=NUL		LINK_CLOSED
	IOXRp	RE, P=NUL		LINK_CLOSED
	ITRp	IH, P=ITOXRp		LINK_CLOSED
	ELSE	RE, P=NUL	[C/R]	LINK_CLOSED
QXR		RE	[C/R]	LINK_CLOSED
	IXRp	TT, P=NUL		
	IOXRp	TT, P=OXRp		
	IXOTRp	IH, P=OTRp		
QTC	NUL	F2, P=ITRp		
	IXRp	IH		
	ITRp	F2, P=IOTRp		
	ELSE	RE, P=NUL	[C/R]	LINK_CLOSED
QTR		RE	[C/R]	LINK_CLOSED
	ITRp	TT, P=NUL		
	ITOXRp	IH, P=OXRp		

8.5.2 Primary Link Stations

8.5.2.1 Primary INOPERATIVE State

CHART P1-E: EVENTS in INOPERATIVE State		
Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
L3RDY	G1, P=NUL	LINK_CLOSED
LSTRT	LE	
LSTOP	LE	
L3NOP	LE	
ERRPK	LE	
XCHID	LE	
LTEST	LE	
SDATA	LE	
CLRST	LE	
LLTOX	LE	

CHART P1-I: DLLUs in INOPERATIVE State		
Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
UDP	LE	

CHART P1-S: S-format QLLUs in INOPERATIVE State		
Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
QRR	LE	

CHART P1-U: U-format QLLUs in INOPERATIVE State		
Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
QSM	LE	
QDC	LE	
QUA	LE	
QRD	LE	
QDM	LE	
QFR	LE	
QXC	LE	
QXR	LE	
QTC	LE	
QTR	LE	

8.5.2.2 Primary LINK_CLOSED State

CHART P2-E: EVENTS in LINK_CLOSED State		
Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
L3RDY	LE	
LSTRT	LE	
#1	A1, P=NUL [QSM]	LINK_OPENING
LSTOP	LE	
L3NOP	G4	INOPERATIVE
ERRPK	RE, P=NUL	
XCHID	G5, P=IXRp [QXC]	
IXRp	LE	
ITRp	LE	
LTEST	G6, P=ITRp [QTC]	
IXRp	LE	
ITRp	LE	
SDATA	LE	
CLRST #2	RE	
LLTOX	LE	

CHART P2-I: DLLUs in LINK_CLOSED State

Stimuli	P: (ALT)	Action(s)	[LLU Transfers]	New State
UDP		RE	[C/R]	
	IXRp	RE, P=NUL	[C/R]	
	ITRp	RE, P=NUL	[C/R]	

CHART P2-S: S-format QLLUs in LINK_CLOSED State

Stimuli	P: (ALT)	Action(s)	[LLU Transfers]	New State
QRR		IP		

CHART P2-U: U-format QLLUs in LINK_CLOSED State

Stimuli	P: (ALT)	Action(s)	[LLU Transfers]	New State
QSM		RE, P=NUL	[C/R]	
QDC		RE, P=NUL	[C/R]	
QUA		IP		
QRD		C4	[QDC]	
QDM		IP, P=NUL		
QFR		RE	[C/R]	
QXC		RE	[C/R]	
QXR	IXRp	G7, P=NUL		
	ELSE	RE, P=NUL	[C/R]	
QTC		RE	[C/R]	
QTR	ITRp	G8, P=NUL		
	ELSE	RE, P=NUL	[C/R]	

8.5.2.3 Primary LINK_OPENING State

CHART P3-E: EVENTS in LINK_OPENING State			
Stimuli P: (ALT)	**Action(s)**	**[LLU Transfers]**	**New State**
L3RDY	RS		LINK_CLOSED
LSTRT	LE		
LSTOP	LE		
L3NOP	G4		INOPERATIVE
ERRPK	RE	[QFR]	LINK_CLOSED
XCHID	LE		
LTEST	LE		
SDATA	LE		
CLRST #2	A4, P=RRp		
or	RS		LINK_CLOSED
RRp #2	A6, P=NUL		INOPERATIVE
LLTOX	IC	[QSM]	
RRp	LE		

CHART P3-I: DLLUs in LINK_OPENING State			
Stimuli P: (ALT)	**Action(s)**	**[LLU Transfers]**	**New State**
UDP	RE	[C/R]	LINK_CLOSED
RRp	LE		

CHART P3-S: S-format QLLUs in LINK_OPENING State			
Stimuli P: (ALT)	**Action(s)**	**[LLU Transfers]**	**New State**
QRR	IP		

CHART P3-U: U-format QLLUs in LINK_OPENING State			
Stimuli P: (ALT)	Action(s)	[LLU Transfers]	New State
QSM	RE	[C/R]	LINK_CLOSED
QDC	RE	[C/R]	LINK_CLOSED
QUA	A5		LINK_OPENED
or	A5	[QRR]	LINK_OPENED
QRD	RS		
QDM	RS		LINK_CLOSED
QFR	RS	[QSM]	
QXC	RE	[C/R]	LINK_CLOSED
QXR	RE	[C/R]	LINK_CLOSED
QTC	RE	[C/R]	LINK_CLOSED
QTR	RE	[C/R]	LINK_CLOSED

8.5.2.4 Primary LINK_CLOSING State

CHART P4-E: EVENTS in LINK_CLOSING State			
Stimuli P: (ALT)	Action(s)	[LLU Transfers]	New State
L3RDY	LE		LINK_CLOSED
LSTRT	LE		
LSTOP	LE		
L3NOP	G4		INOPERATIVE
ERRPK	RE	[QFR]	LINK_CLOSED
XCHID	LE		
LTEST	LE		
SDATA	LE		
CLRST	RS		LINK_CLOSED
LLTOX	IC	[QDC]	

CHART P4-I: DLLUs in LINK_CLOSING State			
Stimuli P: (ALT)	Action(s)	[LLU Transfers]	New State
UDP	IP		

CHART P4-S: S-format QLLUs in LINK_CLOSING State			
Stimuli P: (ALT)	Action(s)	[LLU Transfers]	New State
QRR	IP		

CHART P4-U: U-format QLLUs in LINK_CLOSING State			
Stimuli P: (ALT)	Action(s)	[LLU Transfers]	New State
QSM	RE	[C/R]	LINK_CLOSED
QDC	RE	[C/R]	LINK_CLOSED
QUA	D2		LINK_CLOSED
QRD	RS		
QDM	RS		LINK_CLOSED
QFR	RS	[C/R]	LINK_CLOSED
QXC	RE	[C/R]	LINK_CLOSED
QXR	RE	[C/R]	LINK_CLOSED
QTC	RE	[C/R]	LINK_CLOSED
QTR	RE	[C/R]	LINK_CLOSED

8.5.2.5 Primary LINK_RECOVERY State

LINK_RECOVERY state is Not Applicable to Primary QLLC link stations.

8.5.2.6 Primary LINK_OPENED State

CHART P6-E: EVENTS in LINK_OPENED State			
Stimuli P: (ALT)	Action(s)	[LLU Transfers]	New State
L3RDY	RS		LINK_CLOSED
LSTRT	LE		
LSTOP	C1	[QDC]	LINK_CLOSING
L3NOP	G4		INOPERATIVE
ERRPK	RE	[QFR]	LINK_CLOSED
XCHID	E1, P=IXRp	[QXC]	
IXRp	LE		
ITRp	LE		
LTEST	F1, P=ITRp	[QTC]	
IXRp	LE		
ITRp	LE		
SDATA NUL	G9	[UDP]	
ELSE	LE		
CLRST	RS		LINK_CLOSED
LLTOX	LE		

CHART P6-I: DLLUs in LINK_OPENED State			
Stimuli P: (ALT)	**Action(s)**	**[LLU Transfers]**	**New State**
UDP	B1		

CHART P6-S: S-format QLLUs in LINK_OPENED State			
Stimuli P: (ALT)	**Action(s)**	**[LLU Transfers]**	**New State**
QRR	IP		

CHART P6-U: U-format QLLUs in LINK_OPENED State			
Stimuli P: (ALT)	**Action(s)**	**[LLU Transfers]**	**New State**
QSM	RE	[C/R]	
QDC IXRp	RE, P=NUL	[C/R]	LINK_CLOSED
QUA	RE, P=NUL	[C/R]	LINK_CLOSED
QRD	C1, P=NUL	[QDC]	LINK_CLOSING
IXR	RS		
ITR	RS		
QDM	B2, P=NUL	[C/R]	LINK_CLOSED
QFR	RS, P=NUL	[C/R]	LINK_CLOSED
QXC IXRp	RE, P=NUL	[C/R]	LINK_CLOSED
QXR	RE	[C/R]	LINK_CLOSED
IXRp	G7, P=NUL		
QTC IXRp	RE, P=NUL	[C/R]	LINK_CLOSED
QTR	RE	[C/R]	LINK_CLOSED
ITRp	G8, P=NUL		

8.5.3 Secondary Link Stations

8.5.3.1 Secondary INOPERATIVE State

CHART S1-E: EVENTS in INOPERATIVE State		
Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
L3RDY	G1, P=NUL	LINK_CLOSED
LSTRT	LE	
LSTOP	LE	
L3NOP	LE	
ERRPK	LE	
XCHID	LE	
LTEST	LE	
SDATA	LE	
CLRST	LE	
LLTOX	NA	

CHART S1-I: DLLUs in INOPERATIVE State		
Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
UDP	LE	

CHART S1-S: S-format QLLUs in INOPERATIVE State		
Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
QRR	LE	

CHART S1-U: U-format QLLUs in INOPERATIVE State		
Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
QSM	LE	
QDC	LE	
QUA	LE	
QRD	LE	
QDM	LE	
QFR	LE	
QXC	LE	
QXR	LE	
QTC	LE	
QTR	LE	

8.5.3.2 Secondary LINK_CLOSED State

CHART S2-E: EVENTS in LINK_CLOSED State		
Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
L3RDY	LE	
LSTRT	G2	LINK_OPENING
LSTOP	LE	
L3NOP	G4	INOPERATIVE
ERRPK	RE, P=NUL	
XCHID	LE	
OXRp	G7, P=NUL [QXR]	
LTEST	LE	
OTRp	G8, P=NUL [QTR]	
SDATA	LE	
CLRST #2	RE	
OXRp	RE, P=NUL	
OTRp	RE, P=NUL	
LLTOX	IC	
or	NA	

CHART S2-I: DLLUs in LINK_CLOSED State		
Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
UDP	IP	

CHART S2-S: S-format QLLUs in LINK_CLOSED State				
Stimuli	P: (ALT)	Action(s)	[LLU Transfers]	New State
QRR		IP		

CHART S2-U: U-format QLLUs in LINK_CLOSED State				
Stimuli	P: (ALT)	Action(s)	[LLU Transfers]	New State
QSM		A8	[QDM]	
	OXRp	RE, P=NUL	[C/R]	
	OTRp	RE, P=NUL	[C/R]	
QDC		D4	[QDM]	
QUA	OXRp	RE, P=NUL	[C/R]	
QRD		NA		
QDM		NA		
QFR		RE, P=NUL	[C/R	
QXC	#3	E2, P=OXRp		
	OXRp	RE, P=NUL	[C/R]	
	OTRp	RE, P=NUL	[C/R]	
QXR		NA		
QTC		F2, P=OTRp		
	or	IH	[QTR]	
	OXRp	RE, P=NUL	[C/R]	
	or	IP		
	OTRp	RE, P=NUL	[C/R]	
QTR		NA		

8.5.3.3 Secondary LINK_OPENING State

CHART S3-E: EVENTS in LINK_OPENING State		
Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
L3RDY	LE	LINK_CLOSED
LSTRT	RS	
LSTOP	A8	LINK_CLOSED
L3NOP	RS	INOPERATIVE
ERRPK	RS [QFR]	LINK_RECOVERY
or	RE [QFR]	LINK_CLOSED
XCHID	LE	
OXRp	E2, P=NUL [QXR]	
LTEST	LE	
OTRp	F2, P=NUL [QTR]	
SDATA	LE	
CLRST	RS	LINK_CLOSED
LLTOX	NA	
CTp	RS, P=NUL [QDM]	LINK_CLOSED
OXRp	RS, P=NUL [QDM]	LINK_CLOSED
OTRp	RS, P=NUL [QDM]	LINK_CLOSED

CHART S3-I: DLLUs in LINK_OPENING State		
Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
UDP or	RE [C/R] RE	LINK_CLOSED
CTp	RE, P=NUL [C/R]	LINK_CLOSED

CHART S3-S: S-format QLLUs in LINK_OPENING State		
Stimuli P: (ALT)	Action(s) [LLU Transfers]	New State
QRR	IP	
CTp	TC, P=NUL	LINK_OPENED

CHART S3-U: U-format QLLUs in LINK_OPENING State			
Stimuli P: (ALT)	Action(s)	[LLU Transfers]	New State
QSM	A2	[QUA]	LINK_OPENED
or	A2, P=CTp	[QUA]	
QDC	RS	[QDM]	LINK_CLOSED
QUA	NA		
QRD	NA		
QDM	NA		
QFR	RE	[C/R]	LINK_RECOVERY
or	RE	[C/R]	LINK_CLOSED
QXC	E2, P=OXRp		
or	RE	[C/R]	LINK_CLOSED
QXR	NA		
QTC	F2, P=OTRp		
or	RE	[C/R]	LINK_CLOSED
QTR	NA		

8.5.3.4 Secondary LINK_CLOSING State

CHART S4-E: EVENTS in LINK_CLOSING State			
Stimuli P: (ALT)	Action(s)	[LLU Transfers]	New State
L3RDY	LE		LINK_CLOSED
LSTRT	LE		LINK_CLOSED
LSTOP	LE		
L3NOP	RS		INOPERATIVE
ERRPK	RS	[QFR]	LINK_RECOVERY
or	RS	[QFR]	LINK_CLOSED
XCHID	LE		
OXRp	G7, P=NUL	[QXR]	
LTEST	LE		
OTRp	G8, P=NUL	[QTR]	
SDATA	LE		
CLRST	RS		LINK_CLOSED
LLTOX	NA		

CHART S4-I: DLLUs in LINK_CLOSING State			
Stimuli P: (ALT)	Action(s)	[LLU Transfers]	New State
UDP	B2		

CHART S4-S: S-format QLLUs in LINK_CLOSING State			
Stimuli P: (ALT)	Action(s)	[LLU Transfers]	New State
QRR	IP		

CHART S4-U: U-format QLLUs in LINK_CLOSING State			
Stimuli P: (ALT)	Action(s)	[LLU Transfers]	New State
QSM	RE	[C/R]	LINK_CLOSED
QDC	RS	[QUA]	LINK_CLOSED
QUA	NA		
QRD	NA		
QDM	NA		
QFR	NA		
QXC	RE	[C/R]	LINK_CLOSED
QXR	NA		
QTC	RE	[C/R]	LINK_CLOSED
QTR	NA		

8.5.3.5 Secondary LINK_RECOVERY State

CHART S5-E: EVENTS in LINK_RECOVERY State			
Stimuli P: (ALT)	Action(s)	[LLU Transfers]	New State
L3RDY	RS		LINK_CLOSED
LSTRT	–		LINK_OPENING
LSTOP	G3	[QRD]	LINK_CLOSING
L3NOP	RS		INOPERATIVE
ERRPK	RS	[QFR]	
or	RS	[QFR]	LINK_CLOSED
XCHID	LE		
0XRp	G7, P=NUL	[QXR]	
LTEST	LE		
0TRp	G8, P=NUL	[QTR]	
SDATA	LE		
CLRST	RS		LINK_CLOSED
LLTOX	NA		

CHART S5-I: DLLUs in LINK_RECOVERY State			
Stimuli P: (ALT)	Action(s)	[LLU Transfers]	New State
UDP	RE		LINK_CLOSED

CHART S5-S: S-format QLLUs in LINK_RECOVERY State			
Stimuli P: (ALT)	Action(s)	[LLU Transfers]	New State
QRR	IP		

CHART S5-U: U-format QLLUs in LINK_RECOVERY State			
Stimuli P: (ALT)	Action(s)	[LLU Transfers]	New State
QSM	RS	[QDM]	LINK_CLOSED
QDC	RS	[QUA]	LINK_CLOSED
QUA	NA		
QRD	NA		
QDM	NA		
QFR	NA		
QXC	RE	[C/R]	LINK_CLOSED
QXR	NA		
QTC	RE	[C/R]	LINK_CLOSED
QTR	NA		

8.5.3.6 Secondary LINK_OPENED State

CHART S6-E: EVENTS in LINK_OPENED State				
Stimuli	P: (ALT)	Action(s)	[LLU Transfers]	New State
L3RDY		IH		LINK_CLOSED
LSTRT		RS		
LSTOP		G3	[QRD]	LINK_CLOSING
	OXRp	G3, P=NUL	[QRD]	LINK_CLOSING
	OTRp	G3, P=NUL	[QRD]	LINK_CLOSING
L3NOP		RS		INOPERATIVE
	OXRp	RS, P=NUL		INOPERATIVE
	OTRp	RS, P=NUL		INOPERATIVE
ERRPK		RS	[QFR]	LINK_RECOVERY
	or	RS	[QFR]	LINK_CLOSED
	OXRp	RS, P=NUL	[QFR]	LINK_RECOVERY
	or	RS, P=NUL	[QFR]	LINK_CLOSED
	OTRp	RS, P=NUL	[QFR]	LINK_RECOVERY
	or	RS, P=NUL	[QFR]	LINK_CLOSED
XCHID		LE		
	OXRp	G7, P=NUL	[QXR]	
LTEST		LE		
	OTRp	G8, P=NUL	[QTR]	
SDATA	NUL	G9	[UDP]	
	OXRp	G9	[UDP]	
	OTRp	G9	[UDP]	
	ELSE	LE		
CLRST		RS		LINK_CLOSED
	OXRp	RS, P=NUL		LINK_CLOSED
	OTRp	RS, P=NUL		LINK_CLOSED
LLTOX		NA		

CHART S6-I: DLLUs in LINK_OPENED State			
Stimuli P: (ALT)	**Action(s)**	**[LLU Transfers]**	**New State**
UDP	B1		
OXRp	RE, P=NUL	[C/R]	LINK_CLOSED
or	B1		
OTRp	RE, P=NUL	[C/R]	LINK_CLOSED

CHART S6-S: S-format QLLUs in LINK_OPENED State			
Stimuli P: (ALT)	**Action(s)**	**[LLU Transfers]**	**New State**
QRR	IP		

CHART S6-U: U-format QLLUs in LINK_OPENED State			
Stimuli P: (ALT)	**Action(s)**	**[LLU Transfers]**	**New State**
QSM	RE	[C/R]	LINK_CLOSED
QDC	C3	[QUA]	LINK_CLOSED
QUA	NA		
QRD	NA		
QDM	NA		
QFR	NA		
QXC	E2, P=OXRp		
OXRp	RE, P=NUL	[C/R]	LINK_CLOSED
OTRp	RE, P=NUL	[C/R]	LINK_CLOSED
QXR	NA		
QTC	F2, P=OTRp		
or	F2	[QTR]	
OXRp	RE, P=NUL	[C/R]	LINK_CLOSED
OTRp	RE, P=NUL	[C/R]	LINK_CLOSED
QTR	NA		

8.6 SAMPLE QLLC SEQUENCES

QLLC sequences for "typical" error free peer-to-peer, link activation, initialization, data transfer, disconnection and deactivation derived from the charts in "Balanced Link Stations" on page II-104 and depicted in Figure 27 on page II-134 are described as follows.

1. QLLC link stations, upon recognition of a transition of the supporting logical channel (virtual call or permanent virtual circuit) to the READY state (L3RDY event), become operative (G1), signal adapter enabled (EABLD) to the upper layer(s) of SNA and place the underlying link connection in the LINK_CLOSED state.

2. An SNA_CONTACT results in the upper layer(s) of SNA requesting an exchange of link station identification information (XIDFR) causing the QLLC link station to initiate an exchange of link station identification information (G5) by transferring an Exchange_Identification command QLLU (QXC) and set P=IXRp (incoming link station identification information pending).

   QLLC link stations, upon receipt of the QXID command [QXC] in the LINK_CLOSED state inform a higher layer of SNA (IH), passing the link station identification information contained in the information field of the received QLLU (DATA), sets P=OXRp (outgoing link identification information pending) and may start Query Timer Tq.

3. QLLC link stations in adjacent nodes with P=OXRp (outgoing identification information pending), when authorized by the upper layer(s) of SNA (XRSPR), respond to the received QXID command (G7) by transferring a QXID response [QXR] containing their link station identification information in the information field, set P=SMp (link set mode pending) and stop the Query Timer, Tq, if it is running.

   QLLC link stations with P=IXRp (incoming link identification information pending), upon receipt of the QXID response [QXR] inform the upper layer(s) of SNA (IH) passing the identification information contained in the information field of the received QLLU (DATA) and set P=SMp (link set mode pending).

   When authorized by the upper layer(s) of SNA (LSTRT) QLLC link stations with P=SMp (link set mode pending) initiate the link setup procedure (A1) by transferring a Set_Mode command QLLU, set P=NUL, place the underlying link connection in the LINK_OPENING state and may initiate a timeout for the duration of Query Timer, Tq.

   Upon receipt of the Set_Mode command QLLU (QSM), QLLC link stations with P=SMp (link set mode pending), respond to the received QSM command (A2) by transferring an Unnumbered_Acknowledge response QLLU [QUA], set P=CTp and place the link connection in the LINK_OPENING state.

   Upon receipt of the QUA response, QLLC link stations on connections perceived to be in the LINK_OPENING state with P=SMp (link set mode pending), inform the upper layer(s) of SNA (IH) by signalling CONTACTED, transfer a Receive_Ready command QLLU (QRR) informing the communicating link station in the adjacent node to terminate the CONTACT phase, set P=NUL, place the link connection in the LINK_OPENED state and stop the Query Timer, Tq, if it is running.

   Upon receipt of a QRR command, QLLC link stations in adjacent nodes on connections perceived to be in the LINK_OPENING state with P=CTp, inform the higher layer(s) of SNA (IH), set P=NUL and place the link connection in the LINK_OPENED state.

4. QLLC link stations on connections in the LINK_OPENED state with P=NUL exchange [DLLU]s on behalf of the upper layer(s) of SNA as requested (DTRFR(DATA)) via the logical channel (virtual call or permanent virtual circuit) supporting the link connection and respond to QLLUs and internal stimuli as previously specified in §-8.0.

5. An SNA DISCONTACT results in the upper layer(s) of SNA requesting a link termination (LSTOP) causing QLLC link stations to initiate a link disconnection procedure (G3) by transferring a Disconnect command QLLU [QDC] placing the link connection in the LINK_CLOSED state.

   Upon receipt of a QDISC command (QDC), QLLC link stations on connections perceived to be in the LINK_OPENED state with P=NUL, inform the higher layers of SNA (IH) by signalling INOP_LNK, respond to the received QDISC command (C3) by transferring a QUA response and place the underlying link connection in the LINK_CLOSED state.

Upon receipt of a QUA response on a link connection perceived to be in the LINK_CLOSING state, QLLC link stations on connections with P=NUL, inform the higher layer(s) of SNA (IH) by signalling +RSP and place the underlying link connection in the LINK_CLOSED state.

6. Upon receipt of a signal from the Packet Layer (Level 3) that the supporting logical channel (virtual call or permanent virtual circuit) is in the INOPERATIVE state (L3NOP) QLLC link stations place the associated link connection in the INOPERATIVE state and report this status (RS) to the higher layer(s) of SNA by signalling adapter disabled (DABLD).

   In Figure 27 on page II-134:

   a. Time progresses from top to bottom of the figure.

   b. The various layers at the origin and destination DTEs are represented by vertical lines.

   c. QLLC link station states are represented by their abbreviated names in the vertical line representing the logical link control (LLC) layer.

   d. Signal and data flows are represented by horizontal lines with arrowheads denoting the direction of flow.

   e. External stimuli are represented by labels above the origin end of the flow lines and numbers enclosed in brackets [#] as described above.

   f. QLLC actions and state transitions are shown above the origin end of the flow lines and the resulting command/response/signal transferred is shown below the arrowhead denoting direction of flow; and,

      - DABLD - represents an Adapter Disabled Signal.
      - EABLD - represents an Adapter Enabled Signal.
      - ULSNA - represents the Upper Layer(s) of SNA.
      - X25PL - represents the Packet Layer of X.25.

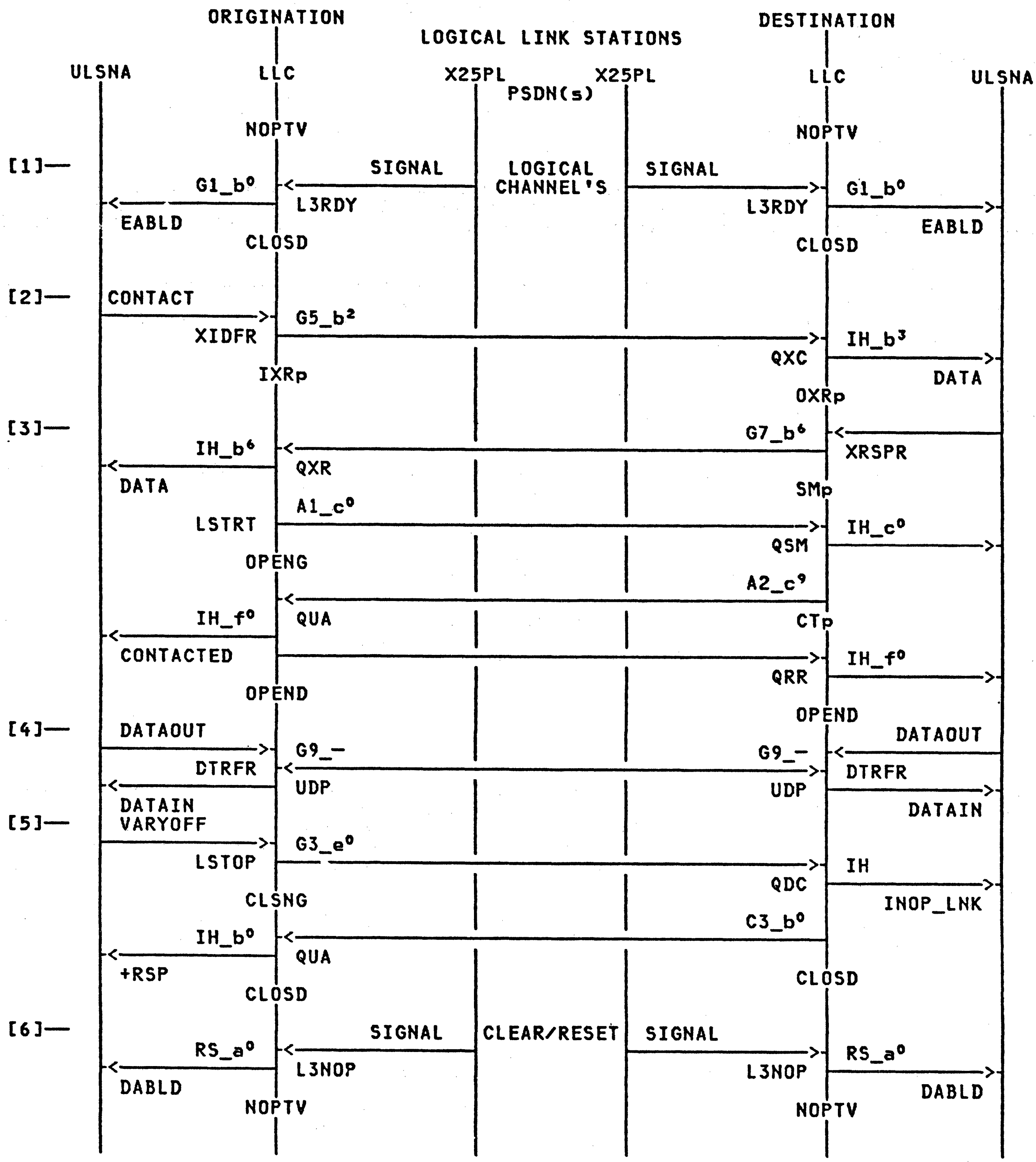


Figure 27. QLLC_Flows: Exchange ID, Link Set-Up, Data Transfer and Link Disconnection

9.0 OTHER SYSTEM CONSIDERATIONS

9.1 SECURITY

9.1.1 SNA-to-SNA Connections

Called DTEs can implement a rudimentary calling DTE identification check by testing the calling DTE address in INCOMING CALL packets. DTEs can elect to implement as a user option the connection identifier capability defined for CALL REQUEST and INCOMING CALL packets.

Care must be exercised in choosing cryptographic techniques. Data link control level cryptographic products defined for SNA products are not defined for the X.25 link and packet levels and cannot be used. Cryptographic products defined for SNA above, and transparent to, the data link control level can be used.

9.1.2 SNA-to-non SNA Connections

Security techniques are specific to the particular non-SNA remote DTE being supported. In general, techniques used for SNA-to-SNA connections are not applicable.

9.2 RELIABILITY, AVAILABILITY AND SERVICEABILITY (RAS)

RAS characteristics of PSDNs are not clearly established. However, numerous error detection and reporting mechanisms are included throughout this interface specification to aid in problem determination.

9.2.1 Philosophy

The fundamental philosophy adopted for error reporting in PSDN environments is one of commonality. IBM SNA X.25 DTEs cover a broad spectrum of RAS capabilities. Therefore, reporting to a higher level may mean different things for different products. These can range from simply reporting an error condition to the local operator of a simple DTE to full compatibility with Network Problem Determination and Analysis programs.

A common set of Diagnostic Codes is specified in Appendix F for use by all IBM SNA X.25 DTEs in reporting error conditions and abnormal situations to higher levels of SNA.

9.2.2 Summary of Error Conditions

Detectable error conditions are divided into four general categories:

1. those resulting from receipt of unsupported packet types (i.e., DCE INTERRUPT or DCE DATAGRAM packets).
2. those that can result from a discrepancy between the DTE and DCE interpretations of the state of some subscribed interface parameter. (i.e., receipt of an INCOMING CALL packet on a logical channel assigned for permanent virtual circuit service); and
3. those most likely resulting from a malfunction of the DCE (i.e., receipt of an unsolicited DCE RESTART CONFIRMATION packet);
4. those caused by failures at the physical level or the link level. (i.e., dropping of the Data Set Ready indication).

IBM SNA X.25 DTEs, upon detection of errors in category:

'1' or '2' - clear the virtual call or reset the permanent virtual circuit if such an action is permitted without violating any procedure. The error condition is reported to a higher level of SNA; the received packet is discarded.

'3' - transmit a RESTART REQUEST packet across the DTE/DCE interface, place all virtual circuits in an inoperative state and report the error condition to the higher levels of SNA.

'4' - place the LAPB link and all virtual circuits at the DTE/DCE interface in an inoperative state and report an interface failure to a higher level of SNA.

9.2.3 General Recommended Actions

Errors detected at the X.25 DTE/DCE interface, either by IBM SNA X.25 DTEs or their associated DCEs, that result in CLEAR, RESET or RESTART indications must be reported to the SNA control point or to the local operator, as appropriate. The Call Progress Signals (CPS) defined in CCITT Recommendation X.96 used for 'Network Generated' Cause and Diagnostic Codes defined in CCITT Recommendation X.25 and a common set of 'DTE Originated' diagnostic codes defined in Appendix F for IBM SNA X.25 DTEs to aid in problem determination are used for reporting purposes. Session outage notifications are propagated in accordance with general SNA mechanisms, using INOPERATIVE (INOP) to the control point and RECORD FORMATTED MAINTENANCE STATISTICS (RECFMS) or RECORD MAINTENANCE STATISTICS (RECMS) to Communication Network Management

A.0 APPENDIX A: ASSIGNMENT OF LOGICAL CHANNELS

Range of logical channels used for virtual calls and permanent virtual circuits (text deleted).

A.1 LOGICAL CHANNEL ASSIGNMENT

Logical channel number one (x'001') is used by DTEs that support a single logical channel.

A range of logical channels must be agreed upon with network Administrations for multiple logical channel DTE/DCE interfaces, according to Figure A-1.

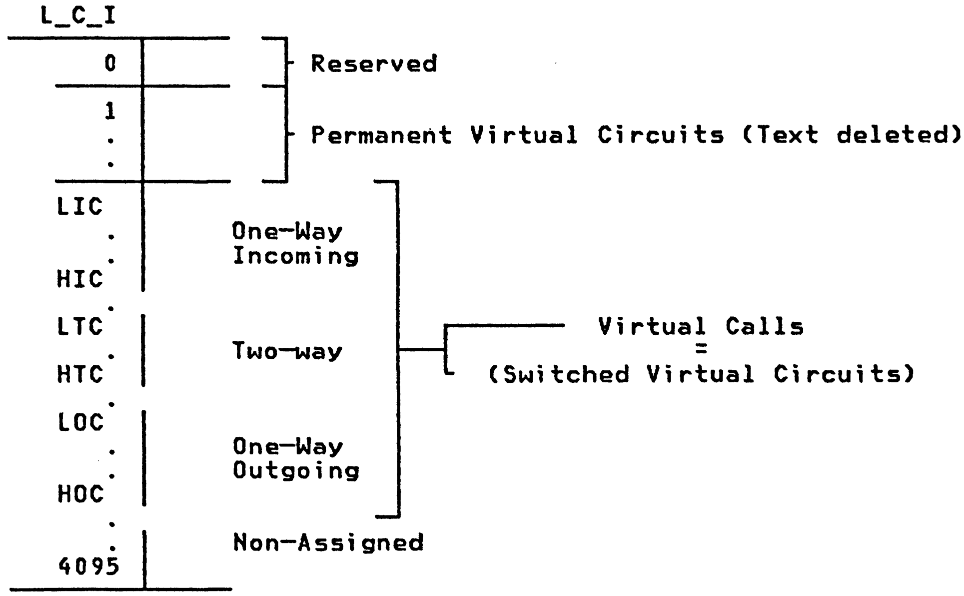


Figure A-1. Assignment: Logical Channels

With reference to Figure A-1:

0 is a logical channel reserved exclusively for the transmission of RESTART and DIAGNOSTIC packets.

1 to LIC-1 is the range of logical channels assigned for permanent virtual circuits.

LIC to HIC is the range of logical channels assigned to one-way incoming logical channels for virtual calls (see §-7.1.8).

LTC to HTC is the range of logical channels assigned to two-way logical channels for virtual calls.

LOC to HOC is the range of logical channels assigned to one-way outgoing logical channels for virtual calls (see §-7.1.7).

HIC+1 to LTC-1, HTC+1 to LOC-1, and HOC+1 to 4095 are unassigned logical channels.

Note:

1. Logical channels are numbered according to a set of contiguous numbers ranging from 0 (lowest) to 4095 (highest) using 12 bits made up of a four (4) bit Logical Channel Group Number (see §-6.1.2). and an eight (8) bit Logical Channel Number (see §-6.1.3). Logical channel numbers are binary coded in bit positions four (4) through one (1) of octet one (1) followed by bit positions eight (8) through one (1) of octet two (2) with bit one (1) of octet (2) being the low order bit.

2. All logical channel boundaries are agreed upon with the network Administration for a period of time.

3. To avoid frequent rearrangement of logical channels, not all logical channels within the range allocated for permanent virtual circuits are necessarily assigned.

4. In the absence of permanent virtual circuits, logical channel number one is available for LIC. In the absence of permanent virtual circuits and one-way incoming logical channels, logical channel one is available for LTC. In the absence of permanent virtual circuits, one-way incoming logical channels and two-way logical channels, logical channel one is available for LOC.

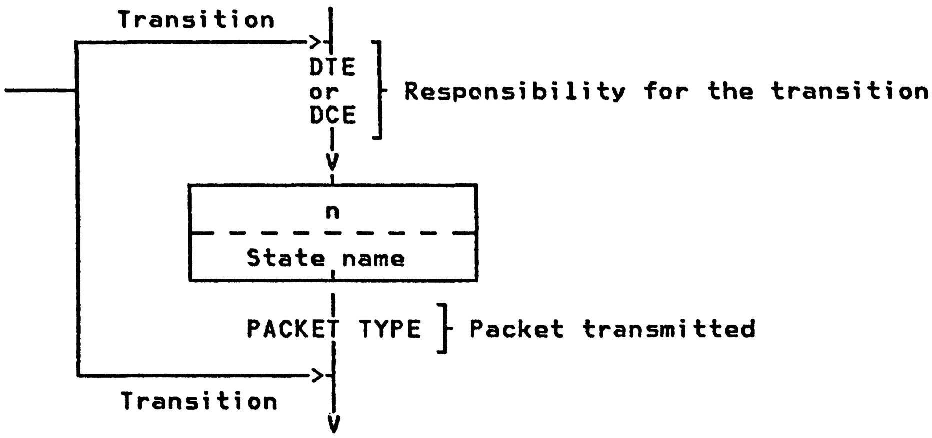
5. DCEs use the lowest numbered logical channel in the READY state in the range LIC to HIC and LTC to HTC as the logical channel for new incoming calls.

6. To minimize the risk of call collision, DTEs use the highest numbered logical channel in the READY state for outgoing calls. DTEs may use either two-way logical channels or one-way outgoing logical channels.

B.0 APPENDIX B: PACKET LEVEL STATE DIAGRAMS

Packet level DTE/DCE interface state diagrams

B.1 SYMBOL DEFINITION OF THE STATE DIAGRAM



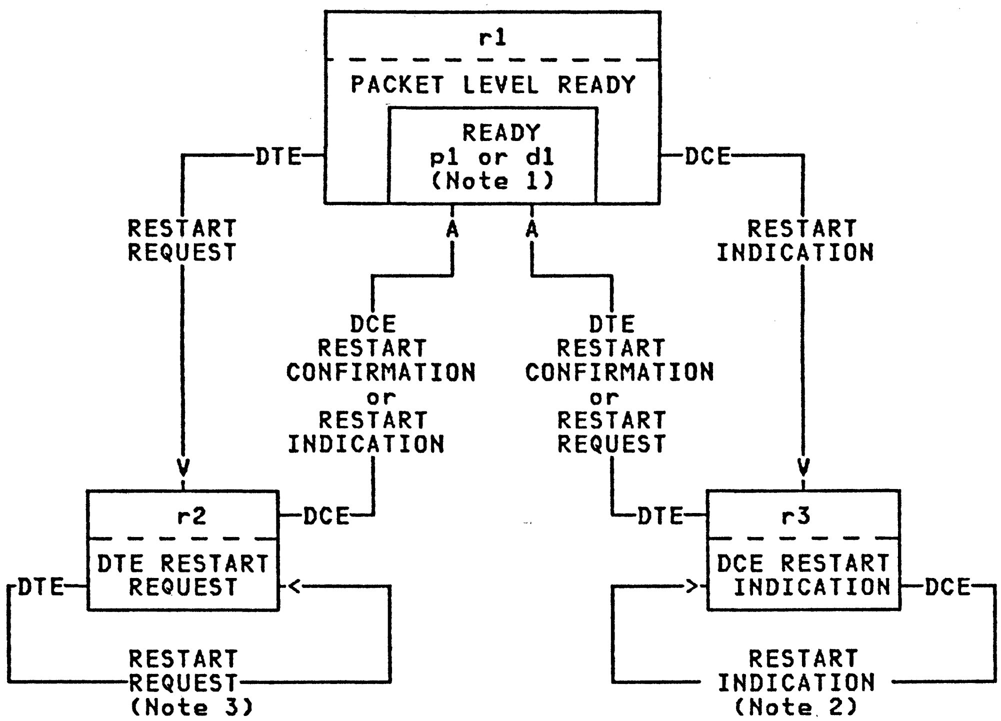
Note:

1. States are represented by boxes wherein the state name and number are indicated.
2. State transitions are represented by arrows. The station (DTE or DCE) responsible for the transition and the packets transferred is indicated inside the arrow.

B.2 ORDER DEFINITION OF THE STATE DIAGRAMS

The normal procedure at the DTE/DCE interface is described in a number of small state diagrams. To describe the normal procedure fully it is necessary to allocate a priority to the different figures and to relate a higher order diagram with a lower one. This is done by the following means:

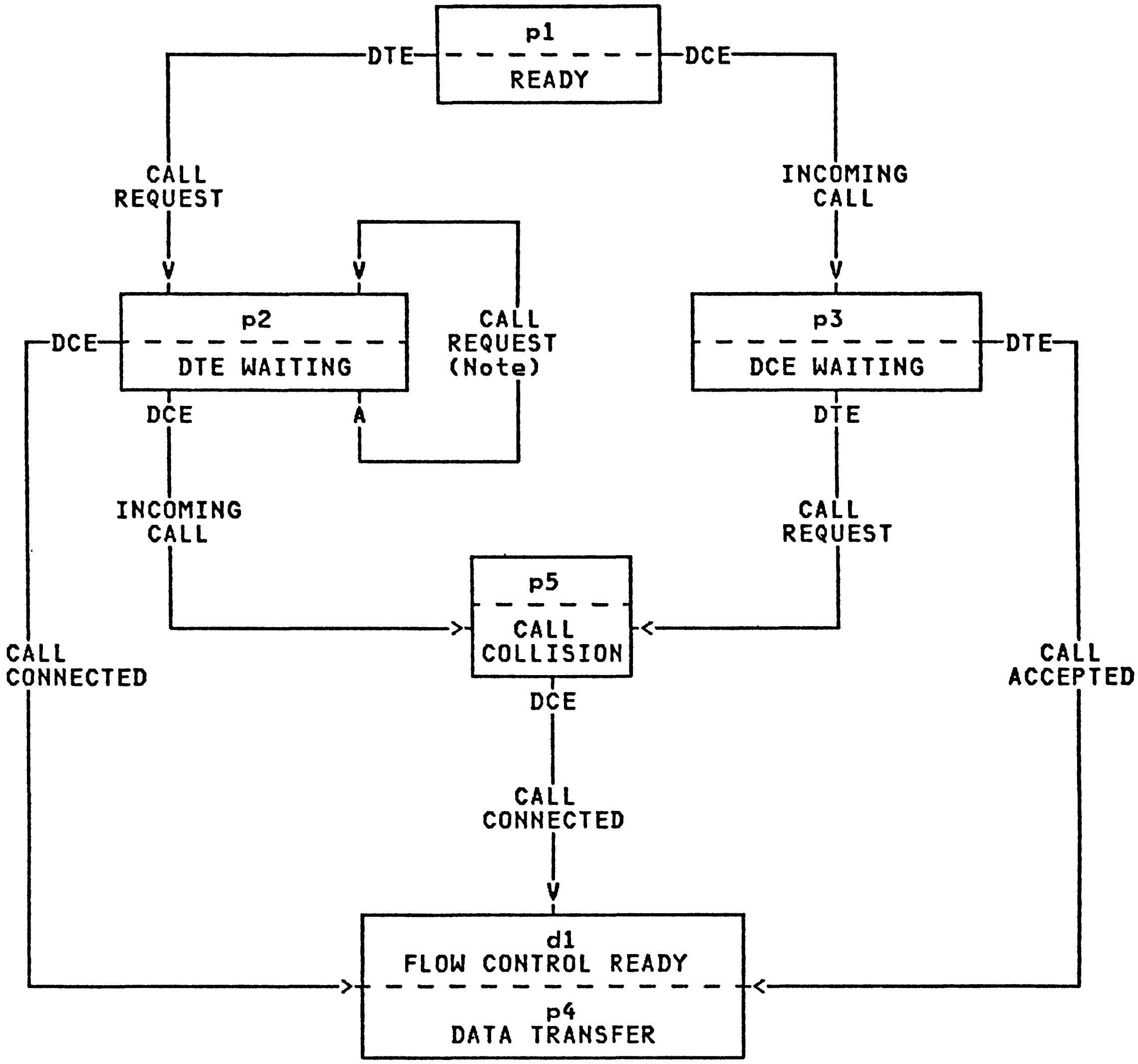
- The figures are arranged in order of priority with Figure B-1 (Restart) having the highest priority and subsequent figures having lower priority. Priority means that when a packet belonging to a higher order diagram is transferred, that diagram is applicable and the lower order one is not.
- The relation with a state in a lower order diagram is given by including that state inside a box in the higher order diagram.



Note:

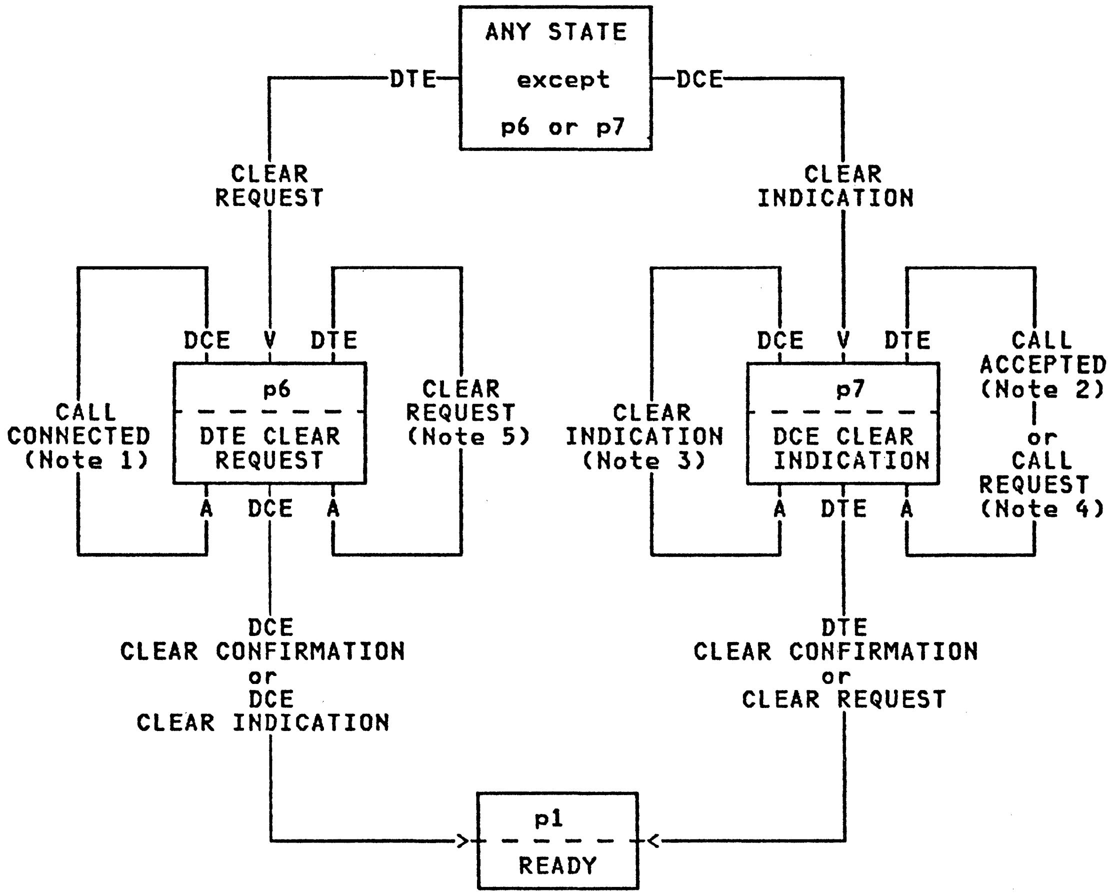
1. State p1 is for virtual calls and state d1 is for permanent virtual circuits.
2. This transition may take place after time-out T10.
3. This transition may take place after a 200 second time-out.

Figure B-1. States for the Transfer of RESTART packets



| **Note:** This transition may take place after a 200 second time-out.

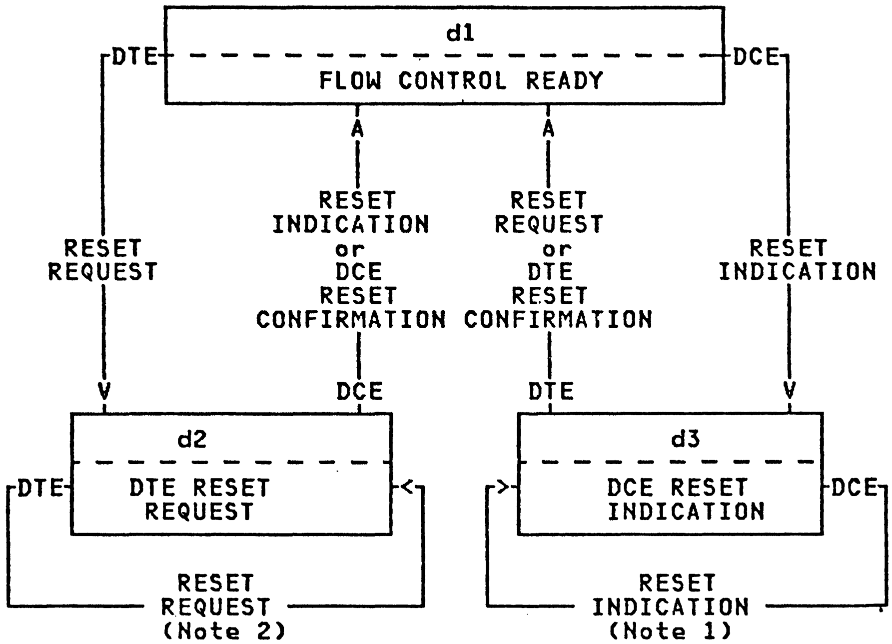
Figure B-2. States for the Transfer of Call Set-Up Packets within the PACKET LEVEL READY (r1) State



Note:

1. This transition is possible only if the previous state was DTE WAITING (p2).
2. This transition is possible only if the previous state was DCE WAITING (p3).
3. This transition may take place after Time-out T13.
4. This transition is possible only if the previous state was READY (p1) or DCE WAITING (p3).
5. This transition may take place after a 200 second time-out.

Figure B-3. States for the Transfer of Call Clearing Packets within the PACKET LEVEL READY (r1) State



Note:

1. This transition may take place after time-out T12.
2. This transition may take place after a 200 second time-out.

Figure B-4. States for the Transfer of RESET Packets within the DATA TRANSFER (p4) State.

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C.0 APPENDIX C: DCE PACKET LEVEL ACTIONS

Actions taken by the DCE on receipt of packets in a given state of the packet level DTE/DCE interface as perceived by the DCE.

C.1 DCE STATE/ACTION TABLES

TABLE C_1: Special Cases	
Numbers following a # are diagnostic codes in decimal notation. (See Appendix E)	
Packet from the DTE	Any State
Any packet with packet length less than 2 octets	DIAG #38
Any packet with incorrect General Format Identifier (GFI)	DIAG #40
Any packet other than RESTART_REQUEST or CONFIRMATION on unassigned logical channel or LCI = x'000'	DIAG #36
Any packet with correct GFI and assigned logical channel	See Table C_2

DIAG: DCEs discard the received packet and, on networks that implement diagnostic packets, transmit a DIAGNOSTIC packet containing the indicated diagnostic code to the DTE.

There may be more than one error associated with a packet. Networks stop normal processing of packets when an error is encountered. Thus, only one diagnostic code is indicated in DIAGNOSTIC packets. The order of packet de-coding and checking is not standardized among networks.

Table C_2: DCE actions on Receipt of packets in a given state of the packet level DTE/DCE interface as perceived by the DCE: Restart Procedure for assigned logical channels

The figures in parentheses () are the new states to be entered. Figures following a # are diagnostic codes in decimal notation. (Note 1).

State of the interface as perceived by the DCE / Packet from the DTE with assigned logical channel	PACKET LEVEL READY r1	DTE RESTART REQUEST r2	DCE RESTART INDICATION r3
RESTART REQUEST	NORMAL (r2)	DISCARD (r2)	NORMAL (p1 or d1) Note 2
DTE RESTART CONFIRMATION	ERROR (r3) #17	ERROR (r3) #18	NORMAL (p1 or d1) Note 2
DATA, [INTERRUPT], CALL SET-UP and CLEARING, FLOW CONTROL or RESET	See Table C_3	ERROR (r3) #18	DISCARD (r3)
RESTART REQUEST OR DTE RESTART CONFIRMATION WITH BITS 1 to 4 of OCTET 1 or BITS 1 to 8 of OCTET 2 NOT EQUAL TO ZERO	See Table C_3	ERROR (r3) #41	DISCARD (r3)
PACKETS HAVING A PACKET TYPE IDENTIFIER WHICH IS SHORTER THAN 1 OCTET OR IS NOT SUPPORTED BY THE DCE	See Table C_3	ERROR (r3) #38 #33	DISCARD (r3)

NORMAL: DCEs follow the procedures defined in §-3. When RESTART_REQUEST packets or DTE_RESTART_CONFIRMATION packets received in state r3 exceed the maximum permitted length, DCEs invoke the ERROR procedure with diagnostic #39 and enter state r3. When RESTART_REQUEST packets received in state r1 exceed the maximum permitted length, the action taken by DCEs is for further study.

DISCARD: DCEs discard the received packet and take no subsequent action as a direct result of receiving that packet.

ERROR: DCEs discard the received packet and indicate a restarting by transmitting a RESTART_INDICATION packet, with the cause, "Local Procedure Error" (diagnostic per Table C_2). On virtual calls, the remote DTE is informed of the restarting by a CLEAR_INDICATION packet, with the cause "Remote Procedure Error" (same diagnostic). On permanent virtual circuits, the remote DTE is informed by a RESET_INDICATION packet, with the cause "Remote Procedure Error" (same diagnostic).

When a RESTART_INDICATION is issued as a result of an error condition in state r2, DCEs eventually consider the DTE/DCE interface to be in the PACKET LEVEL READY state (r1). Eventually consider is interpreted to mean after sixty (60) seconds.

Note:

1. There may be more than one error associated with a packet. Networks stop normal processing of packets when an error is encountered. Thus, only one diagnostic code is associated with an error indication by DCEs. The order of packet de-coding and checking on networks is not standardized.

2. State p1 for logical channels assigned to virtual calls; or, d1 for logical channels assigned to permanent virtual circuits.

TABLE C_3: Actions by DCEs on Receipt of Packets in a given State of the Packet Level DTE/DCE Interface as Perceived by the DCE: Call Setup and Clearing on Assigned Logical Channels.

The letters and numbers in (ln) are the new states to be entered. Numbers following a # are diagnostic codes in decimal notation (Note 1).

Interface States as perceived by the DCE / Packet on assigned LCI	PACKET LEVEL READY r1						
	READY p1	DTE WAITING p2 Note 3	DCE WAITING p3 Note 2	DATA TRANSFER p4	CALL COLLISON p5 Note 2,3	DTE CLEAR REQUEST p6	DCE CLEAR INDICATION p7
CRQ	NORMAL (p2) Note 4	ERROR (p7) #21	NORMAL (p5) Note 4	ERROR (p7)#23 Note 5	ERROR (p7) #24	ERROR (p7) #25	DISCARD (p7)
CAC	ERROR (p7) #20	ERROR (p7) #21	NORMAL (p4) Note 6 ERROR (p7)#42 Note 7	ERROR (p7) #23 Note 5	ERROR (p7) #24	ERROR (p7) #25	DISCARD (p7)
CLR	NORMAL (p6)	NORMAL (p6)	NORMAL (p6)	NORMAL (p6) Note 5	NORMAL (p6)	DISCARD (p6)	NORMAL (p1)
TCC	ERROR (p7) #20	ERROR (p7) #21	ERROR (p7) #22	ERROR (p7)#23 Note 5	ERROR (p7) #24	ERROR (p7) #25	NORMAL (p1)
DIR|FC	ERROR (p7) #20	ERROR (p7) #21	ERROR (p7) #22	See Table C_4	ERROR (p7) #24	ERROR (p7) #25	DISCARD (p7)
IRR|TIR w/LCI≠0	ERROR (p7) #41	ERROR (p7) #41	ERROR (p7) #41	See Table C_4	ERROR (p7) #41	ERROR (p7) #41	DISCARD (p7)
UNK|NUP	ERROR (p7) #38 #33	ERROR (p7) #38 #33	ERROR (p7) #38 #33	See Table C_4	ERROR (p7) #38 #33	ERROR (p7) #38 #33	DISCARD (p7)

CRQ: CALL_REQUEST

CAC: CALL_ACCEPTED

CLR: CLEAR_REQUEST

TCC: DTE_CLEAR_CONFIRMATION

DIR|FC: DATA, [INTERRUPT,] RESET or FLOW_CONTROL

IRR|TIR: RESTART_REQUEST or DTE_RESTART_CONFIRMATION

UNK|NUP: Packets having a Packet Type Identifier shorter than one octet or that are not supported by the DCE.

LCI: Logical Channel Identifier (bits 1-4 of octet #1 plus bits 1-8 of octet #2).

NORMAL: DCEs follow the procedures defined in §-4. For packets exceeding the maximum permitted length, DCEs invoke the ERROR procedure with diagnostic #39 and enter state p7.

DISCARD: DCEs discard the received packet and take no subsequent action as a direct result of receiving that packet.

ERROR: DCEs discard the received packet and indicate a clearing by transmitting a CLEAR INDICATION packet, with the cause "Local Procedure Error" (diagnostic per Table C_3). On virtual calls, the remote DTE is informed of the clearing by a CLEAR_INDICATION packet, with the cause "Remote Procedure Error" (same diagnostic).

It is required that in the absence of an appropriate DTE response to a CLEAR_INDICATION packet issued as a result of an error condition in state p6, the DCE should eventually consider the DTE/DCE interface to be in the READY state (p1). Eventually consider is interpreted to mean after sixty (60) seconds.

Note:

1. There may be more than one error associated with a packet (e.g., packet too long and transmitted in a wrong state). Networks stop processing of packets when an error is encountered. Thus, only one diagnostic code is associated with an ERROR indication by DCEs. The order of packet de-coding and checking is not standardized among networks.

2. This state does not exist for one-way logical channels outgoing (as perceived by DTEs).

3. This state does not exist for one-way logical channels incoming (as perceived by DTEs).

4.

   a. For one-way logical channels incoming (as perceived by DTEs) DCEs transmit a CLEAR_INDICATION packet with the cause "Local Procedure Error" and diagnostic code #34.

   b. DCEs transmit a CLEAR INDICATION packet when a CALL REQUEST packet contains an improper address format or facility field; call progress signals and diagnostic codes are listed below:

	ERROR CONDITION	CAUSE	DIAG
1.	Address contains a non BCD digit	LPE	67,68
2.	Prefix digit not supported	LPE	67,68
3.	National address smaller than national address format permits	LPE	67,68
4.	National address larger than national address format permits	LPE	67,68
5.	DNIC less than four digits	LPE	67,68
6.	Facility length larger than 63	LPE	64
7.	No combination of facilities could equal facility length	LPE	64
8.	Facility length larger than remainder of packet	LPE	38
9.	Facility values conflict (e.g., a particular combination not supported)	LPE	66
10.	Facility code not allowed	IFR	65
11.	Facility value not allowed	IFR	66

LPE = Local procedure error
IFR = Invalid facility request
DNIC = Data Network Identification Code

   c. DCEs transmit a CLEAR_INDICATION packet when a remote DTE makes a procedure error, either for one of the above reasons associated with its call acceptance, or because of an expired timeout (diagnostic #49).

5. For permanent virtual circuits, DCEs discard the received packet and indicate a reset by transmitting a RESET_INDICATION packet, with the cause "Local procedure error" (diagnostic #35). The remote DTE is informed of the reset by a

RESET_INDICATION packet, with the cause "Remote Procedure Error" (same diagnostic).

Text deleted.

6. The ERROR procedure is invoked by DCEs when CALL_ACCEPTED packets contain an improper address format or facility field. Examples are similar to those in Note 4 point (b) above.

7. The presence of the Fast Select facility, indicating restriction on response in an INCOMING CALL packet prohibits the DTE from sending a CALL_ACCEPTED packet.

TABLE C_4: Actions taken by the DCE on Receipt of Packets in a given State of the Packet Level DTE/DCE Interface as Perceived by the DCE: Data Transfer (Flow Control and Reset) on Assigned Logical Channels

The figures in parentheses () are the new states to be entered; the figure following a # is the diagnostic code in decimal notation (Note 1).

State of the interface as perceived by the DCE / Packet from the DTE with assigned logical channel	DATA TRANSFER p4		
	FLOW CONTROL READY d1	DTE RESET REQUEST d2	DCE RESET INDICATION d3
RESET REQUEST	NORMAL (d2)	DISCARD (d2)	NORMAL (d1)
DTE RESET CONFIRMATION	ERROR (d3) #27	ERROR (d3) #28	NORMAL (d1)
DATA, [INTERRUPT] OR FLOW CONTROL	NORMAL (d1) Note 2	ERROR (d3) #28	DISCARD (d3)
RESTART REQUEST OR DTE RESTART CONFIRMATION WITH BITS 1 to 4 OF OCTET 1 OR BITS 1 to 8 OF OCTET 2 ≠ 0	ERROR (d3) #41	ERROR (d3) #41	DISCARD (d3)
PACKETS HAVING A PACKET TYPE IDENTIFIER WHICH IS SHORTER THAN ONE OCTET OR IS NOT SUPPORTED BY THE DCE	ERROR (d3) #27	ERROR (d3) #28	DISCARD (d3)
INVALID PACKET TYPE ON A PERMANENT VIRTUAL CIRCUIT	ERROR (d3) #35	ERROR (d3) #35	DISCARD (d3)
REJECT PACKET NOT SUBSCRIBED	ERROR (d3) #37	ERROR (d3) #37	DISCARD (d3)

NORMAL: DCEs follow the procedures defined in §-4. For packets exceeding the maximum permitted length, DCEs invoke the error procedure using diagnostic code #39 and enter state d3.

DISCARD: DCEs discard the received packet and take no subsequent action as a direct result of receiving that packet.

ERROR: DCEs discard the received packet and indicate a reset by transmitting a RESET_INDICATION packet, with the cause "Local Procedure Error" (diagnostic per Table C-4). On virtual calls and permanent virtual circuits the remote DTE is informed of the reset by a RESET_INDICATION packet with the cause "Remote Procedure Error" (same diagnostic).

When a RESET_INDICATION is issued as a result of an error condition in state d2 for permanent virtual circuits, (text deleted) DCEs should eventually consider the DTE/DCE interface to be in the FLOW CONTROL READY state (d1). The action to be taken on virtual calls is for further study.

Note:

1. There may be more than one error associated with a packet (e.g., Invalid Ps and Invalid Pr). Networks stop processing of packets when an error is encountered. Thus, only one diagnostic code is associated with an error indication by DCEs. The order of packet de-coding and checking is not standardized among networks.

2. DCEs consider the receipt of a DTE_INTERRUPT_CONFIRMATION packet which does not correspond to a yet unconfirmed DCE_INTERRUPT packet as an error and resets the virtual call or permanent virtual circuit (diagnostic #43). DCEs either discard or consider as an error a DTE_INTERRUPT packet received before a previous DTE_INTERRUPT packet has been confirmed (diagnostic #44).

   When Ps or Pr received is not valid, DCEs invoke the error procedure with diagnostics #1 and #2, respectively, and enter state d3.

D.0 APPENDIX D: TIME-LIMITS AND TIME-OUTS

Packet level DCE time-outs and DTE time-limits.

D.1 DCE TIME-OUTS

In certain circumstances DTEs are required to respond to packets issued from DCEs within a stated maximum time.

Table II-D-1 covers these circumstances and the actions that DCEs initiate upon expiration of that maximum time.

| To facilitate recovery from such fault conditions, IBM SNA X.25 DTEs incorporate timers. Time-out values are indicated for DTE implementations in Table II-D-2.

| Text deleted.

TABLE II-D-1: DCE TIME-OUTS

Time-Out		LC State	Starts when	Normally Terminated when	Actions taken when the time-out expires (see Note 1)	
No.	Value				Local Side	Remote Side
T10	60 secs.	r3	DCE sends IRI pkt	DCE leaves state r3 (i.e., the TSC or IRR is rec'd)	DCE remains in r3 and may send a DGN packet. (Note 2)	For PVCs, DCE enters state d3 signalling RSI (remote procedure error)
T11	180 secs.	p3	DCE sends an INC	DCE leaves state p3 (e.g., the CAC, CLR, or CRQ is rec'd).	DCE enters state p7 signalling a CLI (local procedure error)	DCE enters state p7 signalling a CLI (remote procedure error)
T12	60 secs.	d3	DCE sends an RSI	DCE leaves state d3 (e.g., the TRC or RSR is rec'd)	For VCs, DCE enters state p7 signalling CLI (local procedure error). For PVCs, DCE remains in d3 and may send a DGN pkt (Note 3)	For PVCs, DCE enters state p7 signalling CLI (remote procedure error). For PVCs, DCE enters state d3 signalling RSI (remote procedure error)
T13	60 secs. secs.	p7	DCE sends a CLI	DCE leaves state p7 (e.g., the TSC or CRQ is rec'd).	DCE remains in p7 and may send a DGN packet. (Note 4)	

Notes with reference to Table II-D-1:

1. The following Notes 2, 3 and 4 describe alternative DCE actions on timer expiration. It is envisaged that all networks will eventually conform to Table II-D-1, however, for an interim period the following procedures may be used.

   No values have yet been assigned to the time-out t and the maximum number of retries n applying to the following notes, however, it should be noted that some Administrations may use the combination t-infinite, n-zero (i.e., no retries and no recovery action) or t-finite, n-zero (i.e., no retries with recovery action on timer expiration). The values of n and t will not necessarily be the same for the clear, reset and restart procedures.

2. Alternatively, DCEs may retransmit a RESTART INDICATION packet at regular intervals of 't' until a DTE RESTART CONFIRMATION is received or a restart collision occurs or a period ('n+1')'t' elapses since the first transmission of the RESTART INDICATION. If the restart procedure is not completed within the time-out period, appropriate recovery action is taken.

3. Alternatively, DCEs may transmit a RESET INDICATION packet at regular intervals of 't' until a DTE RESET CONFIRMATION is received or a reset collision occurs or a period ('n+1')'t' elapses since the first transmission of the RESET INDICATION. If the reset procedure is not completed within the time-out period DCEs either:

    a. clear the virtual call with a procedure error indication; or,

    b. reset the permanent virtual circuit by transmitting a RESET INDICATION packet (remote procedure error) to the local DTE at regular intervals 't' until a DTE RESET CONFIRMATION is received or a reset collision occurs.

4. Alternatively, DCEs may retransmit a CLEAR INDICATION at regular intervals of 't' until a DTE CLEAR CONFIRMATION is received or a clear collision occurs or a period ('n+1')'t' elapses since the first retransmission of the CLEAR INDICATION. If the clear procedure is not completed within the time-out period, appropriate recovery action is initiated. The nature of the recovery action is for further study.

D.2 DTE TIME-OUTS AND TIME-LIMITS

In certain circumstances DCEs are required to respond to packets from DTEs within a stated maximum time. The actual DCE response times should be well within the specified time-limits. The rare situation where a time-limit is exceeded should only occur when there is a fault condition.

To facilitate recovery from such fault conditions, IBM SNA X.25 DTEs incorporate timers. Time-out values for IBM SNA X.25 DTE implementations are indicated in Table II-D-2.

Text deleted.

TABLE II-D-2: DTE TIME-OUTS and DCE TIME-LIMITS (see NOTE)

DCE Time-Limits		LC State	Starts when	Terminates Normally when	Request pkts may be re-transmitted at 200 sec. intervals 'n≥0' times after an initial time-out. Following which,
T20	180 secs.	r2	DTE sends an IRR	DTE leaves state r2 (i.e., the NSC or IRI rec'd)	the interface becomes inoperative and restart failure notification is given to a higher level.
T21	200 secs.	p2	DTE sends a CRQ	DTE leaves state p2 (e.g., the CCN, CLI or INC pkt is rec'd)	the logical channel becomes inoperative and call failure notification is given to a higher level.
T22	180 Secs.	d2	DTE sends an RSR	DTE leaves state d2 (e.g., the NRC or RSI is rec'd)	the logical channel becomes inoperative and reset failure notification is given to a higher level.
T23	180 secs.	p6	DTE sends a CLR	DTE leaves state p6 (e.g., the NCC or CLI is rec'd) is received)	the logical channel becomes inoperative and clear failure notification is given to a higher level.

Note: DTE time-outs are 200 seconds.

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E.0 APPENDIX E: DCE DIAGNOSTICS

Coding of X.25 network generated diagnostic fields in clear, reset and restart indication and diagnostic packets.

E.1 DIAGNOSTIC CODES

TABLE E_1 DCE Diagnostics (Notes 1, 2 and 3)	Bits 8 7 6 5	Bits 4 3 2 1	Decimal
No Additional Information	0 0 0 0	0 0 0 0	0
Invalid Ps	0 0 0 0	0 0 0 1	1
Invalid Pr	0 0 0 0	0 0 1 0	2
	.	.	.
	0 0 0 0	1 1 1 1	15
Packet Type Invalid	0 0 0 1	0 0 0 0	16
for state r1	0 0 0 1	0 0 0 1	17
for state r2	0 0 0 1	0 0 1 0	18
for state r3	0 0 0 1	0 0 1 1	19
for state p1	0 0 0 1	0 1 0 0	20
for state p2	0 0 0 1	0 1 0 1	21
for state p3	0 0 0 1	0 1 1 0	22
for state p4	0 0 0 1	0 1 1 1	23
for state p5	0 0 0 1	1 0 0 0	24
for state p6	0 0 0 1	1 0 0 1	25
for state p7	0 0 0 1	1 0 1 0	26
for state d1	0 0 0 1	1 0 1 1	27
for state d2	0 0 0 1	1 1 0 0	28
for state d3	0 0 0 1	1 1 0 1	29
	.	.	.
	0 0 0 1	1 1 1 1	31
Packet Not Allowed	0 0 1 0	0 0 0 0	32
unidentifiable packet	0 0 1 0	0 0 0 1	33
call on one way logical channel	0 0 1 0	0 0 1 0	34
invalid packet type on a PVC	0 0 1 0	0 0 1 1	35
packet on unassigned logical channel	0 0 1 0	0 1 0 0	36
REJECT not subscribed to	0 0 1 0	0 1 0 1	37
packet too short	0 0 1 0	0 1 1 0	38
packet too long	0 0 1 0	0 1 1 1	39
invalid general format identifier	0 0 1 0	1 0 0 0	40
restart with nonzero in bits 1-4,9-16 0	0 0 1 0	1 0 0 1	41
packet type not compatible with facility	0 0 1 0	1 0 1 0	42
unauthorized interrupt confirmation	0 0 1 0	1 0 1 1	43
unauthorized interrupt	0 0 1 0	1 1 0 0	44
	.	.	.
	0 0 1 0	1 1 1 1	47
Timer Expired	0 0 1 1	0 0 0 0	48
for INCOMING CALL	0 0 1 1	0 0 0 1	49
for CLEAR INDICATION	0 0 1 1	0 0 1 0	50
for RESET INDICATION	0 0 1 1	0 0 1 1	51
for RESTART INDICATION	0 0 1 1	0 1 0 0	52
	.	.	.
	0 0 1 1	1 1 1 1	63
Call Setup Problem	0 1 0 0	0 0 0 0	64
facility code not allowed	0 1 0 0	0 0 0 1	65
facility parameter not allowed	0 1 0 0	0 0 1 0	66
invalid called address	0 1 0 0	0 0 1 1	67
invalid calling address	0 1 0 0	0 1 0 0	68
	.	.	.
	0 1 0 0	1 1 1 1	79

TABLE E_1 DCE Diagnostics — Continued	Bits 8 7 6 5 4 3 2 1	Decimal
Call clearing problem	0 1 0 1 0 0 0 0	80
non-zero address lengths field	0 1 0 1 0 0 0 1	81
non-zero facility length field	0 1 0 1 0 0 1 0	82
	. .	
	0 1 0 1 1 1 1 1	95
Not Assigned	0 1 1 0 0 0 0 0	96
	. .	.
	0 1 1 0 1 1 1 1	111
Not Assigned	0 1 1 1 0 0 0 0	112
	. .	.
	0 1 1 1 1 1 1 1	127
Reserved for Network Specific Diagnostics	1 0 0 0 0 0 0 0	128
	. .	.
	1 1 1 1 1 1 1 1	255

Note:

1. Not all diagnostic codes need apply to a specific network, but those used are as coded in Table E_1.
2. A given diagnostic need not apply to all packet types (i.e., reset indication, clear indication, restart indication and diagnostic packets).
3. The first diagnostic in each grouping is a generic diagnostic and can be used in place of the more specific diagnostics within the grouping. The decimal '0' diagnostic code can be used in situations where no additional information is available.
4. (Text deleted).

REFERENCES

[1] CCITT Recommendation International user classes of service in public data networks, Vol. VIII, Fascicle VIII.2, Rec. X.1.

[2] CCITT Recommendation International user services and facilities in public data networks, Vol. VIII, Fascicle VIII.3, Rec. X.2.

[3] CCITT Recommendation Hypothetical reference connections for public synchronous data networks, Vol. VIII, Fascicle VIII.3, Rec. X.92.

[4] CCITT Recommendation Call progress signals in public data networks, Vol. VIII, Fascicle VIII.3, Rec. X.96.

F.0 APPENDIX F: DTE DIAGNOSTICS

Codes transferred in the diagnostic code field of CLEAR, RESET AND RESTART REQUEST packets generated IBM SNA X.25 DTEs on SNA-to-SNA connections convey the meaning indicated in Table F_1.

F.1 DTE DIAGNOSTIC CODES ON SNA-TO-SNA CONNECTIONS

TABLE F_1 DTE Diagnostics (Notes 1, 2 and 3)	Bits 8 7 6 5	Bits 4 3 2 1	Decimal
Normal Initialization or Termination	0 0 0 0	0 0 0 0	0
	.	.	:
Invalid LLC Type	0 0 0 0	1 1 0 0	12
	.	.	:
	0 0 0 0	1 1 1 1	15
Invalid Packet Type (General)	0 0 0 1	0 0 0 0	16
for State r1	0 0 0 1	0 0 0 1	17
for State r2	0 0 0 1	0 0 1 0	18
for State r3	0 0 0 1	0 0 1 1	19
for State p1	0 0 0 1	0 1 0 0	20
for State p2	0 0 0 1	0 1 0 1	21
for State p3	0 0 0 1	0 1 1 0	22
for State p4	0 0 0 1	0 1 1 1	23
for State p5	0 0 0 1	1 0 0 0	24
for State p6	0 0 0 1	1 0 0 1	25
for State p7	0 0 0 1	1 0 1 0	26
for State d1	0 0 0 1	1 0 1 1	27
for State d2	0 0 0 1	1 1 0 0	28
for State d3	0 0 0 1	1 1 0 1	29
	.	.	:
	0 0 0 1	1 1 1 1	31
DCE Timer Expired (General)	0 0 1 0	0 0 0 0	32
Incoming Call	0 0 1 0	0 0 0 1	33
Clear Indication	0 0 1 0	0 0 1 0	34
Reset Indication	0 0 1 0	0 0 1 1	35
Restart Indication	0 0 1 0	0 1 0 0	36
	.	.	:
	0 0 1 0	1 1 1 1	47
DTE Timer Expired (General)	0 0 1 1	0 0 0 0	48
Call Request	0 0 1 1	0 0 0 1	49
Clear Request	0 0 1 1	0 0 1 0	50
Reset Request	0 0 1 1	0 0 1 1	51
Restart Request	0 0 1 1	0 1 0 0	52
	.	.	:
	0 0 1 1	1 1 1 1	63
Unassigned (General)	0 1 0 0	0 0 0 0	64
	.	.	.
	0 1 0 0	1 1 1 1	79

TABLE F_1 DTE Diagnostics — Continued	Bits		Decimal
	8 7 6 5	4 3 2 1	
QLLC Error (General)	0 1 0 1	0 0 0 0	80
Undefined C-field	0 1 0 1	0 0 0 1	81
Unexpected C-field	0 1 0 1	0 0 1 0	82
Missing I-field	0 1 0 1	0 0 1 1	83
Undefined I-field	0 1 0 1	0 1 0 0	84
I-field Too Long	0 1 0 1	0 1 0 1	85
Frame Reject Received	0 1 0 1	0 1 1 0	86
Header Invalid	0 1 0 1	0 1 1 1	87
Data Received in Wrong State	0 1 0 1	1 0 0 0	88
Time-out Condition	0 1 0 1	1 0 0 1	89
	.	.	..
	0 1 0 1	1 1 1 1	95
PSH Error (General)	0 1 1 0	0 0 0 0	96
Sequence Error	0 1 1 0	0 0 0 1	97
Header too Short	0 1 1 0	0 0 1 0	98
PSH Format Invalid	0 1 1 0	0 0 1 1	99
Command Undefined	0 1 1 0	0 1 0 0	100
Protocol Invalid	0 1 1 0	0 1 0 1	101
Data Received in Wrong State	0 1 1 0	0 1 1 0	102
	.	.	...
Time-out Condition	0 1 1 0	1 0 0 1	105
	.	.	...
	0 1 1 0	1 1 1 1	111
PAD Error (General)	0 1 1 1	0 0 0 0	112
PAD Access Facility Failure	0 1 1 1	0 0 0 1	113
SDLC FCS Error	0 1 1 1	0 0 1 0	114
SDLC Time-out	0 1 1 1	0 0 1 1	115
SDLC Frame Invalid	0 1 1 1	0 1 0 0	116
I-field too long	0 1 1 1	0 1 0 1	117
SDLC Sequence Error	0 1 1 1	0 1 1 0	118
SDLC Frame Aborted	0 1 1 1	0 1 1 1	119
SDLC FRMR Received	0 1 1 1	1 0 0 0	120
SDLC Response Invalid	0 1 1 1	1 0 0 1	121
	.	.	...
Invalid Packet Type	0 1 1 1	1 0 1 1	123
	.	.	...
PAD Inoperable	0 1 1 1	1 1 1 1	127
2 Product Specific	1 0 0 0	0 0 0 0	128
	.	.	...
	1 0 0 0	1 1 1 1	143
2 Network Specific	1 0 0 1	0 0 0 0	144
2 DDX-P RNR Packet Received	1 0 0 1	0 0 0 1	146
	.	.	...
	1 0 0 1	1 1 1 1	159
Packet Not Allowed (General)	1 0 1 0	0 0 0 0	160
Invalid 'M' bit Packet Sequence	1 0 1 0	0 0 0 1	161
Invalid Packet Type Received	1 0 1 0	0 0 1 0	162
Invalid Packet on PVC	1 0 1 0	0 0 1 1	163
Unassigned LC	1 0 1 0	0 1 0 0	164
Diagnostic Packet Received	1 0 1 0	0 1 0 1	165
Packet too short	1 0 1 0	0 1 1 0	166
Packet too long	1 0 1 0	0 1 1 1	167
Invalid GFI	1 0 1 0	1 0 0 0	168
Not Identifiable	1 0 1 0	1 0 0 1	169
Not Supported	1 0 1 0	1 0 1 0	170
Invalid Ps	1 0 1 0	1 0 1 1	171
Invalid Pr	1 0 1 0	1 1 0 0	172
Invalid 'D' bit Received	1 0 1 0	1 1 0 1	173
Invalid 'Q' bit Received	1 0 1 0	1 1 1 0	174
	1 0 1 0	1 1 1 1	175

	TABLE F_1 DTE Diagnostics – Continued	Bits		Decimal
		8 7 6 5	4 3 2 1	
	DTE Specific (NPSI Gate/Date) (General)	1 0 1 1	0 0 0 0	176
	No LU-to-LU Session	1 0 1 1	0 0 0 1	178
		.	.	...
		1 0 1 1	1 1 1 1	191
	DTE Specific (General)	1 1 0 0	0 0 0 0	192
	Termination Pending	1 1 0 0	0 0 0 1	193
	Channel Inoperative	1 1 0 0	0 0 1 0	194
	Unauthorized Interrupt Confirmation	1 1 0 0	0 0 1 1	195
	Unauthorized Interrupt Request	1 1 0 0	0 1 0 0	196
	PU (PVC) Not Available	1 1 0 0	0 1 0 1	197
2	Inactivity Time-Out	1 1 0 0	0 1 1 0	198
		.	.	...
		1 1 0 0	1 1 1 1	207
	Resources (General)	1 1 0 1	0 0 0 0	208
	Buffers depleted	1 1 0 1	0 0 0 1	209
	PIU too long	1 1 0 1	0 0 1 0	210
		.	.	...
		1 1 0 1	1 1 1 1	223
	Local Procedure Error (General)	1 1 1 0	0 0 0 0	224
	Packet with LC=0 not Received	1 1 1 0	0 0 0 1	225
	Restart or Diagnostic Packet on LCI≠'0'	1 1 1 0	0 0 1 0	226
	INCOMING CALL Received on Wrong LC	1 1 1 0	0 0 1 1	227
	Facility not Subscribed	1 1 1 0	0 1 0 0	228
	Packet Not RESTART or DIAG on LCI='0'	1 1 1 0	0 1 0 1	229
	Facility Parameters not Supported	1 1 1 0	0 1 1 0	230
	Facility not Supported	1 1 1 0	0 1 1 1	231
	Unexpected Calling DTE	1 1 1 0	1 0 0 0	232
	Invalid 'D' bit Request	1 1 1 0	1 0 0 1	233
	RESET INDICATION on Virtual Call	1 1 1 0	1 0 1 0	234
	Invalid Protocol Identifier	1 1 1 0	1 0 1 1	235
	Connection Identifier Mismatch	1 1 1 0	1 1 0 0	236
2	Missing Cause/Diagnostic Code	1 1 1 0	1 1 0 1	237
		1 1 1 0	1 1 1 0	238
		1 1 1 0	1 1 1 1	239
	Remote Procedure Error (General)	1 1 1 1	0 0 0 0	240
		.	.	...
		1 1 1 1	1 1 1 1	255

Note:

1. All diagnostic codes are not necessarily used by all DTEs, but those that are used have the meaning indicated.

2. The first diagnostic in each grouping is a generic code that may be used in place of the more specific codes within the group.

3. These codes, set by transmitting DTEs, in CLEAR, RESET and RESTART packets are normally delivered to the remote DTE in a corresponding INDICATION packet by DCEs. However, DCEs may override DTE requests. In this event, DCEs place a non-zero Cause Code in the Cause field and insert the network Diagnostic Code (see Appendix E) in the Diagnostic Code field of the resulting INDICATION packet delivered to the remote DTE.

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G.0 APPENDIX G: PACKET LEVEL DTE ACTIONS

Actions taken by DTEs on receipt of packets in a given state of the DTE/DCE interface as perceived by the DTE.

G.1 DTE STATE/ACTION TABLES

TABLE G_1 - Special Situations

The characters after the '#' indicate the diagnostic code to be reported (See attachment F).

Packet from DCE	Any State
Length < 2 octets	ADVISE #166
Packet with Incorrect GFI	ADVISE #168
Packet on Unassigned LC	ADVISE #164
DIAGNOSTIC Packet Received	ADVISE #165 (Note)
Any packet with correct GFI on assigned LC	See Table G_2

ADVISE: DTEs discard the received packet and report the condition to a higher level using the indicated Diagnostic Code. No state transition takes place.

DTEs discontinue normal packet processing when an error condition is encountered. Thus, only one diagnostic code is indicated for a single packet. The order in which packets are processed is not specified, therefore, a given packet containing multiple errors could result in different diagnostic indications when processed by different DTEs.

Note: IBM SNA X.25 DTEs also report the contents of the Diagnostic Code and Explanation fields to a higher level.

TABLE G_2: Actions taken by DTEs on receipt of packets in given states of the packet level DTE/DCE interface as perceived by the DTE: Restart procedure for assigned LCs

The codes in parentheses (ln) specify the new states to be entered. The characters after the '#' indicate the diagnostic code to be reported (see Attachment F).

State / Received Packet	r1	r2	r3
RESTART INDICATION	NORMAL (r3)	NORMAL (p1 or d1) Note	ADVISE (r3) #36
DCE RESTART CONFIRMATION	ERROR (r2) #17	NORMAL (p1 or d1) Note	ERROR (r2) #19
ANY PACKET on Logical Channel not equal to Zero	Table G_3	DISCARD (r2)	ERROR (r2) #225
DCE RESTART CONFIRMATION or RESTART INDICATION on Logical Channel not equal to Zero	Table G_3	ADVISE (r2) #226	ERROR (r2) #226
PACKET ON Logical Channel Zero not RESET INDICATION, RESTART INDICATION or DIAGNOSTIC	ERROR (r2) #229	ADVISE (r2) #229	ERROR (r2) #229
UNIDENTIFIABLE PACKET	Table G_3	ADVISE (r2) #169	ERROR (r2) #169
UNSUPPORTED PACKET	Table G_3	ADVISE (r2) #170	ERROR (r2) #170

NORMAL: DTEs process the received packet in accordance with defined procedures.

ADVISE: DTEs discard the received packet and report the condition to a higher level using the specified diagnostic code. No logical channel state transition occurs.

ERROR: DTEs discard the received packet, report the error condition to a higher level and transmit a RESTART_REQUEST packet across the DTE/DCE interface placing all the logical channels in the DTE_RESTART_REQUEST state (r2).

DISCARD: DTEs discard the received packet. No state transition takes place.

Note: State p1 for virtual calls or state d1 for permanent virtual circuits.

TABLE G_3: DTE actions on receipt of packets in given states of the packet level DTE/DCE interface as perceived by the DTE: Call Set-up and Clearing on assigned Logical Channels.

The codes in parentheses (ln) indicate the new state to be entered. The characters after the '#' indicate the diagnostic codes to be reported (see Attachment F).

	PACKET LEVEL READY r1						
State / Packet Received	READY p1	DTE WAIT p2	DCE WAIT p3	DATA XFER p4	CALL COLL p5	DTE CLEAR RQST p6	DCE CLEAR IND. p7
INCOMING CALL	NORMAL (p3) Notes 1, 2	NORMAL (p5) Notes 1, 2	ERROR (p6) #22	ERROR (p6) #23	ERROR (p6) #24	DISC (p6)	ERROR (p6) #26
CALL CONNECTED	ERROR (p6) #20	NORMAL (p4)	ERROR (p6) #22	ERROR (p6) #23	NORMAL (p4)	DISC (p6)	ERROR (P6) #26
CLEAR INDICATION	NORMAL (p7)	NORMAL (p7)	NORMAL (p7)	NORMAL (p7)	NORMAL (p7)	NORMAL (p1)	NORMAL (p7)
DCE CLEAR CONFIRMATION	DISC (p1)	ERROR (p6) #21	ERROR (p6) #22	ERROR (p6) #23	ERROR (p6) #24	NORMAL (p1)	ERROR (p6) #26
OTHER PACKETS	ERROR (p6) #20	ERROR (p6) #21	ERROR (p6) #22	TABLE G_4	ERROR (p6) #24	DISC (p6)	ERROR (p6) #26

NORMAL: DTEs process the received packet in accordance with defined procedures.

ERROR: DTES report an error situation, using the indicated diagnostic code, and clear the virtual call or reset the permanent virtual circuit by transmitting a CLEAR/RESET REQUEST packet across the DTE/DCE interface. Some DTEs may optionally restart the DTE/DCE interface by transmitting a RESTART REQUEST packet.

DISC: The packet is discarded. No state transition occurs.

Note:

1. For one-way outgoing logical channels, DTEs transmit CLEAR_REQUEST with the diagnostic code #227 on SNA-to-SNA connections.

2. For packet format errors, DTEs transmit a RESTART_REQUEST with the diagnostic code #162 on SNA-to-SNA connections. For unsubscribed facilities, DTEs transmit a CLEAR REQUEST with the diagnostic code #228 on SNA-to-SNA connections.

   DTEs transmit a CLEAR REQUEST (on SNA-to-SNA connections, with the diagnostic code #208 if they cannot accept the call for some internal logical reason; and with diagnostic code #12 if the calling DTE has indicated some unsupported end-to-end function (e.g., differing PSH support)).

TABLE G_4: DTE actions on receipt of packets in given States of the packet level DTE/DCE interface as perceived by the DTE: Data transfer, [Interrupt,] (Flow Control and Reset) on Assigned Logical Channels.

The codes in parentheses (ln) specify the new states to be entered The characters after the '#' indicate the diagnostic codes to be reported (see Attachment F).

	DATA TRANSFER p4		
State / Packet Received	FLOW CONTROL READY d1	DTE RESET REQUEST d2	DCE RESET INDICATION d3
RESET INDICATION	NORMAL (d3)	NORMAL (d1 or p6)	ADVISE (d3) #45
DCE RESET CONFIRMATION	ERROR (d2) #27	NORMAL (d1 or p6)	ERROR (d2) #29
DATA, [INTERRUPT,] and FLOW CONTROL	NORMAL (d1)	DISCARD (d2)	ERROR (d2) #29
INVALID PACKET TYPE, QLLC ERROR, PSH ERROR or PACKET NOT SUPPORTED	ERROR (d2) See Attachment F for Diagnostic Codes	DISCARD (d2)	ERROR (d2)

NORMAL: DTEs process the received packet in accordance with defined procedures.

ADVISE: DTEs discard the received packet and report the condition to a higher level using the indicated diagnostic code.

ERROR: DTEs discard the packet, report the error condition using the indicated diagnostic code and clear the virtual call or reset the permanent virtual circuit by transmitting a CLEAR/RESET_REQUEST packet across the DTE/DCE interface.

Some DTEs may optionally restart the DTE/DCE interface by transmitting a RESTART_REQUEST packet.

DISCARD: The packet is discarded. No logical channel state transition occurs.

H.0 APPENDIX H: PSH LOGICAL LINK CONTROL

Logical Link Control (LLC) using Physical Services Headers (PSH)

IBM SNA X.25 DTEs that communicate with remote IBM 5973 Network Interface Adapters (NIAs) use the Physical Services Header (PSH) to perform the logical link control (LLC) functions described in this appendix.

H.1 PHYSICAL SERVICES HEADER FORMATS

PSHs have the structure depicted in Figure H-1.

Octet	Bits 8	7	6	5	4	3	2	1
0	SNA Format Identifier (FID FOX) 1	1	1	1	R	SI	PSI	CPI
1	PSC or SN or Data							
2	PSC or PSC Modifier (PSXID and PSTEST Information field as defined for SDLC XID and TEST, respectively) or Data							
3 . n	PSC Modifier or Data							

Legend:

R — Reserved

SI — Segmenting Indicator
b'1' — More segments to follow
b'0' — Last or only segment

PSI — Packet Sequence Indicator

b'1' — Octet 1 = SN
— Octet 2 = PSC or Data
b'0' — Octet 1 = PSC or Data

— Octet 2 = PSC Modifier or Data

CPI — Control Present Indicator
(Control = PSC or PSC Modifier

b'1' — Control Present
b'0' — Control Not Present

PSC — Physical Services Command

x'02' = PSDISC (DISCONTACT)

x'04' = PSXID (EXCHANGE ID)
x'06' = PSTEST (TEST)
x'08' = PSCONTACT (CONTACT)

SN — Data Packet Sequence Number

Note: Octet 2 of the PSCONTACT and PSTEST responses transmitted by a Secondary/Remote IBM 5973 NIA contains the SDLC station address.

Figure H-1. Physical Services Header (PSH): Formats

PSHs are inserted in front of SNA PIUs transmitted across the network(s), for:

1. Adjacent SNA node physical services - traditional SNA functions such as XID, SNRM, and TEST that are mandatory for IBM SNA X.25 DTEs. Adjacent SNA node physical services are performed according to the same criteria as the equivalent normal response mode SDLC functions.

2. Data Segmentation - permitting IBM SNA X.25 DTEs to segment user data into packets when the 'M' bit procedure is not used.

3. sequence Numbering - an optional end-to-end packet sequence numbering function to provide for the detection of lost, duplicated or disordered data packets.

IBM SNA X.25 DTEs that must remotely connect to an IBM 5973 Network Interface Adapter (NIA) that support only PSH LLC must implement QLLC with 'M' bit segmenting/segment reassembly as well as PSH LLC.

H.2 OPERATING RULES

Rules for use of Physical Services Headers on SNA-to-SNA connections, include:

1. The first octet of the Call User Data field in call control packets is coded with bits 8 through 1 = x'C2' or x'C6' to identify SNA-to-SNA connections that use PSHs.

2. The PSH is used for segmentation. The 'M' bit is not to be set equal to '1' by DTEs in data packets when the PSH is used for segmentation.

3. The maximum User Data field length must be the same at both the local and remote DTE/DCE interfaces.

4. Although either DTE may use the same PSH commands, the use of these is asymmetric. One DTE, designated 'F', may send PSXID, PSTEST or PSCONTACT at any time. The other DTE, designated 'R', must send PSXID, PSTEST or PSCONTACT only after having received the corresponding command.

   Either DTE may send PSDISC at any time.

   After sending PSXID, PSTEST or PSCONTACT, 'F' waits for a reply from 'R'. There is a timeout associated with this wait.

   If 'F' receives a PSXID, PSTEST or PSCONTACT command which is not in response to a corresponding command 'F' sends PSDISC or may terminate the virtual circuit by clearing, resetting or restarting.

   When either 'F' or 'R' receives a PSDISC it responds by sending a PSDISC command (unless a PSDISC collision has occurred) or else terminates the virtual circuit.

5. PSH LLC commands and responses are initiated by the same higher-level events that initiate their SDLC counterparts (see Figure 20 in §-8).

I.0 APPENDIX I: SNA-TO-NON SNA CONSIDERATIONS

Architectural considerations for SNA-to-non_SNA connections

Three implementations approaches are defined for SNA-to-non_SNA connections. In the first one, virtual circuit functions are mapped to an SNA session at the SNA boundary node permitting support of non_SNA nodes across packet-switched networks with limited effect on the subsystems. The second approach provides a transparent path between the X.25 DTE/DCE interface, residing in some SNA boundary node, and an application program interface which handles all the packets defined in CCITT Recommendation X.25. The third approach can provide various degrees of transparency and mapping for X.25 virtual circuit functions.

I.1 IMPLEMENTATION APPROACH 1

A Packet-Mode DTE implemented in an SNA PU.T4 or PU.T5 node acts as a boundary function providing conversion between a virtual circuit and an SNA session. The non-SNA remote nodes may establish several virtual circuits across the network to/from the SNA PU.T4/T5. To each of these virtual circuits, there corresponds a session acting as a transportation mechanism towards some application interface in some SNA host node.

The half session in the PU.T4/T5 will have the appearance of either a SLU or a PLU, depending on the direction of call setting. This is to permit future extension to the SNA pass through function.

The following mappings are possible:

- INCOMING CALL packets may be mapped into either:
  1. Request Contact (with a pseudo ID); or,
  2. Unformatted INITSELF, carrying the contents of the call user data field and the calling DTE address to the USS of an SSCP that controls the PU.T4/T5.
- +RESP/BIND is mapped into CALL ACCEPTED.
- CONNOUT and BIND provide information to create CALL REQUEST.
- CALL CONNECTED is mapped into +RESP/BIND.
- CLEAR INDICATION is mapped into UNBIND.
- UNBIND is mapped into CLEAR REQUEST.
- RESET INDICATION is mapped into an extended SNA CLEAR.
- SNA CLEAR extended is mapped into RESET REQUEST.
- INTERRUPT is mapped into SIGNAL, and vice versa.
- The data field of DATA packets are mapped into RUs.
- Complete packet sequences need not necessarily be reassembled in the PU.T4/T5 before transmission within SNA. Chaining can be used within SNA in order to relate unassembled PIUs which belong to the same packet sequence.
- No direct mapping can be established between the X.25 window rotation mechanism for flow control and the SNA pacing mechanism. The PU.T4/T5 will act as an intermediate buffer and will handle flow control on each network as a function of its general memory assignment strategy by use of the appropriate mechanism on each side.
- The 'D' bit is mapped to the form of RESPONSE REQUESTED bits in the RH, where:
  - 'D'='0' corresponding to the exception response indicator set to '1'.
  - 'D'='1' corresponding to the definite response indicator set to '1'.
- Other higher level SNA functions - such as set and test sequence numbers, brackets and function management header protocols - are not mappable to X.25.

I.2 IMPLEMENTATION APPROACH 2

A possible architecture to permit transparent handling of X.25 is based on the provision of a single session path between the SNA boundary node and the application as depicted in Figure I-2.

All the virtual circuits are multiplexed on this single session flow. Demultiplexing is performed, by analysis of the logical channel number in the packets, by the application. All of the functions of X.25, being thus handled transparently to SNA, can be supported in this environment.

I.3 IMPLEMENTATION APPROACH 3

This hybrid approach is a mixture of approaches 1 and 2. Various degrees of X.25 transparent and mapped function can be acheived on given SNA sessions.

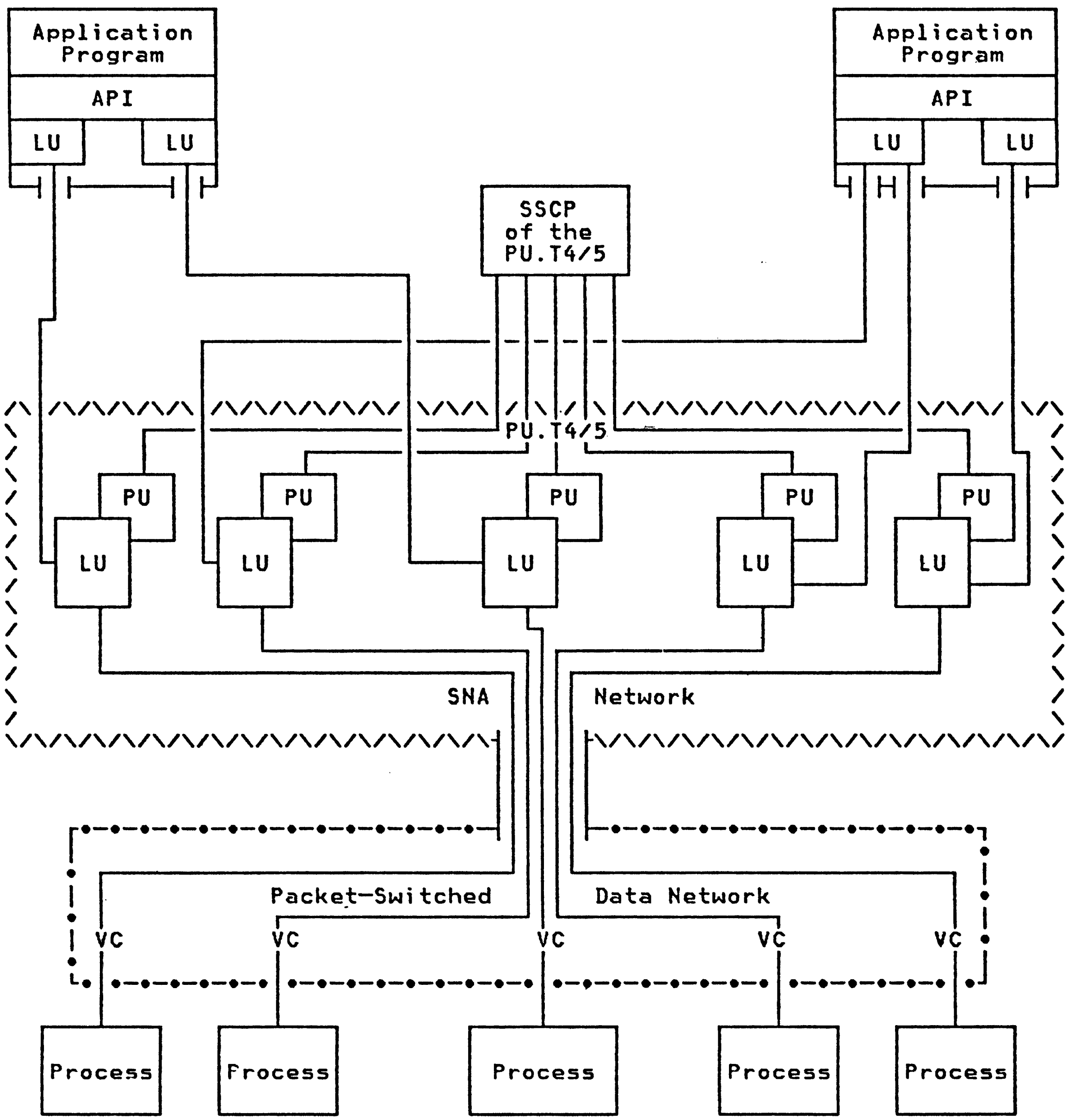

Figure I-1. Virtual Circuit: Relationships to SNA Sessions

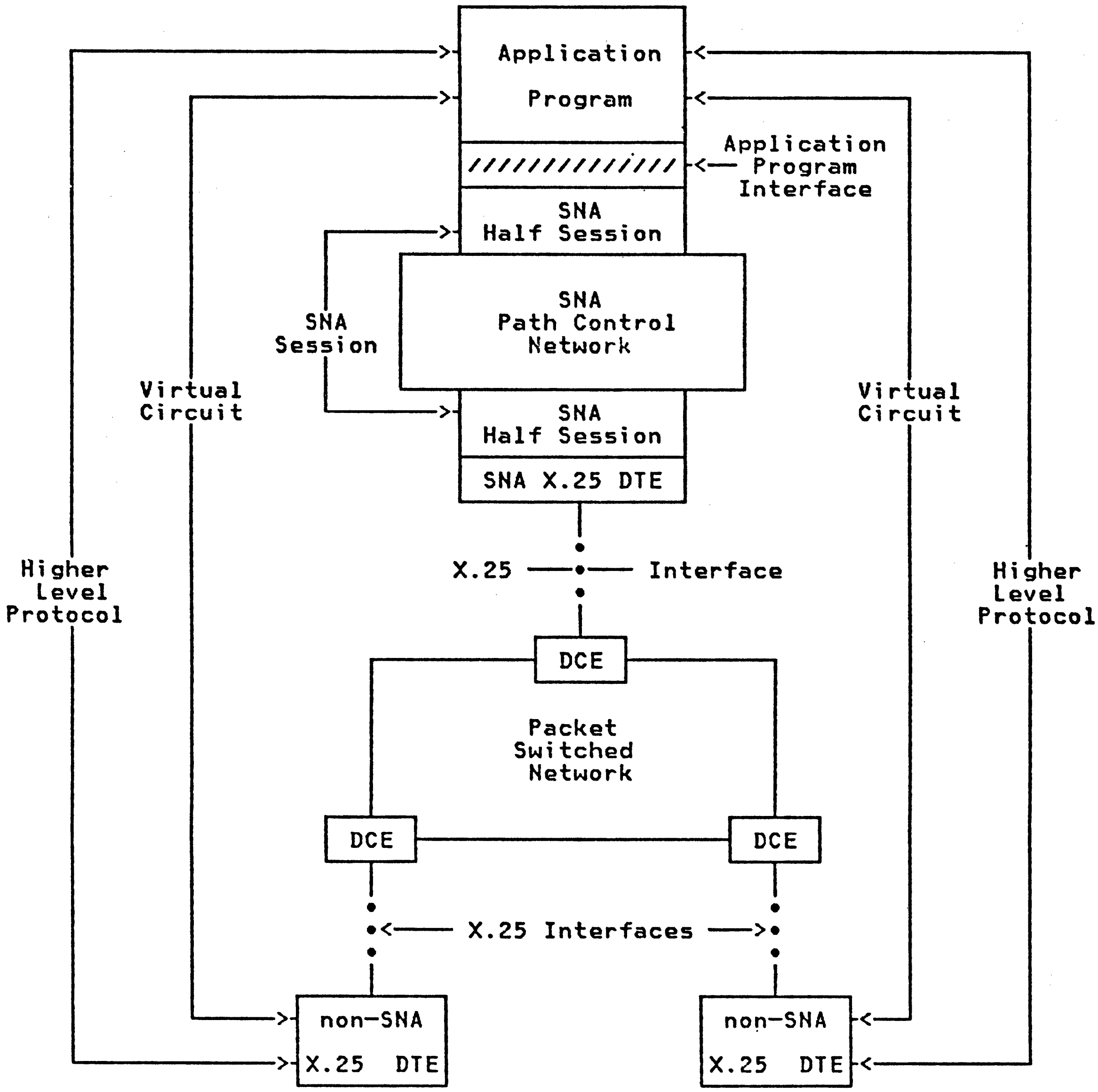

Figure I-2. One Session to Many Virtual Circuits: for SNA-to-non_SNA Connections

J.0 APPENDIX J: LINK LEVEL DTE ACTIONS

Actions taken by DTEs for various link layer events in given Link Channel states of the Link Layer interface as perceived by the DTE

Details on the operation of the Link Layer (Level 2) Balanced Link Access Procedure (LAPB) protocols are given in the form of State/Action tables, in Tables J-1, -2, -3 and -4. Actions to be taken by the DTE as a result of a particular stimulus are shown at the intersection of the various states of the Link Layer interface and the stimuli. Stimuli for the LAPB protocols include the events, commands and responses defined in "LAPB Protocol Stimuli" on page II-J-3. The Link Layer states (identified by single lower case letters '(s)' and the sub-states/options/conditions (identified by superscripts with the state designations '($s^{0,1,,,9}$)') are described in "Link Layer (level 2) States."

Information contained at these intersections show the actions to be taken (indicated by two uppercase letters enclosed in parentheses '(AA)'), the frame types to be sent (if any, indicated by two uppercase letters 'FF') and the new Link Layer states to be entered (if any, indicated by lower case letters enclosed in parentheses '(s)'). A note number reference '#n' is also included when further explanation is required.

The frame type to be sent, 'FF', is any of the commands and responses depicted in Table II-3 of §-2.4.3. Supervisory frames (RR, RNR or REJ identified by RR, NR, and RJ, respectively) are assumed to be responses unless otherwise indicated by the lower case letter 'c' following the frame type to be sent, 'FFc'; and the setting of the Poll/Final 'P/F' bit is indicated by '^{0}' or '^{1}' ('$FF^{0,1}$)'. No frame is transmitted when no frame type to be sent, 'FF', is indicated.

The new Link Layer state(s), (s), indicates which of the defined Link Layer states is to be entered following transmission of the frame type to be sent, 'FF'. The Link Layer interface remains in the current state when no new Link Layer state to be entered, (s), is indicated.

Alternative actions, frame types to be sent and new link layer states (identified by A, F or S, respectively, in the right most position of the STATES column) are shown for sub-states/options/conditions only when they differ from those shown for the base states.

The various Link Layer states/sub-states/options/conditions and the events/commands/responses shown in Tables J-1, -2, -3, and -4 are summarized as follows:

J.1 LINK LAYER (LEVEL 2) STATES

DISCONNECTED State [DISCD - (a)]

Link stations assume the Link Layer DISCONNECTED state (a) (see § 2.4.5.4) when the Physical Layer initially becomes operational, after having received a DISC command and returned a UA response, after having received a UA response to a transmitted DISC command; or, optionally, after having detected the Idle Channel condition on the incoming link channel, if a flag sequence is not received within a specified period of time, Ti (see §§-2.2.12.2 and 2.4.11.5).

LINK SET-UP State [SETUP - (b)]

Link stations desiring to (re)initialize the link layer transmit a SET ASYNCHRONOUS BALANCED MODE (SABM) command and assume the Link Layer LINK SET-UP state (b) until an acknowledging UA or DM response is received from the remote link station (see §-2.4.5.1)

FRAME REJECTION State [FRJCN - (c)]

Link stations having transmitted a FRMR response assume the Link Layer FRAME REJECTION state (c) until reset by the remote link station or until local recovery action is initiated (see §§-2.3.4.10, 2.3.5.6 and 2.4.10).

DISCONNECT REQUESTED State [DCRQD - (d)]

Link stations having transmitted a DISC command assume the Link Layer DISCONNECT REQUESTED state (d) to wait for a UA response from the remote link station (see §-2.4.5.3).

INFORMATION TRANSFER State [IFTRN - (e)]

Link stations having received a UA response to a transmitted SABM command or having returned a UA response to an SABM command from the remote link station assume the Link Layer INFORMATION TRANSFER state (e) (see §-2.4.5.2).

REJECTION State [REJCN - (f)]

Link stations having transmitted a REJ command/response requesting retransmission of an out-of-sequence frame(s) enter the Link Layer REJECTION state (f) (see §§-2.3.5.2, 2.3.5.3 and 2.4.6.5).

CHECKPOINT RECOVERY State [CPRCV - (g)]

Link stations enter the Link Layer CHECKPOINT RECOVERY state (g) upon expiration of Reply Timer, Tp, and transmit an appropriate Supervisory command frame with 'P=1' (see §§-2.3.5.4 and 2.4.6.8).

CHECKPOINT RECOVERY/REJECTION State [CPRRJ - (h)]

The CHECKPOINT RECOVERY/REJECTION state (h) is a composite of the CHECKPOINT RECOVERY state (g) and the REJECTION state (f).

LOCAL STATION BUSY State [LBUSY - (i)]

Link stations having transmitted an RNR command/response, indicating their inability to handle additional information frames due to some internal constraint (i.e., buffer limitation) assume the Link Layer LOCAL STATION BUSY state (i) (see §§-2.3..5.1 and 2.4.6.7).

REMOTE STATION BUSY State [RBUSY - (j)]

Link stations enter the Link Layer REMOTE STATION BUSY state (j) upon receipt of an RNR command/response from the remote link station (see §§-2.3.5.1 and 2.4.6.7).

BOTH STATIONS BUSY State [BBUSY - (k)]

Link stations enter the Link Layer BOTH STATIONS BUSY state (k) upon receipt of an RNR command/response from the remote link station while in the Link Layer LOCAL STATION BUSY state (i); or, after transmitting an RNR command/response while in the Link Layer REMOTE STATION BUSY state (j) (see §§-2.3.5.1 and 2.4.6.7).

REJECTION/LOCAL STATION BUSY [RJNLB - (l)]

This state (l) is a composite of the Link Layer REJECTION state (f) and the Link Layer LOCAL STATION BUSY state (i) (see §§-2.3.5.1, 2.3.5.2, 2.3.5.3, 2.4.6.5, 2.4.6.7).

REJECTION/REMOTE STATION BUSY [RJNRB - (m)]

This state (m) is a composite of the Link Layer REJECTION state (f) and the Link Layer REMOTE STATION BUSY state (j) (see §§-2.3.5.1, 2.3.5.2, 2.3.5.3, 2.4.6.5, 2.4.6.7).

REJECTION/BOTH STATIONS BUSY [RJNBB - (n)]

This state (n) is a composite of the Link Layer REJECTION state (f) and the Link Layer BOTH STATION BUSY state (k) (see §§-2.3.5.1, 2.3.5.2, 2.3.5.3, 2.4.6.5, 2.4.6.7).

CHECKPOINT RECOVERY/LOCAL STATION BUSY [CPRLB - (o)]

This state (o) is a composite of the Link Layer CHECKPOINT RECOVERY state (g) and the Link Layer LOCAL STATION BUSY state (i) (see §§-2.3.5.1, 2.4.6.7 and 2.4.6.8).

CHECKPOINT RECOVERY/REMOTE STATION BUSY [CPRRB - (p)]

This state (p) is a composite of the Link Layer CHECKPOINT RECOVERY state (g) and the Link Layer REMOTE STATION BUSY state (j) (see §§-2.3.5.1, 2.4.6.7 and 2.4.6.8).

CHECKPOINT RECOVERY/BOTH STATIONS BUSY [CPRBB - (q)]

This state (q) is a composite of the Link Layer CHECKPOINT RECOVERY state (g) and the Link Layer BOTH STATIONS BUSY state (k) (see §§-2.3.5.1, 2.4.6.7 and 2.4.6.8).

CHECKPOINT RECOVERY/REJECTION/LOCAL STATION BUSY [CRJLB - (r)]

This state (r) is a composite of the Link Layer CHECKPOINT RECOVERY state (g), the Link Layer REJECTION state (f) and the Link Layer LOCAL STATION BUSY state (i).

CHECKPOINT RECOVERY/REJECTION/REMOTE STATION BUSY [CRJRB - (s)]

This state (s) is a composite of the Link Layer CHECKPOINT RECOVERY state (g), the Link Layer REJECTION state (f) and the Link Layer REMOTE STATION BUSY state (j).

CHECKPOINT RECOVERY/REJECTION/BOTH STATIONS BUSY [CRJBB - (t)]

This state (t) is a composite of the Link Layer CHECKPOINT RECOVERY state (g), the Link Layer REJECTION state (f) and the Link Layer BOTH STATIONS BUSY state (k).

INOPERATIVE [NOPTV - (u)]

The Link Layer assumes the Link Layer INOPERATIVE state (u) when the Physical Layer is not operational (see §-2.4.5.1).

SUB-STATES/OPTIONS/CONDITIONS

Sub-states/Options/Conditions applicable to the various Link Layer states include:

^{0} - Alternatives that may be implemented in lieu of the architecturally preferred procedure.

^{1} - When at a convenient respond opportunity.

^{2} - When a response to a command received with 'P=1" is required.

^{3} - When a response is not appropriate, if desired.

^{4} - When no I-frame is available for transmission or when the link level transmit window is full (e.g., the number of unacknowledged I-frames is equal to 'K').

^{5} - When not prepared to continue operation with, or following, (re)initialization of the Link Layer interface.

^{6} - When enabled and prepared to (re)initialize the link layer interface and support the transfer of information.

^{7} - When not at a convenient respond opportunity and no I-frames have been discarded.

^{8} - When at a convenient respond opportunity and one or more I-frames have been discarded.

^{9} - When not at a convenient respond opportunity and one or more I-frames have been discarded.

J.2 LAPB PROTOCOL STIMULI

Stimuli for the LAPB protocol include the events, commands and responses described in the "Events," "Commands" on page II-J-4 and "Responses" on page II-J-6, respectively.

J.2.1 Events

PLopt (Physical Layer Operational)

The Physical Layer Operational (PLopt) event represents a transition of the Physical Layer (level 1) to the operational state (see §-2.4.5.1).

Lstrt (Link Start)

The Link Start (Lstrt) event represents instruction from a higher layer to set-up (initialize/restart) the Link Layer interface (see §-2.4.5.1).

Lstop (Link Stop)

The Link Stop (Lstop) event represents instruction from a higher layer to terminate Link Layer operation (see §-2.4.5.3).

PLnop (Physical Layer Inoperative)

The Physical Layer Inoperative (PLnop) event represents a transition of the Physical Layer (level 1) to the inoperative state (see §-2.4.5.1).

Ebusy (Local Station Entering Busy Condition)

The Local Station Busy (Ebusy) event occurs when the local station can not accept additional I-frames because of some internal constraint (e.g., buffering limitations, see §-2.4.6.7)

Lbusy (Local Station Exiting Busy Condition)

The Local Station Exiting Busy (Lbusy) event occurs when a local station recovers from a busy condition (see §-2.4.6.7).

TpExp (Timer Tp Expiration)

The Timer Tp Expiration (TpExp) event occurs upon expiration of Reply Timer, Tp (see §-2.4.11.1)

TnExp (Query Timer Tn Expiration)

The Query Timer Tn Expiration (TnExp) event occurs following a period of link inactivity lasting for the duration of Query Timer, Tn (see §§-2.3.4.4, 2.4.6.6 and 2.4.11.1).

FtExp (Nested Time-out Expiration)

This Nested Time-out Expiration event (FtExp) occurs when the maximum number of repetitions (Nd) is exhausted (see §-2.4.11.1).

IlFrm (Illegal Frame)

The Illegal Frame (IlFrm) event represents the correct receipt of a frame containing a command/response that is invalid or not implemented, an information field that exceeds the maximum permissible length, an invalid Nr, an information field that is not permitted, or an S or U frame of incorrect length (see §§-2.3.4.10 and 2.3.5.6).

InFrm (Invalid Frame)

The Invalid Frame (InFrm) event represents the receipt of a frame not properly bounded by two flags, having fewer than 32 bits between flags (see §-2.2.9) or one containing an address other than 'A' or 'B' (see §-2.4.2).

RLchi (Receive Link Channel Idle)

The Receive Link Channel Idle (RLchi) event occurs following detection of the idle condition if a flag sequence is not received within the Idle Time-out period, Ti (see §§-2.2.12.2 and 2.4.11.5).

TLchr (Transmit Link Channel Ready)

The Transmit Link Channel Ready (TLchr) event occurs following transmission of the last bit of the current frame.

J.2.2 Commands

DC^0 (Disconnect with 'P=0')

Represents a DISCONNECT (DISC) command frame with the poll (P) bit set to zero (see §-2.3.4.7).

DC[1] (Disconnect with 'P=1')

Represents a DISCONNECT (DISC) command frame with the poll (P) bit set to one (see §-2.3.4.7).

IR[0] (Requested Information Frame with 'P=0')

Represents the requested information command frame with the poll (P) bit set to zero (see §-2.4.6.5).

IR[1] (Requested Information Frame with 'P=1')

Represents the requested information command frame with the poll (P) bit set to one (see §-2.4.6.5).

IS[0] (In-Sequence Information Frame with 'P=0')

Represents the next in-sequence information (I) command frame with the poll (P) bit set to zero, if available, (see §-2.4.6.2) otherwise continuous flag sequences.

IS[1] (In-Sequence Information Frame with 'P=1')

Represents the next in-sequence information (I) command frame with the poll (P) bit set to one, if available, (see §-2.4.6.2) otherwise continuous flag sequences.

NR[0] (Receive Not Ready with 'P=0')

Represents a RECEIVE NOT READY (RNR) command frame with the poll (P) bit set to zero (see §-2.3.4.4).

NR[1] (Receive Not Ready with 'P=1')

Represents a RECEIVE NOT READY (RNR) command frame with the poll (P) bit set to one (see §-2.3.4.4).

RR[0] (Receive Ready with 'P=0')

Represents a Receive Ready (RR) command frame with the poll (P) bit set to zero (see §-2.3.4.2).

RR[1] (Receive Ready with 'P=1')

Represents a Receive Ready (RR) command frame with the poll (P) bit set to one (see §-2.3.4.2).

RJ[0] (Reject with 'P=0')

Represents a REJECT (REJ) command frame with the poll (P) bit set to zero (see §-2.3.4.3).

RJ[1] (Reject with 'P=1')

Represents a REJECT (REJ) command frame with the poll (P) bit set to one (see §-2.3.4.3).

SE[0] (Out-of-Sequence Information Frame with 'P=0')

Represents an out-of-sequence information command frame with the poll (P) bit set to zero (see §§-2.3.5.2 and 2.4.6.2).

SE[1] (Out-of-Sequence Information Frame with 'P=1')

Represents an out-of-sequence information command frame with the poll (P) bit set to one (see §§-2.3.5.2 and 2.4.6.2).

SM[0] (Set Asynchronous Balanced Mode with 'P=0')

Represents a SET ASYNCHRONOUS BALANCED MODE (SABM) command frame with the poll (P) bit set to zero (see §-2.3.4.6).

SM[1] (Set Asynchronous Balanced Mode with 'P=1')

Represents a SET ASYNCHRONOUS BALANCED MODE (SABM) command frame with the poll (P) bit set to one (see §-2.3.4.6).

Note: Commands followed by 'ak' (LL^0,^{1}ak) indicate a received frame containing an acknowledgement (an Nr greater than the last Nr received) for previously transmitted I-frame(s).

J.2.3 Responses

CF (Continuous Flags)

Represents continuous flag sequences (see §§-2.2.11 and 2.4.5.1).

DM (Disconnected Mode with 'F=0 or 1')

Represents a DISCONNECTED MODE (DM) response frame with the final (F) bit set to either zero or one (see §-2.3.4.9).

FR (Frame Reject with 'F=0 or 1')

Represents a FRAME REJECT (FRMR) response frame with the final (F) bit set to either zero or one (see §-2.3.4.10).

NR^0 (Receive Not Ready with 'F=0')

Represents a RECEIVE NOT READY (RNR) response frame with the final (F) bit set to zero (see §-2.3.4.4).

NR^1 (Receive Not Ready with 'F=1')

Represents a RECEIVE NOT READY (RNR) response frame with the final (F) bit set to one (see §-2.3.4.4).

RJ^0 (Reject with 'F=0')

Represents a REJECT (REJ) response frame with the final (F) bit set to zero (see §-2.3.4.3).

RJ^1 (Reject with 'F=1')

Represents a REJECT (REJ) response frame with the final (F) bit set to one (see §-2.3.4.3).

RR^0 (Receive Ready with 'F=0')

Represents a RECEIVE READY (RR) response frame with the final (F) bit set to zero (see §-2.3.4.2).

RR^1 (Receive Ready with 'F=1')

Represents a RECEIVE READY (RR) response frame with the final (F) bit set to one (see §-2.3.4.2).

UA (Unnumbered Acknowledgement with 'F=0 or 1')

Represents an UNNUMBERED ACKNOWLEDGEMENT (UA) response frame with the final (F) bit set to either zero or one (see §-2.3.4.8).

Note: Responses followed by 'ak' (LL^0,^{1}ak) indicate a received frame containing an acknowledgement (an Nr greater than the last Nr received) for previously transmitted I-frame(s).

J.3 ACTIONS

(AA) Advance Transmit Window and Acknowledge Receipt

Advance the lower transmit window edge to the Nr contained in the received frame, acknowledge receipt (increment Vr by '1') of the received frame and pass the information field to a higher layer (see §§-2.4.6.2, 2.4.6.4 and 2.4.6.8).

(AD) Advance Transmit Window and Discard Frame

Advance the lower transmit window edge to the Nr contained in the received frame and discard the information field (see §§-2.4.6.2.2 and 2.4.6.4).

(AF) Acknowledge Receipt and Forward I-field

Acknowledge receipt (increment Vr by '1') of the received frame and pass the information field to a higher layer (see §-2.4.6.2.1)

(AL) Assure Link

Assure link operation by transmitting a command frame with 'P=1' and starting reply timer, Tp (see §§-2.4.3 and 2.4.6.8).

(AR) Advance Transmit Window and Resume Transmission

Advance the lower transmit window edge to the Nr contained in the received frame and resume sequential transmission of information frames (see§§- 2.4.6.4, 2.4.6.6 and 2.4.6.7).

(AS) Advance Transmit Window and Suspend Transmission

Advance the lower transmit window edge to the Nr contained in the received frame and suspend sequential transmission of information frames (see §§-2.4.6.4 and 2.4.6.6).

(AW) Advance Transmit Window

Advance the lower transmit window edge to the Nr contained in the received frame (see §-2.4.6.4).

(AX) Advance Transmit Window and Set Send Sequence

Advance the lower transmit window edge to the Nr contained in the received frame and set the send sequence variable (Vs) equal to the value of Nr contained in the received frame (see §§-2.4.6.4 and 2.4.6.5).

(DF) Discard Frame

Discard the information field contained in the received frame (see §§-2.4.6.3 and 2.4.6.7).

(DL) Disconnect Link

Initiate the link disconnection procedure described in §-2.4.5.3.

(IC) Increment Count

Increment the retransmission count (see §-2.4.11.2).

(IF) Ignore Frame

Ignore the received frame (see §§-2.2.9, 2.3.5.5 and 2.4.2).

(IH) Inform Higher Layer Protocols

Higher layer protocols may be informed of the event/condition/state using DTE specific internal signalling mechanisms (see §§-2.4.3.1, 2.4.5.1, and 2.4.5.3).

(IL) Initialize Link

Set-up (initialize) the link in accordance with the procedures described in §-2.4.5.1.

(LE) Logical Local Error

Logically erroneous local conditions may be reported to higher layer protocols and the current state maintained pending further instructions.

(PC) Product Criteria

Retransmit the FRMR response until recovery based on local product criteria is initiated.

(NS) No Specific Action

No specific local DTE action required.

(RE) Remote Procedure Error

Logically erroneous remote conditions may be reported to higher layer protocols and the current state maintained pending further instructions.

(RL) Reset Link

Reset (re-initialize) the link in accordance with the procedures described in §-2.4.9.

(RT) Resume Transmission

Resume sequential transmission of information frames (see §§-2.4.6.2.1 and 2.4.6.7).

(SR) Set Send Sequence and Resume Transmission

Set the send sequence variable (Vs) equal to the value of Nr contained in the received frame and resume sequential transmission of information frames (see §§-2.4.6.5 and 2.4.6.7).

(SS) Set Send Sequence

Set the send sequence variable (Vs) equal to the value of Nr contained in the received frame (see §-2.4.6.4).

2 (ST) Suspend Transmission

Suspend sequential transmission of information frames (see §-2.4.6.6).

(TR) Time Reply

Start reply timer, Tp, if it is not already running (see §-2.4.11).

(XR) Advance Window, Set Send Sequence and Resume Transmission

Advance lower transmit window edge, set the send sequence variable (Vs) equal to the value of Nr contained in the received frame and resume sequential transmission of information frames (see §§-2.4.6.4 and 2.4.6.5).

Table II-J-1: Actions taken as a result of Events occurring in various states of the Link Layer Interface as perceived by DTEs

STATES		EVENTS												
		PLopt	Lstrt	Lstop	PLnop	Ebusy	Lbusy	TpExp	TnExp	FtExp	IlFrm	InFrm	RLchi	TLchr
a	DISCD	(LE) – –	(IL) SM^1 (b)	(IH) – –	(IH) – (u)	(IH) – –	(IH) – –	(LE) – –	(LE) – –	(LE) – #3 –	(IH) – #4 –	(IF) – –	(IH) – #1 –	(LE) – –
b	SETUP	(LE) – –	(IH) – –	(DL) DC^1 (d)	(IH) – (u)	(IH) – –	(IH) – –	(IC) SM^1 –	(LE) – –	(IH) – #3 –	(IH) – #4 –	(IF) – –	(IH) – #1 –	(TR) – –
c	FRJCN	(LE) – –	(IH) SM^1 (b)	(DL) DC^1 (d)	(IH) – (u)	(IH) – –	(IH) – –	(PC) FR –	(LE) – –	(IH) – #3 –	(IH) – #4 –	(IF) – –	(IH) – #1 –	(NS) – –
	or F S							DC^1 (d)						
c^0	A F S							(RL) SM^1 (b)						
d	DCRQD	(LE) – –	(LE) – –	(IH) – –	(IH) – (u)	(IH) – –	(IH) – –	(IC) DC^1 –	(LE) – –	(IH) – #3 –	(IH) – #4 –	(IF) – –	(IH) – #1 –	(TR) – –
d^0	A F S										(NS) FR (c)			
e	IFTRN	(LE) – –	(LE) – –	(DL) DC^1 (d)	(IH) – (u)	(IH) – (i)	(LE) – –	(IC) RR^{1}c (g)	(AL) RR^{1}c (g)	(IH) – #3 –	(IH) – #4 –	(IF) – –	(IH) – #1 –	(TR) IS –
e^0	A F S									DC^1 (d)	(NS) FR (c)			
e^1	F					NR								
e^2	F					NR^1								
e^3	F					NR^{1}c								
f	REJCN	(LE) – –	(LE) – –	(DL) DC^1 (d)	(IH) – (u)	(IH) – (l)	(LE) – –	(IC) RR^{1}c (h)	(AL) RR^{1}c (h)	(IH) – #3 –	(IH) – #4 –	(IF) – –	(IH) – #1 –	(TR) IS –
f^0	A F S									DC^1 (d)	(NS) FR (c)			
f^1	F					NR								
f^2	F					NR^1								
f^3	F					NR^{1}c								

Table II-J-1a: Actions taken as a result of Events occurring in various states of the Link Layer Interface as perceived by DTEs

STATES		EVENTS												
		PLopt	Lstrt	Lstop	PLnop	Ebusy	Lbusy	TpExp	TnExp	FtExp	I1Frm	InFrm	RLchi	TLchr
g	CPRCV	(LE) – –	(LE) – –	(DL) DC^1 (d)	(IH) – (u)	(IH) – (o)	(LE) – –	(IC) RR^{1}c –	(AL) RR^{1}c –	(IH) – #3 –	(IH) – #4 –	(IF) – –	(IH) – #1 –	(TR) – –
g^0	A F S									DC^1 (d)	(NS) FR (c)			
g^1	F					NR								
g^2	F					NR^1								
g^3	F					NR^{1}c								
h	CPRRJ	(LE) – –	(LE) – –	(DL) DC^1 (d)	(IH) – (u)	(IH) – (r)	(LE) – –	(IC) RR^{1}c –	(AL) RR^{1}c –	(IH) – #3 –	(IH) – #4 –	(IF) – –	(IH) – #1 –	(TR) – –
h^0	A F S									DC^1 (d)	(NS) FR (c)			
h^1	F					NR								
h^2	F					NR^1								
h3	F					NR^{1}c								
i	LBUSY	(LE) – –	(LE) – –	(DL) DC^1 (d)	(IH) – (u)	(LE) – –	(IH) RR (e)	(IC) NR^{1}c (o)	(AL) NR^{1}c (o)	(IH) – #3 –	(IH) – #4 –	(IF) – –	(IH) – #1 –	(TR) IS –
i^0	A F S									DC^1 (d)	(NS) FR (c)			
i^7	F						RR^{1}c							
i^8	F S						RJ (f)							
i^9	F S						RJ^{1}c (f)							
j	RBUSY	(LE) – –	(LE) – –	(DL) DC^1 (d)	(IH) – (u)	(IH) – (k)	(LE) – –	(IC) RR^{1}c (p)	(AL) RR^{1}c (p)	(IH) – #3 –	(IH) – #4 –	(IF) – –	(IH) – #1 –	(TR) – –
j^0	A F S									DC^1 (d)	(NS) FR (c)			
j1	F					NR								
j^2	F					NR^1								
j^3	F					NR^{1}c								

Table II-J-1b: Actions taken as a result of Events occurring in various states of the Link Layer Interface as perceived by DTEs

STATES		EVENTS												
		PLopt	Lstrt	Lstop	PLnop	Ebusy	Lbusy	TpExp	TnExp	FtExp	IlFrm	InFrm	RLchi	TLchr
k	BBUSY	(LE) – –	(LE) – –	(DL) DC^1 (d)	(IH) – (u)	(LE) – –	(IH) RR (j)	(IC) NR^1c (q)	(AL) NR^1c (q)	(IH) – #3 –	(IH) – #4 –	(IF) – –	(IH) – –	(TR) – –
k^0	A F S									DC^1 (d)	(NS) FR (c)			
k^7	F						RR^1c							
k^8	F						RJ							
k^9	F						RJ^1c							
l	RJNLB	(LE) – –	(LE) – –	(DL) DC^1 (d)	(IH) – (u)	(LE) – –	(IH) RR (f)	(IC) NR^1c (r)	(AL) NR^1c –	(IH) – #3 –	(IH) – #4 –	(IF) – –	(IH) – #1 –	(TR) IS –
l^0	A F S									DC^1 (d)	(NS) FR (c)			
l^3	F						RR^1c							
m	RJNRB	(LE) – –	(LE) – –	(DL) DC^1 (d)	(IH) – (u)	(IH) – (n)	(LE) – –	(IC) RR^1c (s)	(AL) RR^1c –	(IH) – #3 –	(IH) – #4 –	(IF) – –	(IH) – #1 –	(TR) – –
m^0	A F S									DC^1 (d)	(NS) FR (c)			
m1	F					NR								
m^2	F					NR^1								
m^3	F					NR^1c								
n	RJNBB	(LE) – –	(LE) – –	(DL) DC^1 (d)	(IH) – (u)	(LE) – –	(IH) RR (m)	(IC) NR^1c (t)	(AL) NR^1c –	(IH) – #3 –	(IH) – #4 –	(IF) – –	(IH) – #1 –	(TR) – –
n^0	A F S									DC^1 (d)	(NS) FR (c)			
n^3	F						RR^1c							
o	CPRLB	(LE) – –	(LE) – –	(DL) DC^1 (d)	(IH) – (u)	(LE) – –	(IH) RR (g)	(IC) NR^1c –	(AL) NR^1c –	(IH) – #3 –	(IH) – #4 –	(IF) – –	(IH) – #1 –	(TR) – –
o^0	A F S										(NS) FR (c)			
o^3	F						RR^1c							

Table II-J-1c: Actions taken as a result of Events occurring in various states of the Link Layer Interface as perceived by DTEs

STATES		EVENTS												
		PLopt	Lstrt	Lstop	PLnop	Ebusy	Lbusy	TpExp	TnExp	FtExp	IlFrm	InFrm	RLchi	TLchr
p	CPRRB	(LE) – –	(LE) – –	(DL) DC^1 (d)	(IH) – (u)	(IH) – (q)	(LE) – –	(IC) RR^{1}c –	(AL) RR^{1}c –	(IH) – #3 –	(IH) – #4 –	(IF) – –	(IH) – #1 –	(TR) – –
p^0	A F S									DC^1 (d)	(NS) FR (c)			
p1	F					NR								
p^2	F					NR^1								
p^3	F					NR^{1}c								
q	CPRBB	(LE) – –	(LE) – –	(DL) DC^1 (d)	(IH) – (u)	(LE) – –	(IH) RR (p)	(IC) NR^{1}c –	(AL) NR^{1}c –	(IH) – #3 –	(IH) – #4 –	(IF) – –	(IH) – #1 –	(TR) – –
q^0	A F S									DC^1 (d)	(NS) FR (c)			
q^3	F						RR^{1}c							
r	CRJLB	(LE) – –	(LE) – –	(DL) DC^1 (d)	(IH) – (u)	(LE) – –	(IH) RR (h)	(IC) NR^{1}c –	(AL) NR^{1}c –	(IH) – #3 –	(IH) – #4 –	(IF) – –	(IH) – #1 –	(TR) – –
r^0	A F S									DC^1 (d)	(NS) FR (c)			
r^3	F						RR^{1}c							
s	CRJRB	(LE) – –	(LE) – –	(DL) DC^1 (d)	(IH) – (u)	(IH) – (t)	(LE) – –	(IC) RR^{1}c –	(AL) RR^{1}c –	(IH) – #3 –	(IH) – #4 –	(IF) – –	(IH) – #1 –	(TR) – –
s^0	A F S									DC^1 (d)	(NS) FR (c)			
s1	F					NR								
s^2	F					NR^1								
s^3	F					NR^{1}c								
t	CRJBB	(LE) – –	(LE) – –	(DL) DC^1 (d)	(IH) – (u)	(LE) – –	(IH) RR (s)	(IC) NR^{1}c –	(AL) NR^{1}c –	(IH) – #3 –	(IH) – #4 –	(IF) – –	(IH) – #1 –	(TR) – –
t^0	A F S									DC^1 (d)	(NS) FR (c)			
t^3	F						RR^{1}c							
u	NOPTV	(NS) CF (a)	(LE) – –	(IH) – –	(LE) – –	(IH) – –	(IH) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –

Table II-J-2: Actions taken as a result of Information Command Frames received in various states of the Link Layer Interface as perceived by DTEs

STATES		COMMANDS							
		IS^0	IS^0ak	IS^1	IS^1ak	SE^0	SE^0ak	SE^1	SE^1ak
a	DISCD	(IF) – –	(IF) – –	(DF) DM^1 –	(DF) DM^1 –	(IF) – –	(IF) – –	(DF) DM^1 –	(DF) DM^1 –
b	SETUP	(IF) – –	(IF) – –	(DF) DM^1 –	(DF) DM^1 –	(IF) – –	(IF) – –	(DF) DM^1 –	(DF) DM^1 –
c	FRJCN	(DF) FR –	(DF) FR –	(DF) FR^1 –	(DF) FR^1 –	(DF) FR –	(DF) FR –	(DF) FR^1 –	(DF) FR^1 –
c^0	A F	(IF) –	(IF) –	(IF) –	(IF) –	(IF) –	(IF) –	(IF) –	(IF) –
d	DCRQD	(IF) – –	(IF) – –	(DF) DM^1 –	(DF) DM^1 –	(IF) – –	(IF) – –	(DF) DM^1 –	(DF) DM^1 –
e	IFTRN	(AF) IS –	(AA) IS #2 –	(AF) RR^1 –	(AA) RR^1 #2 –	(DF) RJ (f)	(AD) RJ #2(f)	(DF) RJ^1 (f)	(AD) RJ^1 #2(f)
e^4	F	RR	RR						
f	REJCN	(AF) IS (e)	(AA) IS #2(e)	(AF) RR^1 (e)	(AA) RR^1 #2(e)	(DF) IS –	(AD) IS #2 –	(DF) RR^1 –	(AD) RR^1 #2 –
f^0	F					RR	RR		
f^4	F	RR	RR			–	–		
g	CPRCV	(AF) RR –	(AA) RR #2 –	(AF) RR^1 –	(AA) RR^1 #2 –	(DF) RJ (h)	(AD) RJ #2(h)	(DF) RJ^1 (h)	(AD) RJ^1 #2(f)
g^0	S								(h)
h	CPRRJ	(AF) RR (g)	(AA) RR #2(g)	(AF) RR^1 (g)	(AA) RR^1 #2(g)	(DF) RR –	(AD) RR #2 –	(DF) RR^1 –	(AD) RR^1 #2 –
h^0	F	–	–						
i	LBUSY	(DF) NR –	(AD) NR #2 –	(DF) NR^1 –	(AD) NR^1 #2 –	(DF) NR –	(AD) NR #2 –	(DF) NR^1 –	(AD) NR^1 #2 –
j	RBUSY	(AF) RR –	(AA) RR #2 –	(AF) RR^1 –	(AA) RR^1 #2 –	(DF) RJ (m)	(AD) RJ #2(m)	(DF) RJ^1 (m)	(AD) RJ^1 #2(m)

Table II-J-2a: Actions taken as a result of Information Command Frames received in various states of the Link Layer Interface as perceived by DTEs

STATES		COMMAND							
		IS^0	IS^0ak	IS^1	IS^1ak	SE^0	SE^0ak	SE^1	SE^1ak
k	BBUSY	(DF) NR —	(AD) NR #2 —	(DF) NR^1 —	(AD) NR^1 #2 —	(DF) NR —	(AD) NR #2 —	(DF) NR^1 —	(AD) NR^1 #2 —
l	RJNLB	(DF) NR (i)	(AD) NR #2(i)	(DF) NR^1 (i)	(AD) NR^1 #2(i)	(DF) NR —	(AD) NR #2 —	(DF) NR^1 —	(AD) NR^1 #2 —
m	RJNRB	(AF) RR (j)	(AA) RR #2(j)	(AF) RR^1 (j)	(AA) RR^1 #2(j)	(DF) RR —	(AD) RR #2 —	(DF) RR^1 —	(AD) RR^1 #2 —
n	RJNBB	(DF) NR (k)	(AD) NR #2(k)	(DF) NR^1 (k)	(AD) NR^1 #2(k)	(DF) NR —	(AD) NR #2 —	(DF) NR^1 —	(AD) NR^1 #2 —
o	CPRLB	(DF) NR —	(AD) NR #2 —	(DF) NR^1 —	(AD) NR^1 #2 —	(DF) NR —	(AD) NR #2 —	(DF) NR^1 —	(AD) NR^1 #2 —
p	CPRRB	(AF) RR —	(AA) RR #2 —	(AF) RR^1 —	(AA) RR^1 #2 —	(DF) RJ (s)	(AD) RJ #2(s)	(DF) RJ^1 (s)	(AD) RJ^1 #2(s)
q	CPRBB	(DF) NR —	(AD) NR #2 —	(DF) NR^1 —	(AD) NR^1 #2 —	(DF) NR —	(AD) NR #2 —	(DF) NR^1 —	(AD) NR^1 #2 —
r	CRJLB	(DF) NR —	(AD) NR #2 —	(DF) NR^1 —	(AD) NR^1 #2 —	(DF) NR —	(AD) NR #2 —	(DF) NR^1 —	(AD) NR^1 #2 —
s	CRJRB	(AF) RR (p)	(AA) RR #2(p)	(AF) RR^1 (p)	(AA) RR^1 #2(p)	(DF) RR —	(AD) RR #2 —	(DF) RR^1 —	(AD) RR^1 #2 —
t	CRJBB	(DF) NR (q)	(AW) NR #2(q)	(DF) NR^1 (q)	(AW) NR^1 #2(q)	(DF) NR —	(AD) NR #2 —	(DF) NR^1 —	(AD) NR^1 #2 —
u	NOPTV	(LE) — —	(LE) — —	(LE) — —	(LE) — —	(LE) — —	(LE) — —	(LE) — —	(LE) — —

Table II-J-3: Actions taken as a result of Supervisory and Unnumbered Command Frames received in various states of the Link Layer Interface as perceived by DTEs

STATES		COMMAND															
		RR^0	RR^{0}ak	RR^1	RR^{1}ak	RJ^0	RJ^{0}ak	RJ^1	RJ^{1}ak	NR^0	NR^{0}ak	NR^1	NR^{1}ak	SM^0	SM^1	DC^0	DC^1
a	DISCD	(IF) – –	(IF) – –	(DF) DM^1 –	(DF) DM^1 –	(IF) – –	(IF) – –	(DF) DM^1 –	(DF) DM^1 –	(IF) – –	(IF) – –	(DF) DM^1 –	(DF) DM^1 –	(IH) DM –	(IH) DM^1 –	(NS) DM –	(NS) DM^1 –
a^0	A F S													(RL) UA #5(b)	(RL) UA^1 #5(b)		
a^6	F S													UA (e)	UA^1 (e)		
b	SETUP	(IF) – –	(IF) – –	(DF) DM^1 –	(DF) DM^1 –	(IF) – –	(IF) – –	(DF) DM^1 –	(DF) DM^1 –	(IF) – –	(IF) – –	(DF) DM^1 –	(DF) DM^1 –	(IH) UA –	(IH) UA^1 –	(IH) DM (a)	(IH) DM^1 (a)
c	FRJCN	(NS) – –	(NS) – –	(NS) FR^1 –	(NS) FR^1 –	(NS) – –	(NS) – –	(NS) FR^1 –	(NS) FR^1 –	(NS) – –	(NS) – –	(NS) FR^1 –	(SN) FR^1 –	(IH) UA (e)	(IH) UA^1 (e)	(IH) UA (a)	(IH) UA^1 (a)
c^0	F S													UA #5(b)	UA^1 #5(b)		
c^5	F S													UA #6(d)	UA^1 #6(d)		
d	DCRQD	(NS) – –	(NS) – –	(NS) DM^1 –	(NS) DM^1 –	(NS) – –	(NS) – –	(NS) DM^1 –	(NS) DM^1 –	(NS) – –	(NS) – –	(NS) DM^1 –	(NS) DM^1 –	(NS) DM (a)	(NS) DM^1 (a)	(IH) UA –	(IH) UA^1 –
e	IFTRN	(NS) IS –	(AW) IS #2 –	(NS) RR^1 –	(AW) RR^1 #2 –	(SS) IR –	(AX) IR #2 –	(SS) RR^1 –	(AX) RR^1 #2 –	(ST) – (j)	(AS) – #2(j)	(ST) RR^1 (j)	(AS) RR^1 #2(j)	(IH) UA (e)	(IH) UA^1 (e)	(IH) UA (a)	(IH) UA^1 (a)
e^0	F S									RR	RR			UA #5(b)	UA^1 #5(b)		
e^4	F	–	–														
e^5	F S													UA #6(d)	UA^1 #6(d)		
f	REJCN	(NS) IS –	(AW) IS –	(NS) RR^1 –	(AW) RR^1 –	(SS) IR –	(AX) IR #2 –	(SS) RR^1 –	(AX) RR^1 #2 –	(ST) – (m)	(AS) – (m)	(ST) RR^1 (m)	(AS) RR^1 (m)	(IH) UA (e)	(IH) UA^1 (e)	(IH) UA (a)	(IH) UA^1 (a)
f^0	F S									RR	RR			UA #5(b)	UA^1 #5(b)		
f^4	F	–	–														
f^5	F S													UA #6(d)	UA^1 #6(d)		
g	CPRCV	(NS) – –	(AW) – #2 –	(NS) RR^1 –	(AW) RR^1 #2 –	(SS) IR –	(AX) IR #2 –	(SS) RR^1 –	(AX) RR^1 #2 –	(ST) – (p)	(AS) – #2(p)	(ST) RR^1 (p)	(AS) RR^1 #2(p)	(IH) UA (e)	(IH) UA^1 (e)	(IH) UA (a)	(IH) UA^1 (a)
g^0	F S					–	–			RR	RR			UA #5(b)	UA^1 #5(b)		

Table II-J-3a: Actions taken as a result of Supervisory and Unnumbered Command Frames received in various states of the Link Layer Interface as perceived by DTEs

STATES		COMMAND															
		RR^0	RR^{0}ak	RR^1	RR^{1}ak	RJ^0	RJ^{0}ak	RJ^1	RJ^{1}ak	NR^0	NR^{0}ak	NR^1	NR^{1}ak	SM^0	SM^1	DC^0	DC^1
g^5	F S													UA #6(d)	UA^1 #6(d)		
h	CPRRJ	(NS) – –	(AW) – #2 –	(NS) RR^1 –	(AW) RR^1 #2 –	(SS) IR –	(AX) IR #2 –	(SS) RR^1 –	(AX) RR^1 #2 –	(ST) – (s)	(AS) – #2(s)	(ST) RR^1 (s)	(AS) RR^1 #2(s)	(IH) UA (e)	(IH) UA^1 (e)	(IH) UA (a)	(IH) UA^1 (a)
h^0	F S					–	–			RR	RR			UA #5(b)	UA^1 #5(b)		
h^5	F S													UA #6(d)	UA^1 #6(d)		
i	LBUSY	(NS) IS –	(AW) IS #2 –	(NS) NR^1 –	(AW) NR^1 #2 –	(SS) IR –	(AX) IR #2 –	(SS) NR^1 –	(AX) NR^1 #2 –	(ST) – (k)	(AS) – #2(k)	(ST) NR^1 (k)	(AS) NR^1 #2(k)	(IH) UA (e)	(IH) UA^1 (e)	(IH) UA (a)	(IH) UA^1 (a)
i^0	F S									RR	RR			UA #5(b)	UA^1 #5(b)		
i^4	F	–	–														
i^5	F S													UA #6(d)	UA^1 #6(d)		
j	RBUSY	(NS) IS (e)	(AW) IS #2(e)	(NS) RR^1 (e)	(AW) RR^1 #2(e)	(SS) IR (e)	(AX) IR #2(e)	(SS) RR^1 (e)	(AX) RR^1 #2(e)	(NS) – –	(AW) – #2 –	(NS) RR^1 –	(AW) RR^1 #2 –	(IH) UA (e)	(IH) UA^1 (e)	(IH) UA (a)	(IH) UA^1 (a)
j^0	F S									RR	RR			UA #5(b)	UA^1 #5(b)		
j^4	F	–	–														
j^5	F S													UA #6(d)	UA^1 #6(d)		
k	BBUSY	(NS) IS (i)	(AW) IS #2(i)	(NS) NR^1 (i)	(AW) NR^1 #2(i)	(SS) IR (i)	(AX) IR #2(i)	(SS) NR^1 (i)	(AX) NR^1 #2(i)	(NS) – –	(AW) – #2 –	(NS) NR^1 –	(AW) NR^1 #2 –	(IH) UA (e)	(IH) UA^1 (e)	(IH) UA (a)	(IH) UA^1 (a)
k^0	F S									NR	NR			UA #5(b)	UA^1 #5(b)		
k^4	F	–	–														
k^5	F S													UA #6(d)	UA^1 #6(d)		
l	RJNLB	(NS) IS –	(AW) IS #2	(NS) NR^1 –	(AW) NR^1 #2 –	(SS) IR –	(AX) IR #2 –	(SS) NR^1 –	(AX) NR^1 #2 –	(ST) – (n)	(AS) – #2(n)	(ST) NR^1 (n)	(AS) NR^1 #2(n)	(IH) UA (e)	(IH) UA^1 (e)	(IH) UA (a)	(IH) UA^1 (a)
l^0	F S									NR	NR			UA #5(b)	UA^1 #5(b)		
l^4	F S	–	–														

Table II-J-3b: Actions taken as a result of Supervisory and Unnumbered Command Frames received in various states of the Link Layer Interface as perceived by DTEs

STATES		COMMAND															
		RR^0	RR^{0}ak	RR^1	RR^{1}ak	RJ^0	RJ^{0}ak	RJ^1	RJ^{1}ak	NR^0	NR^{0}ak	NR^1	NR^{1}ak	SM^0	SM^1	DC^0	DC^1
1^5	F S													UA #6(d)	UA^1 #6(d)		
m	RJNRB	(NS) IS (f)	(AW) IS #2(f)	(NS) RR^1 (f)	(AW) RR^1 #2(f)	(SS) IR (f)	(AX) IR #2(f)	(SS) RR^1 (f)	(AX) RR^1 #2(f)	(NS) – –	(AW) – #2 –	(NS) RR^1 –	(AW) RR^1 #2 –	(IH) UA (e)	(IH) UA^1 (e)	(IH) UA (a)	(IH) UA^1 (a)
m^0	F S									RR	RR			UA #5(b)	UA^1 #5(b)		
m^4	F	–	–														
m^5	F S													UA #6(d)	UA^1 #6(d)		
n	RJNBB	(NS) IS (l)	(AW) IS #2(l)	(NS) NR^1 (l)	(AW) NR^1 #2(l)	(SS) IR (l)	(AX) IR #2(l)	(SS) NR^1 (l)	(AX) NR^1 #2(l)	(NS) – –	(AW) – #2 –	(NS) NR^1 –	(AW) NR^1 #2 –	(IH) UA (e)	(IH) UA^1 (e)	(IH) UA (a)	(IH) UA^1 (a)
n^0	F S									NR	NR			UA #5(b)	UA^1 #5(b)		
n^4	F	–	–														
n^5	F S													UA #6(d)	UA^1 #6(d)		
o	CPRLB	(NS) – –	(AW) – #2 –	(NS) NR^1 –	(AW) NR^1 #2 –	(SS) – –	(AX) – #2 –	(SS) NR^1 –	(AX) NR^1 #2 –	(ST) – (q)	(AS) – #2(q)	(ST) NR^1 (q)	(AS) NR^1 #2)q)	(IH) UA (e)	(IH) UA^1 (e)	(IH) UA (a)	(IH) UA^1 (a)
o^0	F S						–			NR	NR			UA #5(b)	UA^1 #5(b)		
o^5	F S													UA #6(d)	UA^1 #6(d)		
p	CPRRB	(NS) – (g)	(AW) – #2(g)	(NS) RR^1 (g)	(AW) RR^1 #2(g)	(SS) – (g)	(AX) – #2(g)	(SS) RR^1 (g)	(AX) RR^1 #2(g)	(NS) – –	(AW) – #2 –	(NS) RR^1 –	(AW) RR^1 #2 –	(IH) UA (e)	(IH) UA^1 (e)	(IH) UA (a)	(IH) UA^1 (a)
p^0	F S						–			RR	RR			UA #5(b)	UA^1 #5(b)		
p^5	F S													UA #6(d)	UA^1 #6(d)		
q	CPRBB	(NS) – (o)	(AW) – #2(o)	(NS) NR^1 (o)	(AW) NR^1 #2(o)	(SS) – (o)	(AX) – #2(o)	(SS) NR^1 (o)	(AX) NR^1 #2(o)	(NS) – –	(AW) – #2 –	(NS) NR^1 –	(AW) NR^1 #2 –	(IH) UA (e)	(IH) UA^1 (e)	(IH) UA (a)	(IH) UA^1 (a)
q^0	F S					–	–			NR	NR			UA #5(b)	UA^1 #5(b)		
q^5	F S													UA #6(d)	UA^1 #6(d)		

Table II-J-3c: Actions taken as a result of Supervisory and Unnumbered Command Frames received in various states of the Link Layer Interface as perceived by DTEs

STATES		COMMAND															
		RR^0	RR^{0}ak	RR^1	RR^{1}ak	RJ^0	RJ^{0}ak	RJ^1	RJ^{1}ak	NR^0	NR^{0}ak	NR^1	NR^{1}ak	SM^0	SM^1	DC^0	DC^1
r	CRJLB	(NS) – –	(AW) – #2 –	(NS) NR^1 –	(AW) NR^1 #2 –	(SS) – –	(AX) – #2 –	(SS) NR^1 –	(AX) NR^1 #2 –	(ST) – (t)	(AS) – #2(t)	(ST) NR^1 (t)	(AS) NR^1 #2(t)	(IH) UA (e)	(IH) UA^1 (e)	(IH) UA (a)	(IH) UA^1 (a)
r^0	F S					–	–			NR	NR			UA #5(b)	UA^1 #5(b)		
r^5	F S													UA #6(d)	UA^1 #6(d)		
s	CRJRB	(NS) – (h)	(AW) – #2(h)	(NS) RR^1 (h)	(AW) RR^1 #2(h)	(SS) – (h)	(AX) – #2(h)	(SS) RR^1 (h)	(AX) RR^1 #2(h)	(NS) – –	(AW) – #2 –	(NS) RR^1 –	(AW) RR^1 #2 –	(IH) UA (e)	(IH) UA^1 (e)	(IH) UA (a)	(IH) UA^1 (a)
s^0	F S					–	–			RR	RR			UA #5(b)	UA^1 #5(b)		
s^5	F S													UA #6(d)	UA^1 #6(d)		
t	CRJBB	(NS) – (r)	(AW) – #2(r)	(NS) NR^1 (r)	(AW) NR^1 #2(r)	(SS) – (r)	(AX) – #2(r)	(SS) NR^1 (r)	(AX) NR^1 #2(r)	(NS) – –	(AW) – #2 –	(NS) NR^1 –	(AW) NR^1 #2 –	(IH) UA (e)	(IH) UA^1 (e)	(IH) UA (a)	(IH) UA^1 (a)
t^0	F S					–	–			NR	NR			UA #5(b)	UA^1 #5(b)		
t^5	F S													UA #6(d)	UA^1 #6(d)		
u	NOPTV	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –

Table II-J-4: Actions taken as a result of Response Frames received in various states of the Link Layer Interface as perceived by DTEs

STATES		RESPONSE RR^0	RR^{0}ak	RR^1	RR^{1}ak	RJ^0	RJ^{0}ak	RJ^1	RJ^{1}ak	NR^0	NR^{0}ak	NR^1	NR^{1}ak	UA^0	UA^1	DM^0	DM^1	FR^0
a	DISCD	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF –
b	SETUP	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IH) – (e)	(IF) – –	(IH) – (a)	(IH –
b^0	A																	(IF
c	FRJCN	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(RE) – –	(RE) – –	(RE) – –	(IH –
c^0	A S														(IF)	(IF)	(IF)	(IF
d	DCRQD	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(IF) – –	(FI) – –	(IF) – –	(IH) – (a)	(IF) – –	(IH) – (a)	(IH –
d^0	A S																	(IF
e	IFTRN	(NS) IS –	(AW) IS #2 –	(NS) IS –	(AW) IS #2 –	(SS) IR –	(AX) IR #2 –	(SS) IR –	(AX) IR #2 –	(ST) – (j)	(AS) – #2(j)	(ST) – (j)	(AS) – #2(j)	(IH) DC^1 (d)	(IH) DC^1 (d)	(IH) – (a)	(IH) – (a)	(IH –
e^0	A F S			(IF) –	(IF) –			(IF) –	(IF) –			(IF)	(IF)	SM^1 (b)	SM^1 (b)	SM^1 (b)	SM^1 (b)	DC (c
e^4	F	–	–	–	–													
f	REJCN	(NS) IS –	(AW) IS #2 –	(NS) IS –	(AW) IS #2 –	(SS) IR –	(AX) IR #2 –	(SS) IR –	(AX) IR #2 –	(ST) – (m)	(AS) – #2(m)	(ST) – (m)	(AS) – #2(m)	(IH) DC^1 (d)	(IH) DC^1 (d)	(IH) – (a)	(IH) – (a)	(IH –
f^0	A F S			(IF) –	(IF) –			(IF) –	(IF) –			(IF)	(IF)	SM^1 (b)	SM^1 (b)	SM^1 (b)	SM^1 (b)	DC^1 (c
f^4	F	–	–	–	–	–	–	–	–									
g	CPRCV	(NS) – –	(AR) – #2 –	(RT) IS (e)	(AR) IS #2(e)	(SS) IR –	(AX) IR #2 –	(SS) IR (e)	(AX) IR #2(e)	(NS) – (p)	(AW) – #2(p)	(NS) – (j)	(AW) – #2(j)	(IH) DC^1 (d)	(IH) DC^1 (d)	(IH) – (a)	(IH) – (a)	(IH –
g^0	A F S	(IF)	(IF)			(IF) –	(IF) –			(IF) –	(IF) –			(IF) – –	SM^1 (b)	(IF) –	SM^1 (b)	DC^1 (c
g^4	F			–	–	–	–	–	–									
h	CPRRJ	(NS) – –	(AR) – #2 –	(RT) IS (f)	(AR) IS #2(f)	(SS) IR –	(AX) IR #2 –	(SS) IR (f)	(AX) IR #2(f)	(NS) – (s)	(AW) – #2(s)	(NS) – (m)	(AW) #2(m)	(IH) DC^1 (d)	(IH) (DC^1 (d)	(IH) – (a)	(IH) – (a)	(IH) – –

Table II-J-4a: Actions taken as a result of Response Frames received in various states of the Link Layer Interface as perceived by DTEs

STATES		RESPONSE																
		RR^0	RR^{0}ak	RR^1	RR^{1}ak	RJ^0	RJ^{0}ak	RJ^1	RJ^{1}ak	NR^0	NR^{0}ak	NR^1	NR^{1}ak	UA^0	UA^1	DM^0	DM^1	FR^{0,1}
h^0	A F S	(IF)	(IF)			(IF) –	(IF) –			(IF) –	(IF) –			(IF) – –	 SM^1 (b)	(IF) –	 SM^1 (b)	 DC^1 (d)
h^4	F			–	–	–	–	–	–									
i	LBUSY	(NS) IS –	(AW) IS #2 –	(NS) IS –	(AW) IS #2 –	(SS) IR –	(AX) IR #2 –	(SS) IR –	(AX) IR #2 –	(ST) – (k)	(AS) – #2(k)	(ST) – (k)	(AS) – #2(k)	(IH) DC^1 (d)	(IH) DC^1 (d)	(IH) – (a)	(IH) – (a)	(IH) – –
i^0	A F S			(IF) –	(IF) –			(IF) –	(IF) –			(IF)	(IF)	 SM^1 (b)	 SM^1 (b)	 SM^1 (b)	 SM^1 (b)	 DC^1 (d)
i^4	F	–	–	–	–	–	–	–	–									
j	RBUSY	(RT) IS (e)	(AR) IS #2(e)	(RT) IS (e)	(AR) IS #2(e)	(SR) IR (e)	(XR) IR #2(e)	(SR) IR (e)	(XR) IR #2(e)	(NS) – –	(AW) – #2 –	(NS) – –	(AW) – #2 –	(IH) DC^1 (d)	(IH) DC^1 (d)	(IH) – (a)	(IH) – (a)	(IH) – –
j^0	A F S			(IF) – –	(IF) – –			(IF) – –	(IF) – –			(IF)	(IF)	 SM^1 (b)	 SM^1 (b)	 SM^1 (b)	 SM^1 (b)	 DC^1 (d)
j^4	F	–	–	–	–	–	–	–	–									
k	BBUSY	(RT) IS (i)	(AR) IS #2(i)	(RT) IS (i)	(AR) IS #2(i)	(SR) IR (i)	(XR) IR #2(i)	(SR) IR (i)	(XR) IR #2(i)	(NS) – –	(AW) – #2 –	(NS) – –	(AW) – #2 –	(IH) DC^1 (d)	(IH) DC^1 (d)	(IH) – (a)	(IH) – (a)	(IH) – –
k^0	A F S			(IF) – –	(IF) – –			(IF) – –	(IF) – –			(IF)	(IF)	 SM^1 (b)	 SM^1 (b)	 SM^1 (b)	 SM^1 (b)	 DC^1 (d)
k^4	F	–	–	–	–	–	–	–	–									
l	RJNLB	(NS) IS –	(AW) IS #2 –	(NS) IS –	(AW) IS #2 –	(SS) IR –	(AX) IR #2 –	(SS) IR –	(AX) IR #2 –	(ST) – (n)	(AS) – #2(n)	(ST) – (n)	(AW) – #2(n)	(IH) DC^1 (d)	(IH) DC^1 (d)	(IH) – (a)	(IH) – (a)	(IH) – –
l^0	A F S			(IF) –	(IF) –			(IF) –	(IF) –			(IF)	(IF)	 SM^1 (b)	 SM^1 (b)	 SM^1 (b)	 SM^1 (b)	 DC^1 (d)
l^4	F	–	–	–	–	–	–	–	–									
m	RJNRB	(RT) IS (f)	(AR) IS #2(f)	(RT) IS (f)	(AR) IS #2(f)	(SR) IR (f)	(XR) IR #2(f)	(SR) IR (f)	(XR) IR #2(f)	(NS) – –	(AW) – #2 –	(NS) – –	(AW) – #2 –	(IH) DC^1 (d)	(IH) DC^1 (d)	(IH) – (a)	(IH) – (a)	(IH) – –
m^0	A F S			(IF) – –	(IF) – –			(IF) – –	(IF) – –			(IF)	(IF)	 SM^1 (b)	 SM^1 (b)	 SM^1 (b)	 SM^1 (b)	 DC^1 (d)
m^4	F	–	–	–	–	–	–	–	–									
n	RJNBB	(RT) IS (l)	(AR) IS #2(l)	(RT) IS (l)	(AR) IS #2(l)	(SR) IR (l)	(XR) IR #2(l)	(SR) IR (l)	(XR) IR #2(l)	(NS) – –	(AW) – #2 –	(NS) – –	(AW) – #2 –	(IH) DC^1 (d)	(IH) DC^1 (d)	(IH) – (a)	(IH) – (a)	(IH) – –

Table II-J-4b: Actions taken as a result of Response Frames received in various states of the Link Layer Interface as perceived by DTEs

STATES		RESPONSE																
		RR^0	RR^{0}ak	RR^1	RR^{1}ak	RJ^0	RJ^{0}ak	RJ^1	RJ^{1}ak	NR^0	NR^{0}ak	NR^1	NR^{1}ak	UA^0	UA^1	DM^0	DM^1	FR^{0,1}
n^0	A F S			(IF) – –	(IF) – –			(IF) – –	(IF) – –			(IF)	(IF)	SM^1 (b)	SM^1 (b)	SM^1 (b)	SM^1 (b)	DC^1 (d)
n^4	F	–	–	–	–	–	–	–	–									
o	CPRLB	(NS) – –	(AR) – #2 –	(RT) IS (i)	(AR) IS #2(i)	(SS) – –	(AX) – #2 –	(SR) IR (i)	(AX) IR #2(i)	(ST) – (q)	(AR) – #2(q)	(ST) – (k)	(AS) – #2(k)	(IH) DC^1 (d)	(IH) DC^1 (d)	(IH) – (a)	(IH) – (a)	(IH) – –
o^0	A F S	(IF)	(IF)			(IF) –	(IF) –			(IF)	(IF)			SM^1 (b)	SM^1 (b)	SM^1 (b)	SM^1 (b)	DC^1 (d)
o^4	F			–	–	–	–	–	–									
p	CPRRB	(IH) – (g)	(IH) – #2(g)	(RT) IS (e)	(AR) IS #2(e)	(SR) – (g)	(XR) – #2(g)	(SR) IR (e)	(XR) IR #2(e)	(NS) – –	(AW) – #2 –	(NS) – (j)	(AS) – #2(j)	(IH) DC^1 (d)	(IH) DC^1 (d)	(IH) – (a)	(IH) – (a)	(IH) – –
p^0	A F S	(IF) –	(IF) –			(IF) – –	(IF) – –			(IF)	(IF)			SM^1 (b)	SM^1 (b)	SM^1 (b)	SM^1 (b)	DC^1 (d)
p^4	F			–	–	–	–	–	–									
q	CPRBB	(IH) – (o)	(AR) – #2(o)	(RT) IS (i)	(AR) IS #2(i)	(SS) – (o)	(XR) – #2(o)	(SS) IR (i)	(XR) IR #2(i)	(NS) – –	(AW) – #2(k)	(NS) – –	(AW) – #2(k)	(IH) DC^1 (d)	(IH) DC^1 (d)	(IH) – (a)	(IH) – (a)	(IH) – –
q^0	A F S	(IF) –	(IF) –			(IF) – –	(IF) – –			(IF)	(IF)			SM^1 (b)	SM^1 (b)	SM^1 (b)	SM^1 (b)	DC^1 (d)
q^4	F			–	–	–	–	–	–									
r	CRJLB	(NS) – –	(AR) – #2 –	(RT) IS (l)	(AR) IS #2(l)	(SS) – –	(XR) – #2 –	(SR) IR (l)	(XR) IR #2(l)	(NS) – (t)	(AW) – #2(t)	(NS) – (n)	(AW) – #2(n)	(IH) DC^1 (d)	(IH) DC^1 (d)	(IH) – (a)	(IH) – (a)	(IH) – –
r^0	A F S	(IF) –	(IF) –			(IF) – –	(IF) – –			(IF)	(IF)			SM^1 (b)	SM^1 (b)	SM^1 (b)	SM^1 (b)	DC^1 (d)
r^4	F			–	–	–	–	–	–									
s	CRJRB	(IH) – (h)	(AR) – #2(h)	(RT) IS (f)	(AR) IS #2(f)	(SS) – (h)	(XR) – #2(h)	(SR) IR (f)	(XR) IR #2(f)	(NS) – –	(AW) – #2 –	(NS) – (m)	(AW) – #2(m)	(IH) DC^1 (d)	(IH) DC^1 (d)	(IH) – (a)	(IH) – (a)	(IH) – –
s^0	A F S	(IF) –	(IF) –			(IF) – –	(IF) – –			(IF)	(IF)			SM^1 (b)	SM^1 (b)	SM^1 (b)	SM^1 (b)	DC^1 (d)
s^4	F			–	–	–	–	–	–									
t	CRJBB	(IH) – (r)	(AR) – #2(r)	(RT) IS (l)	(AR) IS #2(l)	(SS) – (r)	(XR) – #2(r)	(SR) IR (l)	(XR) IR #2(l)	(NS) – –	(AW) – #2 –	(NS) – (n)	(AW) – #2(n)	(IH) DC^1 (d)	(IH) DC^1 (d)	(IH) – (a)	(IH) – (a)	(IH) – –

Table II-J-4c: Actions taken as a result of Response Frames received in various states of the Link Layer Interface as perceived by DTEs

STATES		RESPONSE																
		RR^0	RR^0ak	RR^1	RR^1ak	RJ^0	RJ^0ak	RJ^1	RJ^1ak	NR^0	NR^0ak	NR^1	NR^1ak	UA^0	UA^1	DM^0	DM^1	$FR^{0,1}$
t^0	A	(IF)	(IF)			(IF)	(IF)			(IF)	(IF)							
	F					–	–							SM^1	SM^1	SM^1	SM^1	DC^1
	S	–	–			–	–							(b)	(b)	(b)	(b)	(d)
t^4	F			–	–	–	–	–	–									
u	NOPTV	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –	(LE) – –

Note 1 - Detection of the Idle Channel condition may be either ignored; or, if a flag sequence is not received within a period of time (Ti), considered as an event causing a change to the DISCONNECTED state (a) (see § 2.2.12.2).

Note 2 - Upon correct receipt of a frame (containing an Nr that is higher than the last Nr received) acknowledging some previously transmitted I-frame(s), DTEs reset (stop) Reply Timer Tp and if additional unacknowledged I-frame(s) are still outstanding they restart Reply Timer Tp.

Note 3 - Expirations of the Nested Time-out Function (Ft) are reported to a higher layer and the current state(s) of the Link Layer Interface maintained pending instructions from the higher layer.

Note 4 - Illegal frames received are reported to a higher layer and the current state(s) of the Link Layer Interface maintained pending instructions from the higher layer. (FRMR?)

Note 5 - To maintain DTE control, the 3705/X.25 NPSI transmits a SABM command with 'P=1', creating a collision of like commands, and then transmits a UA response to the received SABM command.

>Note 6 - DTEs not prepared to continue/resume normal link level operation transmit a UA response followed by a DISC command and enter the Disconnect Requested (DCRQD) state.

LINK LAYER ACTION CODE REFERENCE SUMMARY

(AA) — Advance Transmit Window, Acknowledge Receipt and Forward

(AD) — Advance Transmit Window and Discard Frame

(AF) — Acknowledge Receipt and Forward

(AL) — Assure Link

(AR) — Advance Transmit Window and Resume Transmission

(AS) — Advance Transmit Window and Suspend Transmission

(AW) — Advance Transmit Window

(AX) — Advance Transmit Window and Set Send Sequence

(DF) — Discard Frame

(DL) — Disconnect Link

(IC) — Increment Count

(IF) — Ignore Frame

(IH) — Report Status/Condition

(IL) — Initialize Link

(LE) — Local Procedure Error

(NS) — No Specific Action

(RE) — Remote Procedure Error

(RL) — Reset Link Level

(RT) — Resume Transmission

(SR) — Set Send Sequence and Resume Transmission

(SS) — Set Send Sequence

(ST) — Suspend Transmission

(TR) — Time Reply

(XR) — Advance Transmit Window, Set Send Sequence and Resume Transmission

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K.0 APPENDIX K: ENHANCED LOGICAL LINK CONTROL - ELLC

The formats and protocols described in this appendix are adaptations of Asynchronous Balanced Mode (ABM) formats defined for HDLC and the X.25 Link Access Procedure - Balanced (LAPB) elements of procedure expanded to include an adaptation of the checksum data integrity mechanism defined in IS-8073 (Open Systems Interconnection Transport Protocol Specification - ISO/TC-97/SC-6-N3240) dated September 1984.

K.1 FUNCTIONAL OVERVIEW

K.1.1 Architecture

Architecture to meet SNA quality of service requirements in packet-switched data network environments:

1. extends the Protocol Identifier defined for QLLC, in chapter 8.0, to allow selection of the ELLC protocol, at call set-up time, as an alternative to QLLC or PSH_LLC;
2. definition of a Connection_Type_Indicator (CTI) field within the Call_User_Data field of X.25 CALL_REQUEST packets to distinguish between initial connection requests and connection recovery requests for ELLC;
3. use of the Connection_Identifier (CID) field in Call Set-up packets to carry Link_Connection_Identification information between adjacent link stations;
4. definition of LPDU headers that include:
   - a two-byte address field;
   - an extended (two-byte) control field;
   - a two-byte checksum field; and,
   - the use of LPDU headers in the User_Data field of X.25 DATA packets and DATA packet sequences to perform sequenced transfer of BTUs between link stations in adjacent SNA nodes.
5. the definition of recoverable call clearing, virtual circuit resetting and interface restarting cause codes together with link connection recovery procedures.

K.1.2 Link Connection Service

With a one-for-one correspondence between DLC.X25 link connections and X.25 virtual circuits, link connection services required for logical link control, to meet quality of service enhancement objectives in PSDN environments, are provided by adaptation of existing X.25 Packet Level call set-up and clearing procedures.

K.1.3 Link Connection Identification

Since a one-for-one correspondence exists between X.25 logical channels and LLC link stations, X.25 logical channel identifiers can be used by LLC to route DATA packets to the appropriate link station. DLC.X25 link connection identification requirements are satisfied by correlating X.25 Calling DTE Address, concatenated with a Connection Identifier carried in CALL REQUEST packets when parallel virtual calls are employed between DTEs, with X.25 logical channel identifiers.

K.1.3.1 Permanent Virtual Circuit Services

The relationship between DLC.X25 link connections employing permanent virtual circuits and X.25 logical channel identifiers are fixed by bilateral agreement between communicating link stations; therefore, X.25 logical channel identifiers can suffice for both LLC routing and error recovery functions, in this environment.

K.1.3.2 Switched_Virtual_Circuit (Virtual Call) Services

Since X.25 logical channel identifiers for switched virtual circuits are dynamically assigned at call set-up time, they suffice only for the LLC routing function; and, are correlated to the X.25 Calling DTE Address, concatenated with the Connection Identifier as required, for use in error situations requiring re-connection procedures.

K.1.4 Error Detection and Recovery

LLC error detection and recovery requirements are satisfied by ELLC which, when selected, provides mechanisms to detect, and procedures to attempt recovery from, the loss, duplication and/or corruption of LPDUs by underlying network services. ELLC incorporates sequence numbering and validity checking mechanisms, as well as circuit assurance procedures.

K.1.4.1 Sequence Numbering

ELLC formats and protocols provide for the sequenced (modulo 128) transfer of information LPDUs, together with LPDU acknowledgment and retransmission recovery procedures to guard against the loss or duplication of LPDUs, or both.

K.1.4.2 Validity Checking

ELLC also employs a checksum mechanism to detect LPDUs that have been corrupted by underlying network services and to insure the integrity of BTUs delivered to higher level using protocols.

K.1.4.3 Circuit Assurance

ELLC circuit assurance capability defines recoverable error conditions reported by PSDNs through CLEAR, RESET and RESTART packets, as well as procedures for ascertaining and performing actual circuit recoverability.

K.2 SCOPE AND FIELD OF APPLICATION

The Logical Link Control (LLC) procedure is described as the element used to enhance the quality of service exhibited to higher level SNA users by the underlying network services in supporting the transfer of information between adjacent SNA nodes in PSDN environments.

The procedure uses the principles and terminology of the High Level Data Link Control (HDLC) procedures specified by the International Organization for Standardization (ISO).

The transmission facility is duplex.

Compatibility of operation with the ISO balanced class of procedure (Class BA, options 1, 2, 8 and 12) is achieved using the provisions found in this specification.

K.3 LINK PROTOCOL DATA UNIT STRUCTURE

All transfers across ELLC link connections are in LLC Protocol Data Units (LPDUs) conforming to one of the formats shown in Figure K-1 and contained in the User Data field of X.25 DATA packets or DATA packet sequences.

Supervisory and Unnumbered Format

Octet	1	2	3	4	5	6
	Address		Control		PDUCS	
	A 16-bits		C 16-bits		X 2 Octets*	Y

Information Format

Octet	1	2	3	4	5	6	7	6+N
	Address		Control		PDUCS		I-Field	
	A 16-bits		C 16-bits		X 2 Octets*	Y	I N-Octets*	

PDUCS = Protocol Data Unit Checking Sequence - (Checksum)
* an Octet is an 8-bit byte.

Figure K-1. LPDU Formats: Supervisory and Unnumbered versus Information

K.3.1 Address (A) Field

The LPDU address is a two-octet (16-bit) field which has the format shown in Figure K-2. The A field is positioned as shown in Figure K-1 and coded as described in "Procedure for Addressing" on page II-K-13.

Octet 1								Octet 2							
Address Bits															
1	-	-	-	-	-	-	-	-	-	-	-	-	-	15	16
ADDRESS															C/R
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x

where:
ADDRESS - is reserved and set to zeroes; and

x - is the LPDU command/response (C/R) indicator which is set to:
'0' in command LPDUs; and,
'1' in response LPDUs.

Figure K-2. LPDU: Address Field Format

K.3.2 Control (C) Field

The C field is two octets positioned as shown in Figure K-1 whose content is described in "LPDU Formats and State Variables" on page II-K-5.

K.3.3 Information (I) Field

The I-field of LPDUs transmitted and received by link stations contain an SNA Path Information Unit (PIU) consisting of an integral number of octets (8-bit bytes).

Note: LPDUs containing other than an integral number of octets may be ignored at the physical or link level.

See "LLC_Protocol_Data_Unit_Reject (LPDUR) Response" on page II-K-9 and "List of LLC Parameters" on page II-K-20 with regard to the maximum information field length.

K.3.4 Protocol Data Unit Checking Sequence (PDUCS) Field

The PDUCS field is two octets positioned as shown in Figure K-1 whose content is described in "Protocol_Data_Unit_Checking_Sequence (PDUCS)" on page II-K-11.

K.3.5 Order of Transmission

Address, control, sequence number, Protocol Data Unit Checking Sequence (PDUCS) and information octets are transmitted in ascending octet number order as indicated in Figure K-1 low order bit first.

K.3.6 Invalid LPDUs

LPDUs having fewer than forty-eight bits (six octets) are invalid.

K.3.7 Link Channel States

A link channel is defined as the means of transmission for one direction.

K.3.7.1 Active State

A link channel is in an active condition when the link station is actively transmitting an LPDU.

K.3.7.2 Idle State

A link channel is defined to be in an idle condition when the link station fails to receive an LPDU for a system specified period of time.

K.4 ELEMENTS OF PROCEDURE

The elements of procedure are defined in terms of actions that occur on receipt of commands or responses or the occurrence of events, at ELLC link stations.

The elements of procedure specified here contain a selection of commands and responses relevant to the ELLC link connection and system configuration described in "Scope and Field of Application" on page II-K-2.

A procedure derived from these elements of procedure is described in "Description of the Procedure" on page II-K-13. Together "LPDU Formats and State Variables" on page

II-K-5 and "Elements of Procedure" form the general requirements for proper management of link connections between ELLC link stations in adjacent nodes.

K.4.1 LPDU Formats and State Variables

The various LPDU formats and link station state variables used for ELLC are described under "Control (C) Field Formats" and "Control Field Parameters."

K.4.1.1 Control (C) Field Formats

The C field contains a command or a response, and sequence numbers, where applicable. Three LPDU C-field formats as shown in Figure K-3 are defined for use:

- IPDUs - to perform sequenced information transfers;
- SPDUs - to perform numbered supervisory functions; and
- UPDUs - to perform unnumbered control functions.

Control field bits	Second Octet 8 7 6 5 4 3 2	1	First Octet 8 7 6	5	4 3	2	1
Information (IPDU)	LNr	P	LNs				0
Supervisory (SPDU)	LNr	P/F	x x x	x	S S	0	1
Unnumbered (UPDU)	LNr	P/F	M M M	0	M M	1	1

LNs = transmitter send sequence number (bit 2 = low order bit).
LNr = transmitter receive sequence number (bit 2 = low order bit).
S = supervisory function bit.
M = modifier function bit.
P/F = poll (P) bit in command frames or final (F) bit in response frames (1 = Poll/Final).

Figure K-3. LPDU: Control Field Formats

Information_Protocol_Data_Unit - IPDU: used to perform sequenced information transfers. Except as otherwise specified (i.e., LPDUR, LTEST, LXID) it is the only LPDU that may contain an information field. The functions of LNs, LNr and P/F are independent; i.e., each IPDU has an LNs, and an LNr which may or may not acknowledge additional IPDUs received by the ELLC link station transmitting the LNr, and a P/F bit.

Supervisory_Protocol_Data_Unit - SPDU: used to perform link supervisory control functions such as acknowledging IPDUs, requesting retransmission of IPDUs, and requesting temporary suspension of IPDU transmission.

Unnumbered_Protocol_Data_Unit - UPDU: used to provide additional link control functions. This format contains no sequence numbers.

K.4.1.2 Control Field Parameters

Parameters associated with the control field formats include a modulus (m), LPDU variables and sequence numbers.

Modulus - 'm': IPDUs are sequentially numbered and may have the value 'LNs=0' through 'LNs=m minus one' (where 'm' is the modulus of the sequence numbers). 'm' is equal to '128' and the sequence numbers cycle through the entire range '0' to '127', inclusive.

State Variables and Sequence Numbers:

1. Link Send State Variable (LVs)

LVs denotes the sequence number of the next in-sequence IPDU to be transferred across the link connection. LVs can take on the value '0' through 'm minus one'. The value of LVs is incremented by one with each successive IPDU transferred but at originating link stations cannot exceed LNr of the last received IPDU or SPDU by more than the maximum permissible number of outstanding IPDUs (Lk). The value of 'Lk' is defined in "Maximum Number of Outstanding IPDUs - (Lk)" on page II-K-23.

2. Link Send Sequence Number (LNs)

   Only IPDUs contain LNs, the send sequence number of transferred PDUs. Prior to transferring an in-sequence IPDU, the value of LNs is set equal to the value of LVs at the originating link station.

3. Link Receive State Variable (LVr)

   LVr denotes the sequence number of the next in-sequence IPDU to be received at destination link stations. LVr can take on the values '0' through 'm minus one'. The value of LVr is incremented by one upon receipt of each error free, in-sequence (with an LNs that is equal to the current value of LVr at the receiving link station) IPDU.

4. Link Receive Sequence Number (LNr)

   All IPDUs and SPDUs contain LNr, the expected sequence number of the next received IPDU. Prior to transmitting an IPDU or SPDU, LNr is set equal to the current value of LVr at the originating link station. LNr indicates that the link station transferring the LNr has correctly received all IPDUs numbered up to and including 'LNr minus 1'.

K.4.1.3 Functions of the Poll/Final Bit

The poll/final (P/F) bit serves a function in both command LPDUs and response LPDUs. In command LPDUs the 'P/F' bit is referred to as the Poll (P) bit. In response LPDUs it is referred to as the Final (F) bit.

Procedures for use of the 'P/F' bit are described in "Procedure for Use of the P/F Bit" on page II-K-14.

K.4.2 Link Commands and Responses

Command and response LPDUs transmitted and received by link stations in adjacent nodes are depicted in Figure K-4 and are described in "LLC_Information (LI) Command" on page II-K-7 through "LLC_Test (LTEST) Command and Response" on page II-K-10.

PDU	CMD	RSP	Second Octet Bit Positions 8 7 6 5 4 3 2	1	First Octet 8 7 6	5	4 3	2	1
(I)	LI		LNr	P	LNs				0
(S) Note	LRR	LRR	LNr	P/F	0 0 0	0	0 0	0	1
	LRNR	LRNR	LNr	P/F	0 0 0	0	0 1	0	1
	LREJ	LREJ	LNr	P/F	0 0 0	0	1 0	0	1
(U) Note		LDM	0 0	F	0 0 0	0	1 1	1	1
	LSABME		0 0	P	0 1 1	0	1 1	1	1
	LDISC		0 0	P	0 1 0	0	0 0	1	1
		LUA	0 0	F	0 1 1	0	0 0	1	1
		LPDUR	0 0	F	1 0 0	0	0 1	1	1
	LXID	LXID	0 0	P/F	1 0 1	0	1 1	1	1
	LTEST	LTEST	0 0	P/F	1 1 1	0	0 0	1	1

LDISC = LLC Disconnect
LDM = LLC Disconnected Mode
LPDUR = LLC Protocol Data Unit Reject
LI = LLC Information
LREJ = LLC Reject
LRNR = LLC Receive Not Ready
LRR = LLC Receive Ready
LSABME = LLC Set Asynchronous Balanced Mode — Extended
LUA = LLC Unnumbered Acknowledgment
LXID = LLC Exchange Identification
LTEST = LLC Test

Note: Link stations transmit all Supervisory and Unnumbered command LPDUs with 'P=1'.

Figure K-4. LPDU: Commands and Responses

K.4.2.1 LLC_Information (LI) Command

LI commands are used to transfer sequentially numbered PDUs that contain informati fields, across link connections between link stations in adjacent nodes.

K.4.2.2 LLC_Receive_Ready (LRR) Command and Response

LRR command/response SPDUs are used by link stations to:

1. indicate that they are prepared to receive IPDUs
2. acknowledge previously received IPDUs numbered up to and including 'LNr minus 1'.

LRR command/response SPDUs may be used to clear busy conditions initiated by the prior transmission of LRNR command/response SPDUs. LRR command SPDUs with 'P=1' may be used by link stations to solicit the status of the communicating link station in the adjacent node.

K.4.2.3 LLC_Reject (LREJ) Command and Response

LREJ command/response SPDUs are used by link stations to request retransmission of IPDUs starting with the IPDU numbered LNr. IPDUs numbered 'LNr minus 1' and below are acknowledged. Additional IPDUs pending initial transmission may be transmitted following the retransmitted IPDU(s).

Only one LREJ exception condition for a given direction of information transfer may be established at any time. LREJ exception conditions are cleared (reset) upon receipt of an IPDU with an LNs equal to the LNr contained in the LREJ SPDU.

K.4.2.4 LLC_Receive_Not_Ready (LRNR) Command and Response

LRNR command/response SPDUs are used by link stations to indicate busy conditions; i.e., temporary inability to accept additional IPDUs. IPDUs numbered up to and including 'LNr-1' are acknowledged. IPDU LNr and subsequent IPDUs received, if any, are not acknowledged; the acceptance status of these IPDUs is indicated in subsequent exchanges.

Indication that a busy condition at a link station has cleared is communicated to the communicating link station in the adjacent node by the transmission of an LUA, LRR, LREJ or LSABME.

LRNR command SPDUs with the 'P=1' may be used by link stations to solicit the status of the communicating link station in adjacent nodes.

K.4.2.5 LLC_Set_Asynchronous_Balanced_Mode_Extended (LSABME) Command

LSABME commands are used to initialize/re-initialize both directions of transmission across the link connection between link stations in adjacent nodes. The DLC.X25.CM initiates transmission of the LSABME command upon receipt of a "CONTACT_ALS" from SNA.PU. No information field is permitted with this command. Link stations in adjacent nodes confirm acceptance of LSABME commands by transferring an LUA response across the link connection at the earliest opportunity. Upon acceptance of an LSABME command, the communicating link station in the adjacent node sets both its send and receive state variables (LVs and LVr) equal to '0' and assumes the link asynchronous balanced mode - extended. When the LUA response is correctly received, the initiating link station also assumes the link asynchronous balanced mode - extended and sets its send and receive state variables (LVs and LVr) equal to '0'. LSABME commands are always transferred with 'P=1'.

Previously transferred IPDUs that are unacknowledged when the LSABME command is initiated and executed remain unacknowledged (see "Waiting for Acknowledgment" under "Procedures for Information Transfer" on page II-K-16). Any transmit buffers that are unacknowledged or pending initial transmission are purged from the link station queue and returned to the upper level user function.

K.4.2.6 LLC_Disconnect (LDISC) Command

LDISC commands are used by link stations to terminate the operational mode previously set. LDISC informs the communicating link station in the adjacent node that the link station is temporarily suspending operation.

No information field is permitted with LDISC commands. Prior to executing LDISC commands, receiving link stations confirm acceptance by transmitting an LUA response. Transmitting link stations enter the link disconnected phase upon receipt of the acknowledging LUA response. LDISC command LPDUs are always transmitted with 'P=1'.

Previously transmitted IPDUs that are unacknowledged when the LDISC command is executed remain unacknowledged (see Waiting for Acknowledgment under "Procedures for Information Transfer" on page II-K-16).

K.4.2.7 LLC_Unnumbered_Acknowledgment (LUA) Response

LUA responses are used by originating link stations to acknowledge receipt and indicate acceptance of LSABME and LDISC commands. Receiving link stations transfer an LUA response before executing the received UPDU command. The LUA response is transferred with 'F=1' when 'P=1' in the received UPDU command. No information field is permitted with LUA responses.

K.4.2.8 LLC_Disconnected_Mode (LDM) Response

LDM responses are used to report a status where the originating link station is logically disconnected, and is in the LLC disconnected phase. The LDM response may be sent in response to a received LSABME command, to inform the adjacent node link station that the originating link station is still in the LLC disconnected phase and cannot execute the LSABME command. No information field is permitted with the LDM response.

Link stations in the link disconnected phase monitor received commands and:

1. react to LSABME and LDISC commands as described in "Link Disconnected Phase" on page II-K-15; and,

2. transfer an LDM response with 'F=1' to any other UPDU command received with 'P=1'.

K.4.2.9 LLC_Protocol_Data_Unit_Reject (LPDUR) Response

LPDUR responses are used by link stations to report error conditions that are not recoverable by retransmission of the identical LPDU to the adjacent link station; i.e., one of the following conditions, resulting from the otherwise error free receipt of an LPDU with:

1. a LPDU command or response that is invalid or not implemented;

2. an information field that exceeds the maximum permissible length;

3. an invalid LNr; or,

4. an information field which is not permitted or an SPDU or UPDU of incorrect length.

An invalid LNr is one that points to an IPDU that has been previously transmitted and acknowledged or to an IPDU that has not been transmitted and is not the next sequential IPDU pending transmission.

An information field which immediately follows the control field, and consists of 5 octets, is returned with the LPDUR response. This format is shown in Figure K-5.

I-field bits 1 ------- 16	17 --- 23	24	25 --- 31	32	33	34	35	36	37	38	39	40
Rejected LPDU Control Field	LVs	0	LVr	C/R	0	0	0	0	Z	Y	X	W

- Rejected LPDU control field is the control field of the received LPDU that caused the PDU reject condition.
- LVs is the current value of LVs at the link station reporting the rejection condition (bit 23 = low order bit).
- LVr is the current value of LVr at the link station reporting the rejection condition (bit 31 = low order bit).
- 'W=1' indicates that the control field received and returned in bits 1 through 16 was considered invalid or not implemented.
- 'X=1' indicates that the control field received and returned in bits 1 through 16 was considered invalid because the LPDU contained an information field which is not permitted or is an SPDU or UPDU with incorrect length. 'W=1' is required in conjunction with this bit.
- 'Y=1' indicates that the information field received exceeded the maximum established capacity of the link station reporting the condition.
- 'Z=1' indicates that the control field received and returned in bits 1 through 16 contained an invalid LNr.
- C/R - Bit 32 is set to:
  - '1' if the rejected LPDU was a response; or,
  - '0' if the rejected LPDU was a command.

Figure K-5. LPDUR: Information Field Format

K.4.2.10 LLC_Exchange_Identification (LXID) Command and Response

LXID commands are used by ELLC link stations to initiate exchanges of identification information with link stations at the adjacent SNA nodes.

K.4.2.11 LLC_Test (LTEST) Command and Response

LTEST commands are used by ELLC link stations to initiate tests of link connections and solicit an LTEST response from ELLC link stations in adjacent nodes.

K.4.3 Exception Condition Reporting and Recovery

Procedures to effect recovery following the detection/occurrence of exception conditions on the connection between link stations in adjacent SNA nodes are described in "Busy Condition" through "LPDU Rejection Condition" on page II-K-12. Exception conditions described include situations that may occur as the result of underlying network malfunctions or abnormal operational situations.

K.4.3.1 Busy Condition

A busy condition results when an ELLC link station is temporarily unable to continue receiving IPDUs due to internal constraints (e.g., receive buffering limitations). Notification of the busy condition is conveyed to the link station in the adjacent node by transferring an LRNR across the link connection. IPDUs pending transmission may be transmitted by link stations experiencing a busy condition, either prior to, or following, transmission of the LRNR. Recovery from a link station busy condition is indicated to link stations in adjacent nodes as described in "LLC_Receive_Not_Ready (LRNR) Command and Response" on page II-K-8.

K.4.3.2 LNs Sequence Error

A sequence exception condition results when an error-free (no PDUCS error) IPDU with an LNs that is not equal to the current value of LVr at the receiving link station is received. Receiving link stations do not acknowledge (increment their LVr) IPDUs that result in sequence exception conditions.

The information field of all IPDUs received with an LNs that is not equal to the current value of LVr at the receiving link station is discarded.

ELLC link stations that receive one or more IPDUs having sequence errors but otherwise error-free accept the control information contained in the LNr field and the 'P' bit to perform link control functions (e.g., to receive acknowledgment of previously transmitted IPDUs and to cause the link station to respond ('P=1')). Therefore, retransmitted IPDUs may contain an LNr field and 'P' bit that are updated, and therefore different from, those contained in the IPDU(s) originally transmitted.

K.4.3.3 LLC REJECT Recovery

LREJ commands and responses are transferred by link stations to initiate exception recovery (retransmission) following detection of sequence errors.

Only one "sent LREJ" exception condition for a link station is established at a time. A "sent LREJ" exception condition is cleared when the requested IPDU is received; or, when a link set-up or disconnection procedure as described in "Link Resetting Procedures" under "Procedures for Information Transfer" on page II-K-16 is performed.

Link stations receiving LREJ initiate sequential (re-)transmission of IPDUs starting with the one indicated by the LNr contained in the received LREJ SPDU, if possible (see §-K.6.5.4).

K.4.3.4 Time-out Recovery

If, due to a transmission error, a link station does not receive (or receives and discards) a single IPDU or the last IPDU in a sequence of IPDUs, it cannot detect an out-of-sequence exception condition and will, therefore, fail to transmit an LREJ. Link stations shall, following completion of a system specified time-out period (see "List of LLC Parameters" on page II-K-20) take appropriate recovery action to determine at which IPDU retransmission must begin.

Link stations use the lost reply protection mechanism, described in "Lost Reply Protection" on page II-K-14, after a system specified time-out period (see "List of LLC Parameters" on page II-K-20) to determine at which IPDU to begin retransmission.

K.4.3.5 Protocol_Data_Unit_Checking_Sequence (PDUCS)

The purpose of the PDUCS is to detect LPDUs that have been corrupted by the underlying network service.

When an LPDU is to be transmitted the sending link station must generate a PDUCS for the LPDU and store it in the PDUCS parameter in the LPDU header.

1. PDUCS (Checksum) Generation Procedure

   a. Set up the complete LPDU, including the header and user data (if any). The header must include the PDUCS parameter. The value field of the PDUCS parameter must be set to zero at this point.

   b. Initialize two variables (called C^0 and C^1) to zero.

   c. For each octet of the LPDU, including the header and the user data (if any), add the octet value to C^0, and then add the value of C^0 to C^1. Octets are processed sequentially, starting with the first octet and proceeding through the LPDU. Addition is performed modulo 256.

d. Calculate the value field of the PDUCS parameter as follows:

- Let the length of the LPDU, i.e., the number of times the above operation was repeated be 'L';
- Let the first octet of the PDUCS value, i.e., the one at offset 'i' (where 'i=5'), be called 'X';
- Let the second octet, at offset 'j' (where 'j=4'), be called 'Y'. (Where the first byte of the LPDU is considered to be at offset '1').

Then:

$$X = (((L - i) \times C^0) - C^1) \text{ modulo } 256; \text{ and,}$$

$$Y = (((L - j) \times (- C^0)) + C^1) \text{ modulo } 256$$

e. Place the computed values of 'X' and 'Y' in the appropriate octets of the LPDU.

Note: An implementation may use one's complement arithmetic as an alternative to modulo 256 arithmetic. However, if either of the PDUCS octets 'X' and 'Y' has the value minus zero (i.e., x'FF') then it must be converted to plus zero (i.e., x'00') before being stored.

2. PDUCS (Checksum) Validation Procedure

When an LPDU is received it is verified to ensure that it has been received correctly. This is done by computing the PDUCS, using the same algorithm by which it was generated. The nature of the PDUCS algorithm is such that it is not necessary to compare explicitly the stored PDUCS octets. The procedure described below may be used to verify that an LPDU has been correctly received.

a. Initialize two variables (called C^0 and C^1) to zero.

b. For each octet in the received LPDU, add the value of the octet to C^0 and then add the value of C^0 to C^1, starting with the first octet and proceeding sequentially through the LPDU. All addition is performed modulo 256.

c. When all octets have been sequentially processed, the values of C^0 and C^1 should be zero. If either or both of them is non-zero, the LPDU has been received incorrectly and the verification has failed. Otherwise, the LPDU has been received correctly and the LPDU is processed normally.

Note: An implementation may use one's complement arithmetic as an alternative to modulo 256 arithmetic. In this case, if either C^0 or C^1 has the value minus zero (i.e., x'FF') it is regarded as though it was plus zero (i.e., x'00').

If a PDUCS verification failure occurs, the received LPDU is discarded and no actions is taken by any link station at the receiving DTE as a result of that LPDU.

K.4.3.6 LPDU Rejection Condition

An LPDU rejection condition may be established upon receipt of an error-free LPDU that contains an invalid command/response in the C field, an invalid LPDU format, an invalid LNr or an information field that exceeds the maximum information field length that can be accommodated.

Receiving ELLC link stations report LPDU rejection conditions to the communicating link station in the adjacent node by transferring an LPDUR response across the link connection. ELLC link stations that receive an LPDUR response are responsible for resolving the rejection condition by initiating either a link resetting or link disconnection procedure; or, by causing a clearing or resetting of the underlying virtual circuit. After transmitting an LPDUR response, ELLC link stations maintain the LPDU rejection condition until the link is reset by the communicating link station in the adjacent node. IPDUs received by ELLC link stations in the LPDU rejection condition are discarded, except for the 'P' bit indication (LNr is ignored). The LPDUR response may be repeated at each opportunity until recovery is effected by the communicating link station in the adjacent node, or until internal recovery is initiated locally.

K.4.3.7 Recoverable Packet Level Error Conditions

Network initiated virtual circuit terminations (clears) and re-synchronizations (resets), as well as interface re-initializations (restarts) considered to be potentially recoverable at the logical link control level include those resulting from the receipt of indication packets with the Cause Codes shown in Figure K-6, Figure K-7 and Figure K-8.

CLEARING CAUSE Code	HEX	DEC
Number busy	01	1
Out of order	09	9
Access Barred	0B	11
Remote Procedure Error	11	17
Local procedure error	13	19
Network congestion	05	5
Not obtainable	0D	13
RPOA out of order	15	21

Figure K-6: Recoverable CLEARING Cause Codes

RESETTING CAUSE Code	HEX	DEC
Out of order	01	1
Remote procedure error	03	3
Local procedure error	05	5
Network congestion	07	7
Remote DTE operational	09	9
Network operational	0F	15
Incompatible destination	11	17

Figure K-7. Recoverable RESETTING Cause Codes

RESTARTING CAUSE Code	HEX	DEC
Local procedure error	01	1
Network congestion	03	3
Network operational	07	7

Figure K-8. Recoverable RESTARTING Cause Codes

K.5 DESCRIPTION OF THE PROCEDURE

The charts in "LINK STATION STATES AND ACTIONS" on page II-K-25 detail the actions taken, LPDUs transferred and state transitions made by ELLC link stations as a result of stimuli that can occur in various states of the link connection.

K.5.1 Procedure for Addressing

LPDUs are transferred with the address field set to indicate their command/response content.

K.5.2 Procedure for Use of the P/F Bit

Upon receipt of any command LPDU with 'P=1', ELLC link stations transfer an appropriate response LPDU with 'F=1' across the link connection at the first respond opportunity (e.g., immediately following the LPDU currently being transmitted, if any). Appropriate responses include:

1. an LUA or LDM response to received LSABME and LDISC commands;

2. an LPDUR, LREJ, LRNR or LRR response to received IPDU commands; and,

3. an LXID or LTEST response to received LXID or LTEST commands, respectively;

4. an LPDUR, LRNR or LRR response to received SPDU commands.

The 'P' bit is also used in conjunction with timer recovery conditions as described in "Waiting for Acknowledgement" on page II-K-18 and may be used as a request for acknowledgment on IPDUs and invitation to transmit, by the upper level user(s), in application environments that exhibit half-duplex characteristics.

K.6 LOST REPLY PROTECTION

ELLC link stations provide a time-out function to protect against dead-lock conditions caused by loss of responses from communicating link stations in the adjacent node due to transmission errors. An LLC Reply Timer, LT1, may be started upon transmission of IPDUs or SPDU commands, or both, during the information transfer phase. Link Reply Timer, LT1, is also used as described in "Link Set-up" and "Link Disconnection" on page II-K-15.

If Link Reply Timer, LT1, expires prior to receipt of an appropriate response from the communicating link station in the adjacent node, ELLC link stations initiate action to recover the link connection. ELLC link stations transfer an appropriate command SPDU and restart Link Reply Timer, LT1. If Link Reply Timer, LT1, expires prior to receipt of an appropriate response with 'F=1' LN2 times, appropriate recovery action is initiated.

K.6.1 Procedures for Link Set-Up and Disconnection

K.6.1.1 Link Set-up

ELLC link stations wishing to set-up the link connection transfer an LSABME command with 'P=1' and start Link Reply Timer, LT1 (see "LLC_Time-Out_Function - (LFt)" on page II-K-20. Upon receipt of an LUA response with 'F=1' from the link station in the adjacent node, the initiating ELLC link station sets both LVs and LVr equal to '0' and stops link Reply Timer, LT1.

Upon receipt of an LSABME command, receiving ELLC link stations prepared to receive IPDUs return an LUA response and set both LVs and LVr equal to '0'. ELLC link stations that, for some reason, are unable or do not desire to enter the information transfer phase, return an LDM response to received LSABME commands.

Upon receipt of an LDM response with 'F=1' indicating that the adjacent link station cannot accept activation of the link connection, the condition is reported to the upper level user and no further action is taken by logical link control.

Upon expiration of Link Reply Timer, LT1, prior to receipt of an appropriate response with 'F=1', ELLC link stations perform the retransmission procedure described in "LLC_Time-Out_Function - (LFt)" on page II-K-20 before declaring the link connection to be inoperative and reporting the condition to a higher level of SNA.

K.6.1.2 Information Transfer Phase

ELLC link stations, having transferred an LUA response to a received LSABME command or having received an LUA response to a transmitted LSABME command, accept and transmit IPDUs and SPDUs in accordance with the procedures described in "Procedures for Information Transfer" on page II-K-16.

Upon receipt of an LSABME command, an LUA response or an LDM response with 'F=0', while in the information transfer phase, ELLC link stations conform to the resetting procedure described in "Link Resetting Procedures" on page II-K-18.

K.6.2 Link Disconnection

During the information transfer phase ELLC link stations, wishing to terminate the link connection, transfer an LDISC command with 'P=1' across the link connection and start Link Reply Timer, LT1, (see "LLC_Time-Out_Function - (LFt)" on page II-K-20).

Upon receipt of a LDISC command, receiving ELLC link stations return an LUA or LDM response and enter the link disconnected phase.

Upon receipt of an LUA or LDM response with 'F=1' from the communicating link station in the adjacent node, initiating ELLC link stations stop Link Reply Timer, LT1.

Upon expiration of Link Reply Timer, LT1, prior to receipt of an appropriate response with 'F=1', ELLC link stations perform the retransmission procedure described in "LLC_Time-Out_Function - (LFt)" on page II-K-20 before declaring the link connection to be inoperative and reporting a failure to the higher levels of SNA.

K.6.2.1 Link Disconnected Phase

ELLC link stations, having received an LDISC command and returned an LUA response, or having received an LUA response to a transmitted LDISC command, enter the link disconnected phase.

ELLC link stations, in the link disconnected phase, may initiate link set-up. While in the link disconnected phase, ELLC link stations react to the receipt of LSABME commands as described in "Link Set-up" on page II-K-14 and transfer an LDM response to received LDISC commands.

Upon receipt of any command (other than LSABME) with 'P=1', receiving ELLC link stations transfer an LDM response with 'F=1'.

Other LPDUs are ignored by receiving ELLC link stations while in the link disconnected phase.

K.6.2.2 Collision of UPDU Commands

UPDU command collision situations are resolved in the following manner.

Like Commands: When the sent and received UPDU commands are the same, both ELLC link stations transfer an appropriate UPDU response at the earliest possible opportunity. ELLC link stations place the associated link connection in the indicated state upon receipt of the appropriate UPDU response.

Unlike Commands: When the sent and received UPDU commands, other than LXID and LTEST, are different ELLC link stations place the associated link connection in the LINK_CLOSED state and transfer an LDM response at the earliest possible opportunity. When the sent and received UPDU commands are LXID or LTEST, ELLC link stations transfer the appropriate LTEST and LXID response, respectively, when available.

K.6.3 Procedures for Information Transfer

These procedures apply to the transmission of IPDUs in each direction of transmission during the link information transfer phase.

In the following text, "number one higher" is in reference to a continuously repeated sequence series, i.e., '127' is one higher than '126' and '0' is one higher than '127' for modulo one hundred twenty eight series.

K.6.3.1 Sending IPDUs

ELLC link stations having IPDUs to transfer (i.e., IPDUs not already transferred, or having to be retransmitted as described in "Receiving Reject" on page II-K-17 or "Waiting for Acknowledgement" on page II-K-18, transfer them with an LNs equal to the current value of that link stations LVs, and an LNr equal to the current value of the link stations LVr. Upon completion of transmission of each successive IPDU, ELLC link stations increment their LVs by one (1) and start Link Reply Timer, LT1, if it is not already running.

When the value of LVs, at an ELLC link station, is equal to the last value of LNr received from the communicating link station in the adjacent node plus 'Lk' (where 'Lk' is the maximum permissible number of outstanding IPDUs allowed (see "Maximum Number of Outstanding IPDUs - (Lk)" on page II-K-23), that ELLC link stations does not transfer any new IPDUs, but may retransmit IPDUs as described in "Receiving Reject" on page II-K-17 or "Waiting for Acknowledgement" on page II-K-18.

Note: To ensure the integrity of information transfer, ELLC link stations do not transfer any IPDUs when the link stations LVs is equal to the last value of LNr received from the link station in the adjacent node plus '127'.

ELLC link stations in the busy condition may continue to transfer IPDUs, provided the communicating link station in the adjacent node is not also in a busy condition. ELLC link stations in the link rejection condition, do not transfer IPDUs.

K.6.3.2 Receiving IPDUs

ELLC link stations not in the busy condition accept the I-field of in sequence IPDUs (IPDUs with an LNs equal to the current value of the link stations LVr) received with the correct PDUCS, increment the value of the link stations LVr by one and acknowledge receipt of the IPDU(s) by transferring:

- the next sequential IPDU to be transferred, if it is available, or an LRR response SPDU with LNr equal to the current value of its LVr; or,
- an LRR response SPDU response with LNr equal to the current value of its LVr, if no IPDU is available to transfer.

ELLC link stations may ignore the information field contained in IPDUs receive while they are in a busy condition.

Note: ELLC link stations treat IPDUs with zero length information fields the same as any other IPDU at the link station.

K.6.3.3 Receipt of Incorrect LPDUs

ELLC link stations ignore LPDUs received with an incorrect PDUCS and cause a clearing or resetting of the underlying virtual call or permanent virtual circuit, respectively, upon receipt of LPDUs with invalid formats (see "Invalid LPDUs" on page II-K-4).

ELLC link stations receiving IPDUs with the correct PDUCS, but with an incorrect LNs (i.e., one that is not equal to the current value of LVr at the receiving link station) discard the I-field and transfer an LREJ response with an LNr one higher than the LNs contained in the last correctly received IPDU. Then they discard the I-field, but use the LNr and 'P' bit indications of all IPDUs received with an LNs that is not equal to the current value of LVr at the receiving ELLC link station. Upon receipt of the expected IPDU (i.e., one with an LNs equal to the current value of LVr), receiving ELLC link stations acknowledge the IPDU as described in "Receiving IPDUs" on page II-K-16.

K.6.3.4 Receiving Acknowledgement

ELLC link stations, even in a busy condition, consider the LNr contained in correctly received IPDUs or SPDUs (LRR, LRNR and LREJ) as acknowledgment for all IPDUs transferred with an LNs up to and including 'LNr minus 1'. ELLC link stations reset Link Reply Timer, LT1, upon correct receipt of an IPDU or SPDU that actually acknowledges some previously transferred IPDU(s) (i.e., an LPDU with an LNr higher than the value of the last LNr received); or, upon receipt of an SPDU with 'F=1'.

If Link Reply Timer, LT1, has been reset with IPDU(s) still unacknowledged, ELLC link stations restart Link Reply Timer, LT1. If Link Reply Timer, LT1, expires prior to receipt of an acknowledgment, ELLC link stations follow the retransmission procedure described in "Receiving Reject" and "Waiting for Acknowledgement" on page II-K-18 with respect to the unacknowledged IPDU(s).

K.6.3.5 Receiving Reject

Upon receipt of an LREJ SPDU, receiving ELLC link stations, supporting LPDU retransmission recovery (see §-K.6.5.4), set LVs equal to the LNr contained in the received LREJ, then transfer the corresponding IPDU when it is available or retransmit it; otherwise, they cause a clearing or resetting the the virtual circuit.

ELLC link stations conform to the following with respect to the re-transmission of IPDUs:

1. An ELLC link station that is transmitting a SPDU or an UPDU when it receives a LREJ, will complete the transmission in progress before commencing transmission of the requested IPDU.

2. An ELLC link station that is transmitting an IPDU when an LREJ is received, may abort transmission of the IPDU and commence transmission of the requested IPDU immediately after abortion.

3. An ELLC link station that is not transmitting any LPDU when an LREJ is received, will commence transmission of the requested IPDU immediately.

Other unacknowledged IPDUs already transferred, following the one indicated in the LREJ, are retransmitted following retransmission of the requested IPDU.

If the LREJ was received as a command with 'P=1', receiving ELLC link stations transfer an LRR or LRNR response with 'F=1' prior to transmitting or retransmitting the corresponding IPDU.

K.6.3.6 Receiving LRNR

Upon receipt of an LRNR command or response SPDU, ELLC link stations may start timer LTn if it is not running. If timer LTn then expires prior to the receipt of a LUA, LRR, LREJ or LSABME from the communicating link station in the adjacent node, ELLC link stations transmit an appropriate SPDU command with P=1 and may perform the retransmission procedure described under "LLC_Time-Out_Function - (LFt)" on page II-K-20 before declaring the link connection to be inoperative and reporting the condition to upper level user(s).

K.6.3.7 Link Station Busy Condition

ELLC link stations experiencing a busy condition transfer an LRNR command or response at the earliest opportunity. While in the busy condition, ELLC link stations accept and process SPDUs and respond LRNR with 'F=1' to IPDUs and SPDU commands received with 'P=1'. To clear a busy condition, ELLC link stations transfer either LREJ commands or responses or LRR commands or responses with LNr set to the current value of LVr, depending on whether or not information fields of correctly received IPDUs were discarded.

K.6.3.8 Waiting for Acknowledgement

Originating ELLC link stations maintain an internal retransmission count (Y) which is set equal to '0' upon receipt of an LUA or LRNR, or upon correct receipt of an IPDU or an SPDU with an LNr higher than the last LNr received from the communicating link station in the adjacent node (actually acknowledging some IPDU(s)).

If Link Reply Timer, LT1, expires, ELLC link stations enter or (re-)enter the timer recovery condition, increment 'Y' by one (1) and set an internal variable (X) to the current value of LVs.

ELLC link stations restart Link Reply Timer, LT1, set LVs equal to the value of the last LNr received from the communicating link station in the adjacent node and transfer an appropriate SPDU command with 'P=1'.

Timer recovery conditions are cleared upon receipt of a valid SPDU response with 'F=1'

Upon correct receipt of a SPDU response with 'F=1' and an LNr within the range from the current value of LVs to 'X' included, ELLC link stations reset the timer recovery condition and set LVs equal to the value of LNr in the received SPDU.

Upon correct receipt of an SPDU with 'F=0' and with an LNr within the range from the current value of LVs to 'X' included, ELLC link stations do not reset the timer recovery condition. The received LNr may be used to update LVs.

When 'Y' is equal to LN2, ELLC link stations initiate a resetting procedure as described in "LLC Rejection Conditions" on page II-K-19 The value of LN2 is a system parameter (see "Maximum Number of LPDU Transmissions - (LN2)" on page II-K-22).

K.6.3.9 Link Resetting Procedures

The resetting procedures described here are used, only on link connections perceived by the ELLC link station to be in the information transfer phase, to (re)-initialize both directions of information transfer.

1. Local Reset

   ELLC link stations indicate a resetting of the link by transferring an LSABME command LPDU across the link connection. Upon receipt of an LSABME command, ELLC link stations prepared to resume normal operation of the link, return an LUA response at the earliest opportunity, and set LVs and LVr equal to '0'. This also clears link station busy conditions, if present. Prior to initiating this link resetting procedure, ELLC link stations may initiate a link disconnection procedure as described in "Remote Reset" below.

2. Remote Reset

   Under certain rejection conditions listed in "LLC Rejection Conditions" on page II-K-19, ELLC link stations may request the adjacent link station to reset the link by transferring an LPDUR response.

   After transmitting an LPDUR response, originating ELLC link stations enter the link rejection condition. The link rejection condition is cleared when the ELLC link station receives an LSABME or an LDISC command or an LDM response from the communicating link station in the adjacent node. Other LPDU commands received while in the link rejection condition cause receiving ELLC link stations to retransmit the LPDUR response with the same information field originally transferred.

Upon receipt of an LPDUR response, ELLC link stations prepared to resume normal operation of the link transfer an LSABME command LPDU with 'P=1' across the link connection and start Link Reply Timer, LT1. Otherwise, ELLC link stations initiate the link disconnection procedure described in "Link Disconnection" on page II-K-15; or, cause a clearing or resetting of the underlying virtual circuit.

ELLC link stations may start Link Reply Timer, LT1, on transferring the LPDUR response. If Link Reply Timer, LT1, then expires prior to the receipt of an LSABME or a LDISC command from the communicating link station in the adjacent node, ELLC link stations may retransmit the LPDUR response and restart Link Reply Timer, LT1. Following transmission of the LPDUR response LN2 times ELLC link stations may reset the link as described in "Link Resetting Procedures" on page II-K-18. The value of LN2 is defined in "Maximum Number of LPDU Transmissions - (LN2)" on page II-K-22.

K.6.3.10 LLC Rejection Conditions

ELLC link stations may initiate a resetting procedure as described in "Link Resetting Procedures" on page II-K-18 upon receipt, during the information transfer phase, of an LPDU with the correct PDUCS, and with one of the following conditions:

1. the LPDU is unknown as a command or as a response;

2. the LPDU does not conform to one of the valid formats;

3. the LPDU information field is invalid; or,

4. the LPDU contains an invalid LNr as defined in "LLC_Protocol_Data_Unit_Reject (LPDUR) Response" on page II-K-9.

Coding of the information field of LPDUR responses transferred is given in "LLC_Protocol_Data_Unit_Reject (LPDUR) Response" on page II-K-9.

Unsolicited LDM - ELLC link stations initiate a resetting procedure as described in "Link Resetting Procedures" on page II-K-18 upon receipt, during the information transfer phase, of an LDM response or an LPDUR response.

Unsolicited Response - ELLC link stations may initiate a resetting procedure as described in "Link Resetting Procedures" on page II-K-18 upon receipt, during the information transfer phase an LUA response or an unsolicited LPDU response with 'F=1'.

K.6.4 Link Connection Procedures

K.6.4.1 Initial Connection Establishment

The ELLC protocols employ the X.25 call set-up procedures described in -- Heading id 'ch8' unknown -- for initial establishment of link connections.

K.6.4.2 Connection Recovery

Procedures are described to allow recovery from certain link connection failures, indicated by PSDNs, to be attempted at the LLC level when ELLC has been selected. Link failures reported by PSDNS in CLEAR_INDICATION, RESET_INDICATION and RESTART_INDICATION packets with the network generated Cause Codes listed in Figure K-6, Figure K-7 and Figure K-8 are assumed to be temporary in nature and, therefore, potentially recoverable.

1. Clears

ELLC link stations attempt to re-establish virtual calls (switched virtual circuits) cleared by PSDNs via CLEAR_INDICATION packets that carry recoverable Cause Codes, as defined in Figure K-6, up to LN2 times before indicating link/station INOP to the higher layers of SNA. Connection recovery is initiated by transferring a CALL_REQUEST packet across the access channel, as depicted in Figure K-10. (5), indicating:

- LLC recovery mode;
- connection recovery request; and,
- connection identification information, if required.

Upon receipt of an INCOMING CALL packet on a logical channel associated with a link connection perceived to have a connection recovery pending, ELLC link stations cause a clearing of the incoming call by transferring a CLEAR REQUEST packet with the Cause Code x'00', 'DTE Generated', and the diagnostic code x'5C', 'Logical Channel Reserved'.

2. Resets

ELLC link stations only need to log network initiated resets, of switched or permanent virtual circuits indicated by PSDNs via RESET_INDICATION packets that carry recoverable Cause Codes as defined in Figure K-7, for future problem determination purposes. Specific recovery action is not required in such instances since ELLC LPDU sequence numbering, acknowledgment and re-transmission procedures provide adequate data integrity mechanisms to cope with temporary failures in this category.

3. Restarts

ELLC link stations treat network initiated restarts, of the X.25 DTE/DCE interface indicated by PSDNs via RESTART_INDICATION packets that carry potentially recoverable Cause Codes as defined in Figure K-8, as a clearing of all virtual calls and a resetting of all permanent virtual circuits at the X.25 DTE/DCE interface.

K.6.5 List of LLC Parameters

The LLC parameters are as follows:

K.6.5.1 LLC_Time-Out_Function - (LFt)

The duration of the LLC time-out function (LFt) is:

$$LFt = (LT1 \bullet LN2 + LTd) \bullet LNd$$

where:

LT1 is a function of the time allowed by link stations between the transmission of commands and receipt of the corresponding acknowledgment.

Upon expiration of timer LT1, Link stations retransmit the unacknowledged command with 'P=1' and restart timer LT1.

LN2 ≥'1' is the maximum number of transmissions and retransmissions of a LPDU following the expiration of time LT1.

LTd is typically many time greater than time LT1 and is the time to be delayed between consecutive repetitions of LT1•LN2.

LNd ≥'1' is the maximum number of repetitions of LT1•LN2+LTd to be performed before declaring the logical link connection to be inoperative.

Although LTd may be defined as zero, experience suggests that when LTd='0' and LNd='1' are used, link connections may often be declared inoperative prematurely, resulting in unnecessary session outages due to momentary network service disruptions.

It is, therefore, essential that LT1, LN2, LTd and LNd have default values that can be overridden by customers as experience indicates.

ELLC link stations start Link Reply Timer, LT1, upon completion of transmission IPDUs or SPDU and UPDU commands with 'P=1'.

The component parts of Times LT1 and LTn for link stations are illustrated in Figure K-9 to assist in the succeeding description of Time-limit LT2.

```
|<------------------------------------ LT1 | LTn ------------------------------------>|

E              E          A              T              E              R          A
O              O          R              A              O              A          K
T              R          Q              K              A              K          D
|     T1       |    T2    |      T3      |      T4      |      T5      |    T6    |
|--------------|----------|--------------|--------------|--------------|----------|
|Propagation   |Process   |Maximum time  |Transmission  |Propagation   |Process   |
|time          |time      |to seize line |time          |time          |time      |
```

Where:

EOT - represents the end of transmission of the last bit of the LPDU requiring acknowledgment by the link station;

EOR - represents receipt of the last bit of the LPDU requiring acknowledgment by the communicating link station in the adjacent node;

ARQ - represents recognition of the LPDU requiring acknowledgment by the communicating link station in the adjacent node;

TAK - represents transmission of the first bit of the acknowledging LPDU by the communicating link station in the adjacent node;

EOA - represents transmission of the last bit of the acknowledging LPDU by the communicating link station in the adjacent node;

RAK - represents receipt of the last bit of the acknowledging LPDU by the link station;

AKD - represents recognition of the acknowledgment for the outstanding LPDU at the link station; and,

T^1 & T^5 - are the propagation times to and from the link station in the adjacent node station, respectively.

T^2 & T^6 - are the stated processing times for the link station in the adjacent node and this link station, respectively.

T^3 - time to complete transmission of those LPDUs in the acknowledging link station's "transmit queue" that are neither displaceable nor modifiable in an orderly manner.

T^4 - time to transmit the acknowledging LPDU.

LT1 & LTn - $T^1 + T^2 + T^3 + T^4 + T^5 + T^6$ (minimum value).

Figure K-9. LINK REPLY TIMER - LT1: Components

K.6.5.2 LRNR Time-out - (LTn)

LTn is equivalent to, and may in fact employ the same timer as, Link Reply Time-out, LT1.

K.6.5.3 LLC Time-Limit - (LT2)

Time-limit LT2 is the maximum time allowed between receipt of a command LPDU from the link station in the adjacent node and transmission of an appropriate response LPDU. This value is product and configuration specific. LT2 must never exceed the time needed to transmit one maximum length frame plus fifty (50) milliseconds.

The duration of Time-limit LT2 is an LLC parameter that is determined by bilateral agreement between communicating link stations. The period of Timer-limits LT2' and LT2" for a link station and its counterpart in the adjacent node, respectively, take into account:

1. the transmission time of the acknowledging LPDU;

2. the propagation time across the link connection;

3. the processing times for the link station and its counterpart in the adjacent node; and,

4. the time required to complete transmission of the LPDUs in the transmit queues, at both the link station and its counterpart in the adjacent node, that are neither displaceable nor modifiable in an orderly manner.

   For example, to insure receipt of an acknowledging LPDU before a link stations Link Reply Timer, LT1, expires, the communicating link station in the adjacent node must begin transmission of the acknowledging LPDU early enough to take the values of T^4, T^5 and T^6, indicated above, into account. That is to say, the link station in the adjacent node must initiate transmission of the acknowledgment within at least time T^3 after ascertaining that an acknowledgment is required.

For the direction of data transmission from a link station to its counterpart in the adjacent node, LT2' indicates the maximum amount of time allowed between receipt, at the link station in the adjacent node, of an LPDU requiring an acknowledgment and initiation of transmission, by the link station in the adjacent node, of the acknowledging LPDU to insure its receipt prior to the expiration of the link stations Link Reply Timer, LT1. The value of LT2' must be less than the value of LT1.

For the direction of data transmission from a link station to its counterpart in the adjacent node, LT2' indicates the maximum amount of time allowed between receipt, at the link station in the adjacent node, of an LPDU requiring an acknowledgment and initiation of transmission, by the link station in the adjacent node, of the acknowledging LPDU to insure its receipt prior to the expiration of the link stations Link Reply Timer, LT1. The value of LT2' must be less than the value of LT1.

Given a value for Link Reply Timer LT1, the value of Timer LT2' must be no greater than LT1 less:

- the propagation time across the link connection from the link station to its counterpart in the adjacent node;
- the LPDU processing time at the link station in the adjacent node;
- the time required to transmit the acknowledgment from the link station in the adjacent node;
- the propagation time across the link connection from the link station in the adjacent node; and,
- the LPDU processing time at the link station.

For the direction of data transmission from the remote to the local link station, LT2" indicates the maximum amount of time allowed between receipt of an LPDU requiring an acknowledgment and initiation of the transmission of the acknowledging LPDU to insure its receipt at the remote link station prior to the expiration of Timer LT1. The value of LT2" must be less than the value of LT1.

Given a value for Timer LT1, the value of Timer LT2" must be no greater than LT1 less:

- the propagation time across the link connection from the link station in the adjacent node;
- the LPDU processing time at the link station;
- the time required to transmit the acknowledging LPDU to the link station in the adjacent node;
- the propagation time across the link connection to the link station in the adjacent node; and,
- the LPDU processing time at the link station in the adjacent node.

K.6.5.4 Maximum Number of LPDU Transmissions - (LN2)

The maximum number of transmissions and retransmissions of a given LPDU following the expiration of Link Reply Timer LT1 is a LLC parameter (LN2) whose value is determined by bilateral agreement between adjacent link stations.

Note: To facilitate throughput enhancement in environments where the quality of service exhibited by underlying network services afford adequate data integrity support of the retransmission recovery function may be bypassed when the value of LN2 is equal to one (1).

K.6.5.5 Maximum Number of Bytes in an IPDU - (LN1)

The maximum permissible number of octets (bytes) in an IPDU is an LLC parameter (LN1) which depends upon the maximum length of the information fields transferred across the link connection.

K.6.5.6 Maximum Number of Outstanding IPDUs - (Lk)

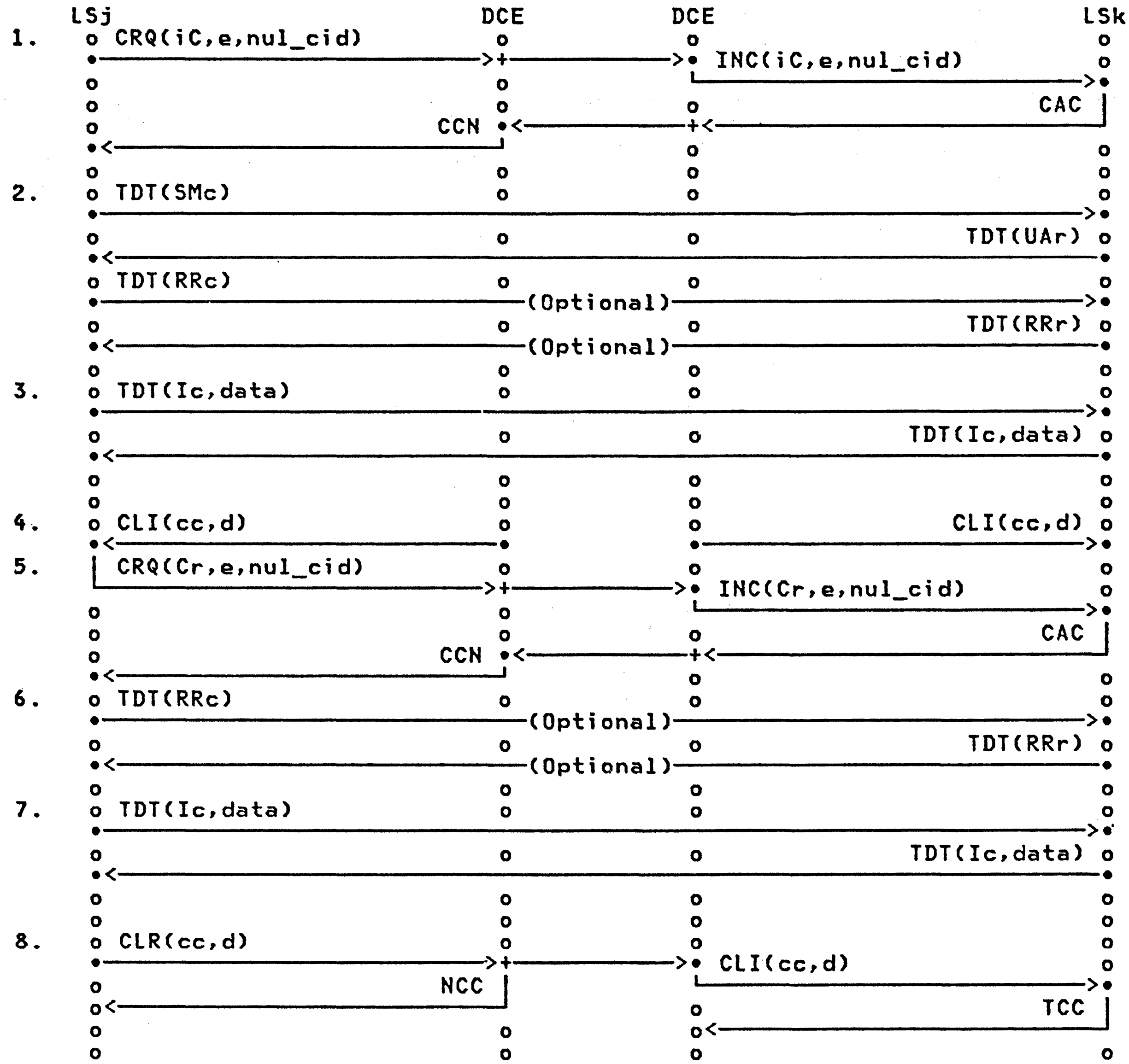
The maximum permissible number (Lk) of sequentially numbered IPDUs that link stations may have outstanding (i.e., unacknowledged) at any given time is an LLC parameter which can never exceed one hundred twenty-seven (127). The value of 'Lk' is determined by bilateral agreement between adjacent link stations. It is recommended that 'Lk' be a parameter whose default value can be overridden.

K.6.5.7 Link Idle Timer - (LTi)

The period of time that a link station may allow the link connection to remain in the idle state (see "Link Channel States" on page II-K-4) before, initiating a procedure to protect against half-open link connections by, transmitting an LRR command LPDU. LTi is many times greater than LT1, and typically has a value in the order of (LN2 * LT1)/2.

K.7 LPDU FLOW EXAMPLES

Sample ELLC LPDU flows depicting initial link establishment, initialization, information exchange, recoverable call clearing and connection recovery are shown in Figure K-10.



Legend:

cc:	Clearing Cause code
cid:	Connection Identifier
Cr:	Connection Recovery Indication
d:	Diagnostic code
e:	ELLC protocol identifier
Ic:	Information command
iC:	Initial Connection indication
LS(i):	Link Station 'i'
nul:	Null
SM:	SABME Unnumbered command
UA:	Unnumbered Acknowledgement response

Figure K-10. ELLC: Protocol_Data_Unit Flows

The following notes are keyed to Figure K-10.

1. Initial Connection Initiation

   Link connection establishment is initiated by the transfer of a CALL_REQUEST packet, to the network access DCE, with the following parameters in the CUD field:

   - (iC) - Initial connection indicator
   - (e) - Extended LLC protocol indicator

- (cid) - Connection identifier (optional)

2. Link Initialization

   Link initialization is initiated by the transfer of a DTE_DATA packet containing an LSABME command LPDU in the user data field and may be terminated either by the receipt of an LUA command LPDU or receipt of an LUA command LPDU followed by an exchange of DTE_DATA packets containing LRR command and response LPDUs, respectively.

3. Information Exchange

   Information is exchanged between adjacent link stations by the transfer of DATA packets or packet sequences with the user data field containing an information command LPDU.

4. Network Initiated Call Clearing

   Network initiated call clearing is signalled by the transfer of unsolicited CLEAR_INDICATION packets to both the calling and called link stations containing:

   - (cc) - Cause Codes in the Clearing Cause field.
   - (d) - Diagnostic Code in the Diagnostic Code field.

5. Connection Recovery

   Link connection recovery, following a recoverable network initiated call clearing is initiated by the transfer of a CALL_REQUEST packet, to the network access node, with the following parameters in the CUD field:

   - (Cr) - Connection Recovery indication
   - (e) - Enhanced LLC protocol indicator
   - (cid) - Connection identifier (optional)

6. Link Initialization/Assurance

   Link re-initialization is accomplished by an exchange of LRR command and response LPDUs, respectively.

7. Continue Information Exchange

   Proceeds as in item 3. above.

8. Connection Termination

   Termination of a link connection is initiated by the transfer of a CLEAR_REQUEST packet, to the network access node, containing the following parameters:

   - (cc) - Clearing Cause Code; and,

   - (d) - Diagnostic Code.

K.8 LINK STATION STATES AND ACTIONS

K.8.1 Chart Description

Operation of the ELLC protocol for link stations is formalized by the charts contained in "Link Station States and Actions" on page II-K-32 for the link connection states defined in "ELLC STATE DESCRIPTIONS" on page II-K-26. Action(s) taken by link station(s) as a result of particular stimuli are shown at the intersection of the various link connection states and the stimulus. ELLC link connection states include the predicate conditions defined in "PREDICATES" on page II-K-27 and the state variables defined in "State Variables" on page II-K-28, either or both of which are indicated under the heading(s) 'P: V:' (when appropraite) in the charts in "Link Station States and Actions" on page II-K-32. ELLC stimuli include the events as well as the command and response LPDUs defined in "ELLC Stimuli" on page II-K-28.

Information contained at these intersections specify the action(s) taken (denoted by two uppercase letters 'LL'), the basic procedure executed (denoted by the small letters 'bp' concatenated with an uppercase letter 'L'), the PDU(s) transferred (if any), signified by the protocol data unit identifier enclosed in brackets with any required parameters [PDU_id(p1,..,pn)] and the new state of the link connection to be entered (if any).

The PDU transferred, [PDU], may be any of the LLC command or response LPDUs listed in "Commands Sent and Received" on page II-K-29 and "Responses Sent and Received" on page II-K-29 and a small letter 'c' or 'r' may be appended signifying command or response, respectively; or the LPDU indicated by the PDU output scheduling algorithm signified by an undefined protocol machine [PDU_Out_UPM]. XPo, TPo and LPo signify the output PDU indicated by execution of the basic procedures X, T and L, respectively. Additional appendages that specify the value of the P-bit for command LPDUs and the F-bit for response LPDUs when necessary, include:

- 0 - signifying a P/F-bit value of '0';
- 1 - signifying a P/F-bit value of '1';
- " - signifying a P/F-bit value equal to the value of the variable, Vf; and
- ' - signifying an F-bit value equal to the value of the P-bit in the received command LPDU to which it responds.

In the event the PDU transferred causes a packet level clearing or resetting of the associated virtual circuit, an appropriate diagnostic code is included (see Appendix F for DTE Generated Diagnostic codes used when the virtual circuit for SNA-to-SNA connections are cleared, reset or restarted). When no [PDU] is indicated, nothing is transferred across the link connection to the link station in the adjacent node as the result of that particular stimulus.

Applicable ELLC link connection state transitions are specified under the heading New State when the link connection is to be placed in a different state following the specified action(s) and/or PDU transfer. Link connections remain in the current state when no new state to be entered is specified at a particular intersection.

Alternative procedures, denoted by lower case letters 'l' or the word 'or' under the 'ALT' heading, are specified where appropriate.

References to clarifying notes (denoted by '#n' (where 'n' is a decimal digit) under the 'ALT' heading) are also provided at certain intersections, where deemed necessary, to explain extenuating circumstances considered essential to proper operation of the protocol, including:

1. When an exchange of link station identification information is not required prior to link set-up.

2. The virtual call (switched virtual circuit) supporting the link connection is cleared (e.g., CLEAR_REQUEST or CLEAR_INDICATION) the underlying virtual circuit is terminated and the link connection placed in the INOPERATIVE state.

The sample sequences shown in Figure K-10 on page II-K-24 represent one example of how the tables may be used.

K.8.1.1 ELLC STATE DESCRIPTIONS

INOPERATIVE: The link station, not having resources allocated sufficient to support link connection, is non-functional and reacts positively only to link activation stimulus as specified in "INOPERATIVE State" on page II-K-32

LINK_CLOSED: The link station, having sufficient resources to support link connection allocated, reacts to stimuli as specified in "LINK_CLOSED State" on page II-K-33 when authorized and prepared to support link initialization.

LINK_OPENING: Link stations having initiated the link set-up procedure, by transferring an SABME command LPDU across the link connection, react to stimuli as specified in "LINK_OPENING State" on page II-K-35 pending receipt of link set-up confirmation (UA response LPDU) from the link station in the adjacent node.

LINK_CLOSING: Link stations having initiated the link disconnection procedure, by transferring a DISC command LPDU across the link connection, react to stimuli as specified in -- Heading id 'closg' unknown --.

LINK_OPENED: Link stations having completed the link set-up procedure react to stimuli as specified in "LINK_OPENED State" on page II-K-39 in the absence of error or exception condition(s) effecting the associated link connection.

CHECKPOINTING: Link stations having transferred an S-format command LPDU with 'P=1' across the link as a result of the expiration of the link reply timeout, Timer LT1, on the associated link connection react to stimuli as specified in "CHECKPOINTING State" on page II-K-42.

LINK_RESETING: Link stations having received an SABME command LPDU from the link station in the adjacent node, initiating the link resetting procedure, react to stimuli as specified in "LINK_RESETING State" on page II-K-48 until the resetting procedure is completed by the transfer of either a UA or DM response LPDU as directed by a higher level function.

LINK_RECOVERY: Link stations having received a FRMR response LPDU from, or transferred a FRMR response to, the link station in the adjacent node react to stimuli as specified in "LINK_RECOVERY State" on page II-K-49 until a resetting procedure is completed for the link.

K.8.1.2 PREDICATES

ELLC predicate conditions include:

P: which signifies general condition(s) for the link connection and may take on the values:

1. 'Nul' — signifying that no outstanding exceptional general conditions exists for the link connection.

2. 'RJN' — signifying that an out-of-sequence IPDU has resulted in the transfer of an REJ command or response LPDU to the link station in the adjacent node.

Pb_Busy: Signifies condition(s) for the link relative to resource constraints that temporarily prevent acceptance of I-format LPDU(s):

- 'B' by both the local link station and its communicating partner in the adjacent node;
- 'L' by the local link station;
- 'N' by neither the local nor its communicating partner in the adjacent node; or,
- 'R' by the link station in the adjacent node.

Pc_Pending Command Identifies the pending command LPDU when a command transmission is awaiting completion of a checkpointing cycle, and may take on the values:

- 'D' signifying a Disconnect command;

- 'R' signifying a Receive_Ready command;

- 'T' signifying a Test command;

- 'X' signifying an Exchange_Identification; or

- 'N' signifying that no command LPDU is pending.

Pr_Recovery.Status:

- 'Nul' signifying no recovery procedure in process;

- 'L' signifying recovery due to a locally detected PDU_Rejection condition in process; or,

- 'R' signifying recovery due to a remotely detected PDU_Rejection condition in process.

Pt_TEST.Status:

- 'Nul' signifying that no TEST of the link connection is in process;

- 'I' signifying that an incoming TEST response LPDU from the link station in the adjacent node is pending;

- 'O' signifying that an outgoing TEST response LPDU to the link station in the adjacent node is pending;

- 'IO' signifying that an incoming TEST response LPDU from and an outgoing TEST response LPDU to the link station in the adjacent node are both pending.

Px_XID.Status:

- 'Nul' signifying that no exchange of identification information (XID) is in process;

- 'I' signifying that an incoming XID response LPDU from the link station in the adjacent node is pending;

- 'O' signifying that an outgoing XID response LPDU to the link station in the adjacent node is pending;

- 'IO' signifying that an incoming XID response LPDU from and an outgoing XID response LPDU to the link station in the adjacent node are both pending.

K.8.1.3 State Variables

ELLC state variables include:

Va – Acknowledged LPDU: containing the last Nr value received, or '0' immediately following completion of the link set-up procedure;

Vf – Final Bit Value: containing the value for a final bit pending transmission (e.g., associated P-bit value received).

Vi – Initialization Status: Signifies link initialization progress and may take on the values:

- 'L' signifying locally initiated link set-up;

- 'R' signifying remotely initiated link set-up;

- 'B' signifying locally and remotely initiated link set-up;

- 'P' signifying initialization confirmation pending; or,

- 'Nul' signifying initialization completed/not started.

Vr – Next IPDU In: denoting the sequence number (Ns) of the next in-sequence I-format LPDU to be received across the link connection from the link station in the adjacent node.

Vs – Next IPDU Out: denoting the sequence number (Ns) of the next in-sequence I-format LPDU to be transferred across the link connection to the link station in the adjacent node.

K.8.1.4 ELLC Stimuli

ELLC protocol stimuli include the events, commands and responses described in the following paragraphs.

Events

- L3RDY – PACKET_LAYER (Level 3) READY: representing a signal from the X.25 Packet Layer (level 3) that the underlying virtual circuit, in the READY (p4 or d1) state, is prepared to support a link connection.

- LSTRT – LINK_START: representing a higher level stimulus to establish a link connection to a communicating link station in the adjacent node.

- LSTOP – LINK_STOP: repesenting a higher level stimulus to terminate the link connection to the communicating link station in the adjacent node.

- L3NOP — LEVEL_3_INOPERATIVE: representing a signal from the X.25 Packet Layer (level 3) that the underlying virtual circuit, in the INOPERATIVE state, is no longer capable of supporting a link connection.

- ELBSY — ENTER_LOCAL_BUSY: representing a signal from the DLC.X25_Manager informing the link station of a local resource constraint that temporarily prohibits the continued acceptance of I-format LPDUs.

- XLBSY — EXIT_LOCAL_BUSY: representing a signal from the DLC.X25_Manager informing the link station of the removal of an existing local resource constraint.

- ELPDU — ERRONEOUS_LLC_PROTOCOL_DATA_UNIT: representing receipt of an erroneous LPDU (e.e., one containing an unidentifiable LLC command or response, etc.) on the link connection.

- XCHID — EXHCANGE_IDENTIFICATION: representing a higher level request/authorization to transfer LLC link station identification information.

- LTEST — LINK_TEST: representing a higher level request/authorization to transfer LLC link test data.

- SDATA — SEND_DATA: representing a higher level request for the transfer of user data to the link station in the adjacent node.

- ELT1X — ELLC_LINK_REPLY_TIMEOUT_EXPIRATION: representing expiration of the LLC link reply timeout, Timer LT1.

- ELTiX — ELLC_LINK_IDLE_TIMEOUT_EXPIRATION: representing expiration of LLC link query timeout, Timer LTi.

Commands Sent and Received

- LI — I-format LPDU: representing a DATA packet or packet sequence containing an I-format LPDU in the user data field(s).

- LSM — LLC_SET_MODE (LSABME): representing a DATA packet containing a Set_Mode command LPDU (LSM) in the user data field.

- LDC — LLC_DISCONNECT (LDISC): representing a DATA packet containing a Disconnect command LPDU (LDC) in the user data field.

- LXC — LLC_EXCHANGE_IDENTIFICATION: representing a DATA packet or packet sequence containing an Exchange_Identification command LPDU (LXC) in the user data field(s).

- LTC — LLC_LOGICAL_LINK_TEST: representing a DATA packet or packet sequence containing a Link_Test command LPDU (LTC) in the user data field(s).

- LRR — LLC_RECEIVE_READY: representing a DATA packet containing a Receive_Ready command LPDU (LRR) in the user data field.

Responses Sent and Received

- LDM — LLC_DISCONNECTED_MODE: representing a DATA packet containing a Disconnected_Mode response LPDU (LDM) in the user data field.

- LPR — LLC_PDU_REJECT: representing a DATA packet containing a PDU_Reject response LPDU (LPR) in the user data field.

- LUA — LLC_UNNUMBERED_ACKNOWLEDGE: representing a DATA packet containing an Unnumbered_Acknowledge response LPDU (LUA) in the user data field.

- LXR — LLC_EXCHANGE_IDENTIFICATION: representing a DATA packet or packet sequence containing an Exchange_Identification response LPDU (LXID), including link station identification information, in the user data field(s).

- LTR — LLC_TEST: representing a DATA packet or packet sequence containing a Link_Test response LPDU (LTR), including test data, in the user data field(s).

- LRR — RECEIVE_READY: representing a DATA packet containing a Receive_Ready response LPDU (LRR) in the user data field.

K.8.1.5 BASIC PROCEDURES

Basic procedures defined for ELLC link stations, specified at the intersection of a state/condition/option and a stimulus, denoted by a small letter 'bp' concatenated with a capital letter 'L' (bpL), include:

bpA – Acknowledgment: Process the received Nr value according to the procedure specified by CHART_A in "Acknowledgment" on page II-K-50 and if Va<Nr<Vs : Va=Nr, RT1; Va<Nr=Vs : Va=Nr, TT1, ITi; ELSE ; NS.

bpL – Limit: Perform the procedure specified by CHART_L in "Limit" on page II-K-51 which increments the (re)-transmission count 'Ct' by one, then if Ct=N2 : report the failing procedure to, and await further direction from, a higher level of SNA; Else : retry the indicated protocol procedure.

bpR – Rejection: Process the received REJECT command/response LPDU according to the procedure specified by CHART_R in "Rejection" on page II-K-51 and if Va<Nr<Vs : Va=Vs=Nr, RT1; Va<Nr=Vs : Va=Vs=Nr, TT1, ITi; ELSE : Vs=Nr.

bpT – TEST: Perform the procedure specified by CHART_T in "Link Test" on page II-K-51 with the result that if Pt=Nul : Pt=Ip, TTi, RT1, Ct='0', [LTC^1] > CHECKPOINTING; Pt=Rp : IH, Pt=Nul, [LTR(F=Vf,id)]; Pt=IRp : IH, Pt=Ip, [LTR(F=Vf,id)]; Else : LE.

bpX – EXCHANGE_IDENTIFICATION: Perform the procedure specified by CHART_X in "Exchange Identification" on page II-K-51 with the result that if Px=Nul : Px=Ip, TTi, RT1, Ct='0', [LXC^1] > CHECKPOINTING; Px=Rp : IH, Px=Nul, [LXR(F=Vf,id)]; Px=IRp : IH, Px=Ip, [LXR(F =Vf,id)]; Else : LE.

K.8.1.6 Actions

Actions taken by ELLC link stations, denoted at the intersection of a state/condition/option and a stimulus, are identified by two capital letters 'LL' which are defined as follows:

DB - Discard BTU: Discard the contents of the information field of the received PDU and take no further action as a result of its receipt.

DL - Disable Link: Destroy the link connection, releasing the Access Channel and Media Access Port associated with the link appearance.

EL - Enable Link: Establish a link connection by associating a specific Access Channel and Media Access Port as required to create a link appearance.

FB - Forward BTU: Forward the received Basic Transmission Unit to the higher level using protocol entity.

IH - Inform Higher Layers: Inform a higher layer of SNA of the occurrence via internal signalling mechanisms.

IP - Ignore Protocol Data Unit: Take no action and ignore the received protocol data unit in its entirety.

ITi - Initiate Query Timer, LTi: Initiate a logical link timeout for the duration of Query Timer, LTi.

LE - Local Procedure Error: Representing an internal signalling error or illogical protocol sequence on the part of the ELLC link station that may be either ignored or reported to a higher layer of SNA for analysis.

NA - Not Applicable: Identifies events/actions/responses that cannot occur for a given state/condition/alternative.

NS - No Specific Action: No specific action is required by the ELLC link station protocol.

QL - Queue LPDU: Place the output BTU in the information field of an Information LPDU, place the LPDU on the outbound queue for the associated logical link, and pass control to the PDU_Out_UPM.

RE - Remote Procedure Error: Representing a protocol procedure error on the part of the ELLC link station in the adjacent node that may be either ignored or reported to a higher layer of SNA for future analysis.

RS - Report Status: Report the current status of the ELLC link station to a higher level of SNA.

SL - Set-Up Link: Initiate the link set-up procedure described in §-4.5.4.1.

TC - Terminate Contact: Terminate the SNA_CONTACT phase and signal CONTACTED to a higher level of SNA.

TL - Terminate Link: Terminate the link initialization procedure and transfer an unsolicited DISCONNECTED_MODE response to inform the link station in the adjacent node.

TTi - Terminate Timer LTi: Terminate LLC Query Timer, LTi.

K.8.2 Link Station States and Actions

K.8.2.1 INOPERATIVE State

CHART 1-E: EVENTS in INOPERATIVE State		
Stimuli P: V: ALT	Action(s) [PDU Transfers]	New State
L3RDY	EL, P=Nul	LINK_CLOSED
LSTRT	LE	
LSTOP	LE	
L3NOP	LE	
ELBSY	LE	
XLBSY	LE	
XCHID	LE	
LTEST	LE	
SDATA	LE	
ELPDU	IP	
ELT1X	LE	
ELTiX	LE	

CHART 1-I: I-Format LPDUs in INOPERATIVE State		
Stimuli P: V: ALT	Action(s) [PDU Transfers]	New State
LI	IP	

CHART 1-S: S-format LPDUs in INOPERATIVE State		
Stimuli P: V: ALT	Action(s) [PDU Transfers]	New State
LRR	IP	
LNR	IP	
LRJ	IP	

CHART 1-U: U-format LPDUs in INOPERATIVE State		
Stimuli P: V: ALT	Action(s) [PDU Transfers]	New State
LSM|LUA	IP	
LDC|LDM	IP	
LXC|LXR	IP	
LTC|LTR	IP	
LPR	IP	

K.8.2.2 LINK_CLOSED State

CHART 2-E: EVENTS in LINK_CLOSED State

Stimuli	P: V: ALT	Action(s)	[PDU Transfers]	New State
L3RDY		LE		
LSTRT	c+t+xNul+ iNul	SL, Vi=L, Ct=0, TTi, RT1	[LSM^{1}]	LINK_OPENING
	iR	SL, Vi=P, TT1, ITi	[LUA"]	LINK_OPENING
	ELSE	LE		
LSTOP		TL, Vi=Nul, TT1, ITi	[LDM^{0}]	
L3NOP		DL		INOPERATIVE
ELBSY	bR	Pb=B		
	ELSE	Pb=L		
XLBSY		LE		
XCHID		bpX	[XPo']	
LTEST		bpT	[TPo']	
SDATA		LE		
ELPDU		RE		
ELT1X	Ct<LN2+ xI|IO	bpL	[LXC^{1}(id)]	
	tI|IO	bpL	[LTC^{1}(data)]	
	ELSE	LE		
ELTiX	Nul	LE		

CHART 2-I: I-Format LPDUs in LINK_CLOSED State

Stimuli	P: V: ALT	Action(s)	[PDU Transfers]	New State
LIc^{0}		IP		
LIc^{1}		NS	[LDM^{1}]	
LIr$^{0\|1}$		IP		

CHART 2-S: S-format LPDUs in LINK_CLOSED State

Stimuli	P: V: ALT	Action(s)	[PDU Transfers]	New State
LRR|LNR|LRJc^{0}		IP		
LRR|LNR|LRJc^{1}		NS	[LDM^{1}]	
LRR|LNR|LRJr$^{0\|1}$		IP		

CHART 2-U: U-format LPDUs in Received LINK_CLOSED State

Stimuli P: V: ALT	Action(s) [PDU Transfers]	New State
LSM Nul+iNul|R	IH, Vi=R, Vf=P, ITi	
iP	IH, Pc=Pt=Px=Va=Vf=Vs=0, ITi [LUA"]	LINK_OPENING
ELSE	LE	
LDC	DL [LDM']	
LUA	IP	
LDM	IP	
LPR	IP_(RE)	

CHART 2-U: U-format LPDUs in LINK_CLOSED State (Continued)

Stimuli P: V: ALT	Action(s) [PDU Transfers]	New State
LXC	IH, Px=0, Vf=P	
LXR$^{0\|1}$ xI	IH, Px=Nul, TT1	
xI0	IH, Px=0, TT1	
ELSE	IP_(RE)	
LTC	IH, Pt=0, Vf=P	
LTR$^{0\|1}$ tI	IH, Pt=Nul, TT1	
tI0	IH, Pt=0, TT1	
ELSE	IP_(RE)	

K.8.2.3 LINK_OPENING State

CHART 3-E: EVENTS in LINK_OPENING State			
Stimuli P: V: ALT	**Action(s)**	**[PDU Transfers]**	**New State**
L3RDY	LE		
LSTRT	LE		
LSTOP	Vi=Nul, TT1, ITi	[LDM^{0}]	LINK_CLOSED
L3NOP	DL		INOPERATIVE
ELBSY bR	Pb=B		
ELSE	Pb=L		
XLBSY bB	Pb=R		
ELSE	Pb=Nul		
XCHID	LE		
LTEST	LE		
SDATA	LE		
ELPDU	IP		

CHART 3-E: EVENTS in LINK_OPENING State (Continued)			
Stimuli P: V: ALT	**Action(s)**	**[PDU Transfers]**	**New State**
ELT1X	bpL	[LPo']	
ELTiX	LE		

CHART 3-I: I-Format LPDUs in LINK_OPENING State			
Stimuli P: V: ALT	**Action(s)**	**[PDU Transfers]**	**New State**
LIic|r^{0} iP	IH, Vi=Nul, FB, RTi	[LRRr^{0}]	LINK_OPENED
ELSE	IP		
LIic^{1} iP	IH, Vi=Nul, FB, RTi	[LRRr^{1}]	LINK_OPENED
ELSE	IP		
LIir^{1}	IP		

CHART 3-S: S-format LPDUs in LINK_OPENING State

Stimuli P: V: ALT	Action(s) [PDU Transfers]	New State
LRR|LNR|LRJc^{0}	IP	
LRR(0)| LRJ(0)c^{1} iR	IH, Pb=Nul, Vi=Nul, RTi [LRRr^{1}]	LINK_OPENED
ELSE	IP	
LNR(0)c^{1}	IH, Pb=R, Vi=Nul, RTi [LRRr^{1}]	LINK_OPENED
ELSE	IP	
LRR|LNR|LRJr^{0,1}	IP	

CHART 3-U: U-format LPDUs in LINK_OPENING State

Stimuli P: V: ALT	Action(s) [PDU Transfers]	New State
LSM	Vi=R, TT1, ITi [LUA']	
LDC	IH, Vi=Nul, TT1, ITi [LDM']	LINK_CLOSED
LUA^{1}	IH, Pc=Pt=Px=Va=Vf=Vi=Vr=Vs=Nul, TTi, RTi [LRRc^{1}]	CHECKPOINTING
LDM^{1}	IH, Vi=Nul, TT1, ITi	LINK_CLOSED
LDM|LUA^{0}	IP	
LXC	IP	
LTC	IP	
LPR	IP_(RE)	
LTR	IP_(RE)	
LXR	IP_(RE)	

K.8.2.4 LINK_CLOSING State

CHART 4-E: EVENTS in LINK_CLOSING State

Stimuli P: V: ALT	Action(s) [PDU Transfers]	New State
L3RDY	LE	LINK_CLOSED
LSTRT	LE	
LSTOP	LE	
L3NOP	RS	INOPERATIVE
ELBSY	Pb=L	
XLBSY	LE	
XCHID	LE	
LTEST	LE	
SDATA	LE	
ELPDU	IP	
ELT1X	bpL	
ELTiX	LE	

CHART 4-I: I-Format LPDUs in LINK_CLOSING State

Stimuli P: V: ALT	Action(s) [PDU Transfers]	New State
LI	IP	

CHART 4-S: S-format LPDUs in LINK_CLOSING State

Stimuli P: V: ALT	Action(s) [PDU Transfers]	New State
LRR|LNR|LRJ	IP	

<table>
<tr><td colspan="3">CHART 4-U: U-format LPDUs in LINK_CLOSING State</td></tr>
<tr><td>Stimuli P: V: ALT</td><td>Action(s) [PDU Transfers]</td><td>New State</td></tr>
<tr><td>LSM</td><td>IH, TT1, ITi [LDM']</td><td>LINK_CLOSED</td></tr>
<tr><td>LDC</td><td>IH, TT1, ITi [LUA']</td><td>LINK_CLOSED</td></tr>
<tr><td>LUA^1|LDM</td><td>IH, TT1, ITi</td><td>LINK_CLOSED</td></tr>
<tr><td>LUA^0</td><td>IP</td><td></td></tr>
<tr><td>LXC</td><td>IP</td><td></td></tr>
<tr><td>LTC</td><td>IP</td><td></td></tr>
<tr><td>LPR</td><td>IP_(RE)</td><td></td></tr>
<tr><td>LTR</td><td>IP_(RE)</td><td></td></tr>
<tr><td>LXR</td><td>IP_(RE)</td><td></td></tr>
</table>

K.8.2.5 LINK_OPENED State

CHART 5-E: EVENTS in LINK_OPENED State				
Stimuli	P: V: ALT	Action(s)	[PDU Transfers]	New State
L3RDY		LE		
LSTRT		LE		
LSTOP		TTi, RT1, Ct=0	[LDC^{1}]	LINK_CLOSING
L3NOP		LE		
ELBSY	bL|B	LE		
	RJN+|bR	Pb=B		
	ELSE	Pb=L		
XLBSY	bL	Pb=Nul, RT1, Ct=0	[LRRc^{1}]	CHECKPOINTING
	bB	Pb=R, RT1, Ct=0	[LRRc^{1}]	CHECKPOINTING
	RJN+bL	Pb=Nul, TTi, IT1, Ct=0	[LRRc^{1}]	CHECKPOINTING
	RJN+bB	Pb=R, TTi, RT1, Ct=0	[LRRc^{1}]	CHECKPOINTING
	ELSE	LE		
XCHID	xNul	Px=I, TTi, RT1, Ct=0	[LXC^{1}]	CHECKPOINTING
	xO	IH, Px=Nul	[LXR"]	
	xIO	IH, Px=I	[LXR"]	
	ELSE	LE		
LTEST	tNul	Pt=I, TTi, RT1, Ct=0	[LTC^{1}]	CHECKPOINTING
	t/o	IH, Pt=Nul	[LTR"]	
	tIO	IH, Pt=I	[LTR"]	
	ELSE	LE		
SDATA		QL	[PDU_Out_UPM]	
ELPDU		IH_(RE), TT1, ITi, Pr=L	[LPR^{0}]	LINK_RECOVERY
ELT1X	RJN+|bR	RT1, Ct=0	[LRRc^{1}]	CHECKPOINTING
	RJN+bL|B	RT1, Ct=0	[LNRc^{1}]	CHECKPOINTING
	bL|B	IT1, Ct=0	[LNRc^{1}]	CHECKPOINTING
	ELSE	IT1, Ct=0	[LRRc^{1}]	CHECKPOINTING
ELTiX		LE		

CHART 5-I: I-Format LDPUs in LINK_OPENED State				
Stimuli	P: V: ALT	Action(s)	[PDU Transfers]	New State
LIic|r^0	RJN	bpA, FB, P=Nul	[PDU_Out_UPM]	
	bL|B	bpA, DB	[LNRr^0]	
	bR	bpA, DB	[LRRr^0]	
	RJN+bL|B	bpA, DB, P=Nul	[LNRr^0]	
	RJN+bR	bpA, FB, P=Nul	[LRRr^0]	
	ELSE	bpA, FB	[PDU_Out_UPM]	
LIic^1	RJN	bpA, FB, P=Nul	[LRRr^1]	
	bL|B	bpA, DB	[LNRr^1]	
	RJN+bL|B	bpA, DB, P=Nul	[LNRr^1]	
	RJN+bR	bpA, FB, P=Nul	[LRRr^1]	
	ELSE	bpA, FB	[LRRr^1]	
LIir^1	ELSE	IH_(RE), Va=Vs=Nr, TT1, ITi, Pr=L	[LPR^0]	LINK_RECOVERY
LIec|r^0	RJN,bL|B	bpA, DB	[LNRr^0]	
	RJN+bL|B	bpA, DB	[LNRr^0]	
	bR	bpA, DB, P=RJN	[LRJr^0]	
	RJN+bR	bpA, DB		
	ELSE	bpA, DB, P=RJN	[LRJr^0]	
LIec^1	RJN,bL|B	bpA, DB	[LNRr^1]	
	RJN+bL|B	bpA, DB	[LNRr^1]	
	bR	bpA, DB, P=RJN	[LRJr^1]	
	RJN+bR	bpA, DB	[LRRr^1]	
	ELSE	bpA, DB, P=RJN	[LRJr^1]	
LIer^1	ELSE	IH_(RE), Va=Vs=Nr, TT1, ITi, Pr=L	[LPR^0]	LINK_RECOVERY
LRRc|r^0	RJN+bL	bpA		
	bL	bpA	[PDU_Out_UPM]	
	RJN+|bB	bpA, Pb=L	[PDU_Out_UPM]	
	ELSE	bpA, Pb=Nul	[PDU_Out_UPM]	
LRRc^1	RJN|bL	bpA	[LNRr^1]	
	RJN+|bB	bpA, Pb=L	[LNRr^1]	
	ELSE	bpA, Pb=Nul	[LRRr^1]	
LRRr^1	RJN+bL	IH_(RE), Va=Nr, TT1, ITi, Pr=L	[LPR^0]	LINK_RECOVERY
	RJN+bR	IH_(RE), Pb=Nul, Va=Vs=Nr, TT1, ITi, Pr=L	[LPR^0]	LINK_RECOVERY
	ELSE	IH_(RE), Va=Vs=Nr, TT1, ITi, Pr=L	[LPR^0]	

CHART 5-S: S-format LPDUs in LINK_OPENED State (Continued)

Stimuli	P: V: ALT	Action(s)	[PDU Transfers]	New State
LNRc|r^0	RJN+bL	bpA, Pb=B		
	bNul	bpA, Pb=R	[LRRr^0]	
	bL	bpA, Pb=B	[LNRr^0]	
	ELSE	bpA		
LNRc^1	bNul	bpA, Pb=R	[LRRr^1]	
	bL	bpA, Pb=B	[LNRr^1]	
	bB	bpA	[LNRr^1]	
	ELSE	bpA	[LRRr^1]	
LNRr^1	bL	IH_(RE), Pb=B, Va=Vs=Nr, TT1, ITi, Pr=L	[LPR^0]	LINK_RECOVERY
	ELSE	IH_(RE), Pb=R, Va=Vs=Nr, TT1, ITi, Pr=L	[LPR^0]	LINK_RECOVERY
LRJc|r^0	RJN|bL	bpR	[PDU_Out_UPM]	
	bB	bpR, Pb=L	[PDU_Out_UPM]	
	ELSE	bpR, Pb=Nul	[PDU_Out_UPM]	
LRJc^1	RJN	bpR	[LRRr^1]	
	RJN+|bL	bpR	[LNRr^1]	
	RJN+|bB	bpR, Pb=L	[LNRr^1]	
	ELSE	bpR, Pb=Nul	[LRRr^1]	
LRJr^1	bB	bpR, Pb=L, Pr=L	[LPR^0]	LINK_RECOVERY
	RJN+bR	IH_(RE), Pb=Nul, Va=Vs=Nr, TT1, ITi, Pr=L	[LPR^0]	LINK_RECOVERY
	ELSE	IH_(RE), Va=Vs=Nr, TT1, ITi, Pr=L	[LPR^0]	LINK_RECOVERY

CHART 5-U: U-format LPDUs in LINK_OPENED State

Stimuli	P: V: ALT	Action(s)	[PDU Transfers]	New State
LSM		IH, Vi=R, Vf=P, TT1, ITi		LINK_RESETING
LDC		IH, TT1, ITi	[LUA']	LINK_CLOSED
LUA		IH_(RE), TT1, ITi, Pr=L	[LPR^0]	LINK_RECOVERY
LDM		IH, TT1, ITi		LINK_CLOSED
LPR		IH, TT1, ITi, Ct=0, Pr=R		LINK_RECOVERY
LXC		IH, Px=0, Vf=P		
LXR		IH_(RE), Px=Nul, TT1, ITi, Pr=R	[LPR^0]	LINK_RECOVERY
LTC		IH, Pt=0, Vf=P		
LTR		IH_(RE), Pt=Nul, TT1, ITi, Pr=R	[LPR^0]	LINK_RECOVERY

K.8.2.6 CHECKPOINTING State

CHART 6-E: EVENTS in CHECKPOINTING State

Stimuli	P: V: ALT	Action(s)	[PDU Transfers]	New State
L3RDY		LE		
LSTRT		LE		
LSTOP	cNul	Pc=D		
	RJN+cR	Pc=D		
	ELSE	LE		
L3NOP		LE		
ELBSY	RJN+|cR	Pb=L, Pc=Nul		
	RJN+|bR	Pb=B, Pc=Nul		
	bL|B	LE		
	ELSE	Pb=L		
XLBSY	RJN+|bL	IH, Pb=Nul, Pc=R	[LRRr^{0}]	
	ELSE	LE		
XCHID	cNul+			
	xNul	Pc=X		
	x0	IH, Px=Nul	[LXR"]	
	xI0	IH, Px=I	[LXR"]	
	ELSE	LE		
LTEST	cNul+			
	tNul	Pc=T		
	t0	IH, Pt=Nul	[LTR"]	
	tI0	IH, Pt=I	[LTR"]	
	ELSE	LE		
SDATA		QL	[PDU_Out_UPM]	
ELPDU		IH_(RE), TT1, ITi, Pr=L	[LPR^{0}]	LINK_RECOVERY
ELT1X	t|x0	LE		
	t+x≠0 Ct=LN2	Ct=Ct+1 IH, IT1, ITi		LINK_CLOSED
	t+xNul	IT1	[LRRc^{1}]	
	x0|I0+ Ct<LN2	IT1	[LXC^{1}(id)]	
	t0|I0+ Ct<LN2	IT1	[LTC^{1}(data)]	
ELTiX		LE		

CHART 6-I: I-Format LPDUs in CHECKPOINTING State

Stimuli	P: V: ALT	Action(s)	[PDU Transfers]	New State
LIic|r^0	RJN+cR+ aNr<Vs	P=Pc=Nul, FB	[LRRr^0]	
	<Nr≤Vs	P=Pc=Nul, Va=Nr, FB	[LRRr^0]	
	cR+ aNr<Vs	Pc=Nul, FB	[LRRr^0]	
	<Nr≤Vs	Pc=Nul, Va=Nr, FB	[LRRr^0]	
	bL+aNr<Vs	DB	[LNRr^0]	
	<Nr≤Vs	Va=Nr, DB	[LNRr^0]	
	RJN|RJN+bL aNr<Vs	P=Nul, FB	[LRRr^0]	
	<Nr≤Vs	Va=Nr, P=Nul, FB	[LRRr^0]	
	ELSE aNr<Vs	FB	[LRRr^0]	
	<Nr≤Vs	Va=Nr, FB	[LRRr^0]	
LIic^1	RJN+cR+ aNr<Vs	P=Pc=Nul, FB	[LRRr^1]	
	a<Nr≤Vs	P=Pc=Nul, Va=Nr, FB	[LRRr^1]	
	cR+ aNr<Vs	Pc=Nul, FB	[LRRr^1]	
	a<Nr≤Vs	Pc=Nul, Va=Nr, FB	[LRRr^1]	
	bL+aNr<Vs	DB	[LNRr^1]	
	a<Nr≤Vs	Va=Nr, DB	[LNRr^1]	
	RJN|RJN+bL aNr<Vs	P=Nul, FB	[LRRr^1]	
	a<Nr≤Vs	Va=Nr, P=Nul, FB	[LRRr^1]	
	ELSE aNr<Vs	FB	[LRRr^1]	
	a<Nr≤Vs	Va=Nr, FB	[LRRr^1]	
LIir^1		IP_(RE)		
LIec|r^0	cR+aNr<Vs	Pc=Nul, DB, P=RJN	[LRJr^0]	
	a<Nr≤Vs	Pc=Nul, Va=Nr, DB, P=RJN	[LRJr^0]	
	RJN+cR+ aNr<Vs	Pc=Nul, DB, P=RJN		
	a<Nr≤Vs	Pc=Nul, Va=Nr, DB, P=RJN		
	bL+aNr<Vs	DB, P=RJN	[LNRr^0]	
	a<Nr≤Vs	Va=Nr, DB, P=RJN	[LNRr^0]	
	RJN|RJN+bL+ aNr<Vs	DB		
	a<Nr≤Vs	Va=Nr, DB		
	ELSE aNr<Vs	DB, P=RJN	[LRJr^0]	
	a<Nr≤Vs	Va=Nr, DB, P=RJN	[LRJr^0]	

CHART 6-I: I-Format LPDUs in CHECKPOINTING State (Continued)				
Stimuli	P: V: ALT	Action(s)	[PDU Transfers]	New State
LIec[1]	cR+aNr<Vs	Pc=Nul, DB, P=RJN	[LRJr[1]]	
	a<Nr≤Vs	Pc=Nul, Va=Nr, DB, P=RJN	[LRJr[1]]	
	RJN+cR+ aNr<Vs	Pc=Nul, DB, P=RJN	[LRRr[1]]	
	a<Nr≤Vs	Pc=Nul, Va=Nr, DB, P=RJN	[LRRr[1]]	
	bL+aNr<Vs	DB, P=RJN	[LNRr[1]]	
	a<Nr≤Vs	Va=Nr, DB, P=RJN	[LNRr[1]]	
	RJN+ aNr<Vs	DB	[LRRr[1]]	
	a<Nr≤Vs	Va=Nr, DB	[LRRr[1]]	
	RJN+bL+ aNr<Vs	DB	[LNRr[1]]	
	a<Nr≤Vs	Va=Nr, DB	[LNRr[1]]	
	ELSE aNr<Vs	DB, P=RJN	[LRJr[1]]	
	a<Nr≤Vs	Va=Nr, DB, P=RJN	[LRJr[1]]	
LIer[1]		IP_(RE)		

CHART 6-S: S-format LPDUs in CHECKPOINTING State				
Stimuli	**P: V: ALT**	**Action(s)**	**[PDU Transfers]**	**New State**
$LRRc \vert r^{0}$	cR	Va=Nr		
	RJN+ $\vert$ bL+			
	aNr<Vs	NS	[$LNRr^{0}$]	
	a<Nr≤Vs	Va=Nr	[$LNRr^{0}$]	
	RJN+bR+cR+			
	aNr<Vs	IH, Pb=Nul	[$LNRr^{0}$]	
	a<Nr≤Vs	IH, Pb=Nul, Va=Nr	[$LNRr^{0}$]	
	ELSE			
	aNr<Vs	NS		
	a<Nr≤Vs	Va=Nr		
$LRRc^{1}$	RJN+ $\vert$ bL+			
	aNr<Vs	NS	[$LNRr^{1}$]	
	a<Nr≤Vs	Va=Nr	[$LNRr^{1}$]	
	RJN+bR+cR+			
	aNr<Vs	IH, Pb=Nul	[$LNRr^{1}$]	
	a<Nr≤Vs	IH, Pb=Nul, Va=Nr	[$LNRr^{1}$]	
	ELSE			
	aNr<Vs	NS	[$LRRr^{1}$]	
	a<Nr≤Vs	Va=Nr	[$LRRr^{1}$]	
$LRRr^{1}$		IP_(RE)		
$LNRc \vert r^{0}$	bNul+cR	IH, Vb=R, Va=Nr		
	bL+cR	IH, Vb=B, Va=Nr		
	RJN+cR	IH, Pb=R, Va=Nr		
	RJN+bL+			
	aNr<Vs	IH, Pb=B		
	a<Nr≤Vs	IH, Pb=B, Va=Nr		
	RJN+			
	aNr<Vs	IH, Pb=R		
	a<Nr≤Vs	IH, Pb=R, Va=Nr		
	ELSE			
	aNr<Vs	NS		
	a<Nr≤Vs	Va=Nr		
$LNRc^{1}$	bNul+cR	IH, Pb=R, Va=Nr	[$LRRr^{1}$]	
	bL+cR	IH, Pb=B, Va=Nr	[$LNRr^{1}$]	
	RJN+bL+			
	aNr<Vs	IH, Pb=B	[$LNRr^{1}$]	
	a<Nr≤Vs	IH, Pb=B, Va=Nr	[$LNRr^{1}$]	
	RJN $\vert$ RJN+cR+			
	aNr<Vs	IH, Pb=R	[$LRRr^{1}$]	
	a<Nr≤Vs	IH, Pb=R, Va=Nr	[$LRRr^{1}$]	
	RJN+bR+cR+			
	aNr<Vs	NS	[$LRRr^{1}$]	
	a<Nr≤Vs	IH, Va=Nr	[$LRRr^{1}$]	
	ELSE			
	aNr<Vs	NS	[$LRRr^{1}$]	
	a<Nr≤Vs	Va=Nr	[$LRRr^{1}$]	

CHART 6-S: S-format LPDUs in CHECKPOINTING State (Continued)				
Stimuli	**P: V: ALT**	**Action(s)**	**[PDU Transfers]**	**New State**
LNRr[1]		IP_(RE)		
LRJc|r[0]	cR+RJN+bL	Va=Nr		
	bL+aNr<Vs	NS		
	a<Nr≤Vs	Va=Nr		
	RJN+bR+cR+ aNr<Vs	IH, Pb=Nul		
	a<Nr≤Vs	IH, Pb=Nul, Va=Nr		
	ELSE aNr<Vs	NS		
	a<Nr≤Vs	Va=Nr		
LRJc[1]	cR+aNR<Vs	IH	[LRRr[1]]	
	aNR≤Vs	Va=Nr	[LRRr[1]]	
	RJN+bL	Va=Nr	[LNRr[1]]	
	bL+aNr<Vs	NS	[LNRr[1]]	
	a<Nr≤Vs	Va=Nr	[LNRr[1]]	
	RJN+cR+ aNr<Vs	NS	[LRRr[1]]	
	a<Nr≤Vs	Va=Nr	[LRRr[1]]	
	RJN+bR+cR+ aNr<Vs	IH, Pb=Nul	[LRRr[1]]	
	a<Nr≤Vs	IH, Pb=Nul, Va=Nr	[LRRr[1]]	
	ELSE aNr<Vs	NS	[LRRr[1]]	
	a<Nr≤Vs	Va=Nr	[LRRr[1]]	
LRJr[1]		IP_(RE)		

CHART 6-U: U-format LPDUs in CHECKPOINTING State

Stimuli	P: V: ALT	Action(s)	[PDU Transfers]	New State
LSM		IH, Vi=R, Vf=P, TT1, ITi		LINK_RESETING
LDC		IH, TT1, ITi	[LUA']	LINK_CLOSED
LUA		IH_(RE), TT1, ITi, Pr=L	[LPR°]	LINK_RECOVERY
LDM		IH, TT1, ITi		LINK_CLOSED
LPR		IH, TT1, ITi, Ct=0, Pr=R		LINK_RECOVERY
LXC		IH, Vf=P, Px=R		
LXR°|¹	cNul|R+ xNul|0	IH_(RE), TT1, ITi, Pr=L	[LPR°]	LINK_RECOVERY
	xI	IH, Px=Nul, RT1	[LRRc¹]	
	xI0	IH, Px=0, RT1	[LRRc¹]	
	cD	Pc=Nul, TTi, RT1, Ct=0	[LDC¹]	LINK_CLOSING
	cX	Pc=Nul, Px=I, TTi, RT1, Ct=0	[LXC¹(id)]	
	cT	Pc=Nul, Pt=I, TTI, RT1, Ct=0	[LTC¹(data)]	
LTC		IH, Vf=P, Pt=0		
LTR°|¹	cNul|R+ tNul|0	IH_(RE), TT1, ITi, Pr=L	[LPR°]	LINK_RECOVERY
	tI	IH, Pt=Nul, RT1	[LRRc¹]	
	tI0	IH, Pt=0, RT1	[LRRc¹]	
	cD	Pc=Nul, TTi, RT1, Ct=0	[LDC¹]	LINK_CLOSING
	cX	Pc=Nul, Px=I, TTi, RT1, Ct=0	[LXC¹(id)]	
	cT	Pc=Nul, Pt=I, TTI, RT1, Ct=0	[LTC¹(data)]	

K.8.2.7 LINK_RESETING State

CHART 7-E: EVENTS in LINK_RESETING State

Stimuli P: V: ALT		Action(s)	[PDU Transfers]	New State
L3RDY		LE		
LSTRT		Vi=P, Va=Vr=Vs=0, ITi	[LUA"]	LINK_OPENING
LSTOP		Vi=NUL, TT1, ITi	[LDM°]	LINK_CLOSED
L3NOP		LE		
ELBSY	bNUL	Pb=L		
	bR	Pb=B		
	ELSE	LE		
XLBSY	bNUL	LE		
XCHID		LE		
LTEST		LE		
SDATA		LE		
ELPDU		IH_(RE), TT1, ITi, Pr=L	[LPR°]	LINK_RECOVERY
ELT1X		NA		
ELTiX		IH, ITi		

CHART 7-I: I-Format LPDUs in LINK_RESETING State

Stimuli P: V: ALT	Action(s)	[PDU Transfers]	New State
LIic	LE		
LIec	LE		
LIi|er	LE		

CHART 7-S: S-format LPDUs in LINK_RESETING State

Stimuli P: V: ALT	Action(s)	[PDU Transfers]	New State
LRR|LNR|LRJ	IP		

CHART 7-U: U-format LPDUs in LINK_RESETING State		
Stimuli P: V: ALT	Action(s) [PDU Transfers]	New State
LSM	IH, Vf=P	
LDC	IH, Vi=Nul, TT1, ITi [LUA']	LINK_CLOSED
LUA	IH_(RE)	
LDM	IH, Vi=Nul, TT1, ITi	LINK_CLOSED
LPR	IH, Vi=NUL, TT1, ITi, Ct=0, Pr=R	LINK_RECOVERY
LXC	IP	
LXR	IP_(RE)	
LTC	IP	
LTR	IP_(RE)	

K.8.2.8 LINK_RECOVERY State

CHART 8-E: EVENTS in LINK_RECOVERY State		
Stimuli P: V: ALT	Action(s) [PDU Transfers]	New State
L3RDY	LE	
LSTRT	Vi=L, TTi, IT1, Ct=0 [LSM^{1}]	LINK_OPENING
LSTOP	TTi, IT1, Ct=0 [LDC^{1}]	LINK_CLOSING
L3NOP	LE	
ELBSY bNul	Pb=L	
bR	Pb=B	
ELSE	LE	
XLBSY bL	Pb=Nul	
bB	Pb=R	
ELSE	LE	
XCHID	LE	
LTEST	LE	
SDATA	LE	
ELPDU	IP	
ELT1X	LE	
ELTiX rL	IH	
rR	bpL [Lo']	

CHART 8-I: I-Format LPDUs in LINK_RECOVERY State			
Stimuli P: V: ALT	Action(s)	[PDU Transfers]	New State
LIc|r	DB	[LPR'(Vs,Vr,v)]	LINK_CLOSED

CHART 8-S: S-format LPDUs in LINK_RECOVERY State			
Stimuli P: V: ALT	Action(s)	[PDU Transfers]	New State
LRR|LNR|LRJ	IP		

CHART 8-U: U-format LPDUs in LINK_RECOVERY State			
Stimuli P: V: ALT	Action(s)	[PDU Transfers]	New State
LSM	IH, Pr=Nul, Vi=R, Vf=P, ITi		LINK_RESETING
LDC	IH, TT1, ITi	[LUA']	LINK_CLOSED
LUA	IP		
LDM	IH, TT1, ITi		LINK_CLOSED
LPR	IH, Pr=R, TT1, ITi		
LXC	IP		
LXR	IP		
LTC	IP		
LTR	IP		

K.8.3 Basic Procedure Definitions

K.8.3.1 Acknowledgment

CHART A: Procedure for the ELLC Acknowledgment Processing			
Stimuli P: V: ALT	Action(s)	[Frame Transfers]	New State
a<Nr<Vs	Va=Nr, RT1		
=Vs	Va=Nr, TT1, ITi		
ELSE	NS		

K.8.3.2 Limit

CHART L: Procedure for the ELLC Limit Processing		
Stimuli P: V: ALT	**Action(s) [Frame Transfers]**	**New State**
Ct=LN2	Ct='Ct+1' then IH, TT1, ITi	
ELSE	IT1	

K.8.3.3 Rejection

CHART R: Procedure for the ELLC Rejection Processing		
Stimuli P: V: ALT	**Action(s) [Frame Transfers]**	**New State**
a<Nr<Vs	Va=Nr, RT1	
=Vs	Va=Vs=Nr, TT1, ITi	
ELSE	Vs=Nr	

K.8.3.4 Link Test

CHART T: Procedure for the Link_Test Processing		
Stimuli P: V: ALT	**Action(s) [Frame Transfers]**	**New State**
c+x+tNul	Pt=I, TTi, RT1, Ct=0 [LTC^1]	CHECKPOINTING
c+xNul+t0	IH, Pt=Nul [LTR"]	
c+xNul+tI0	IH, Pt=I [LTR"]	
ELSE	LE	

K.8.3.5 Exchange Identification

CHART X: Procedure for the Exchange_Identification Processing		
Stimuli P: V: ALT	**Action(s) [Frame Transfers]**	**New State**
c+t+xNul	Px=I, TTi, RT1, Ct=0 [LXC^1]	CHECKPOINTING
c+tNul+x0	IH, Px=Nul [LXR"]	
c+tNul+xI0	IH, Px=I [LXR"]	
ELSE	LE	

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