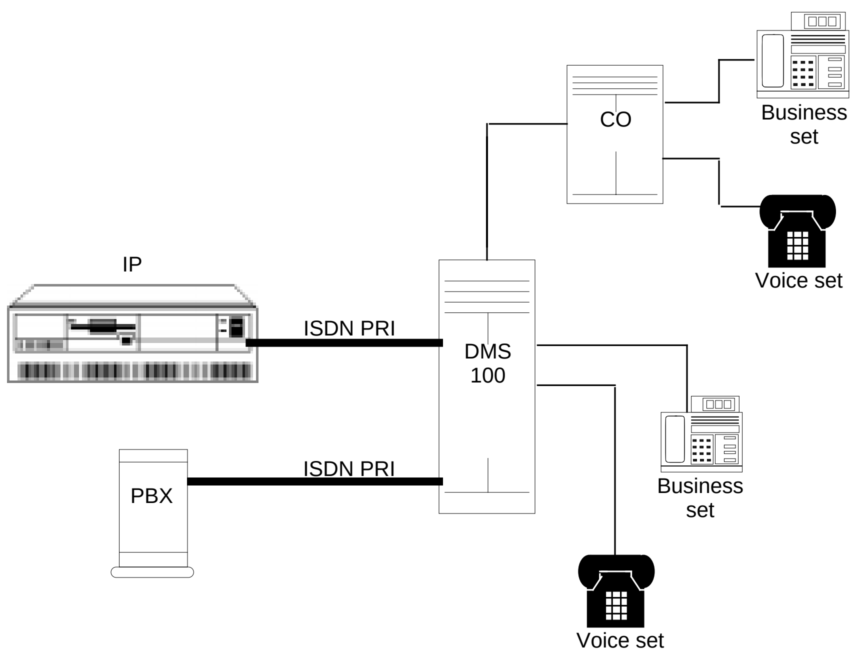
NIS-A233-1

Digital Switching Systems

NT-NI Primary Rate User-Network Interface Specification

NA012 Standard 05.03 Aug. 3, 1999



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Digital Switching Systems

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Publication number: NIS-A233-1
Product release: NA012
Document release: Standard release 05.03
Issue date: Aug. 3, 1999

Publication History

February 1997

NA007 Draft NIS A233-1 Release 1. The initial release modifies NIS A211-1, Release 6 to reflect the required functionality for NI-2 compliant PRI for IP connectivity. All sections of NIS A211-1, Release 6 have been modified.

May 1997

NA008 Draft NIS A233-1 Standard Release 02.03. This release modifies NIS A233-1 to reflect the NA008 changes that have been incorporated into the Nortel NI-2 PRI User-Network interface.

Sept. 1997

NA008 NIS A233-1 Standard Release 02.04. This release corrects minor typographical errors and two documentation errors (one associated with the FACILITY message format and one associated with the valid Called Party Number combinations).

Dec. 1997

NA009 NIS A233-1 Standard Release 03.01. This release modifies NIS A233-1 to reflect the NA009 changes that have been incorporated into the Nortel NI-2 plus enhancements PRI User-Network interface.

Aug. 1998

NA011 NIS A233-1 Standard Release 04.01. This release modifies NIS A233-1 to reflect the NA011 changes that have been incorporated into the Nortel NI-2 plus enhancements PRI User-Network interface.

Apr. 1999

NA012 NIS A233-1 Standard Release 05.01. This release modifies NIS A233-1 to reflect the NA012 changes that have been incorporated into the Nortel NI-2 plus enhancements PRI User-Network interface.

June 1999

NA012 NIS A233-1 Standard Release 05.02. List services not in SPM.

Aug. 1999

NA012 NIS A233-1 Standard Release 05.03. Show DWS is not in SPM.

Approved by: Stanley Abell

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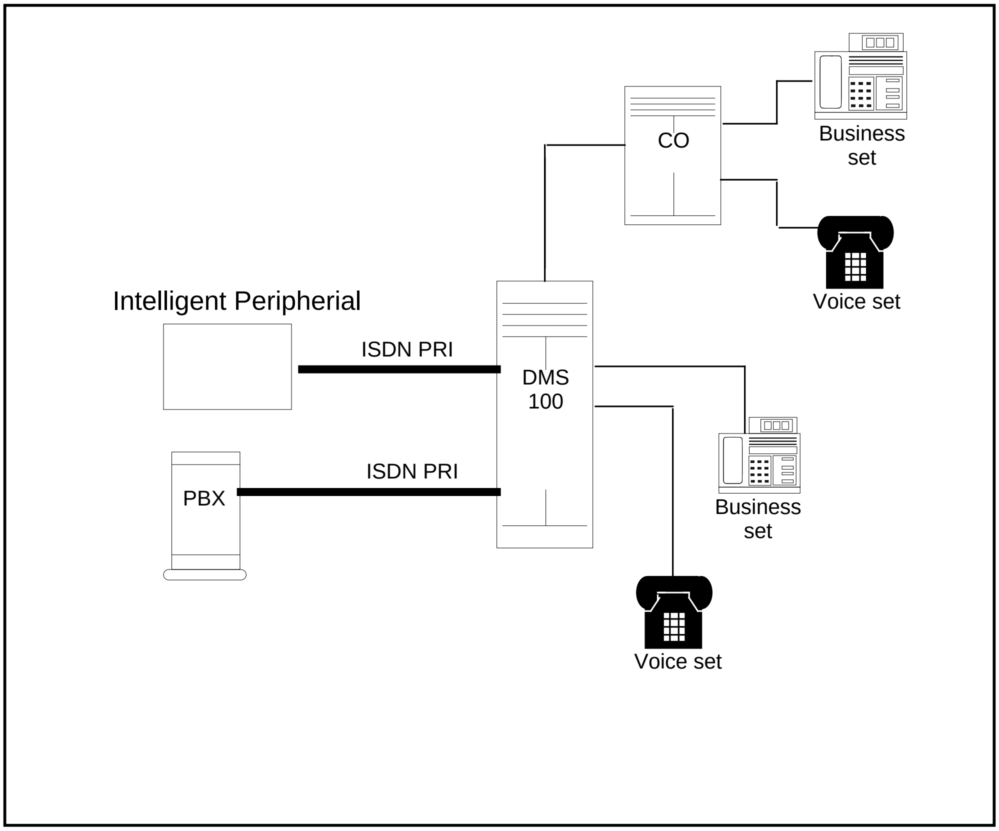
About this specification

This document contains the specification for the network side of the Integrated Services Digital Network (ISDN) Primary Rate Interface (PRI) user-network interface, based upon National ISDN specifications, as implemented on the Nortel DMS-100 switch. The user side of the interface terminates on Class II National ISDN-2 compliant equipment (typically a PBX or an Intelligent Peripherial). The interface described in this document is based on the CCITT ISDN I and Q Series Recommendations, ISDN Standards established by ANSI/ECSA-T1, and the National ISDN-2 requirements as specified in Bellcore Special Report SR-NWT-002120 and Bellcore ISDN Primary Rate Interface Call Control Switching and Signaling Generic Requirements for Class II Equipment TR-TSY-001268.

In addition to the existing layer 1 wire interface, Nortel offers NTNI PRI on an OC-3 fiber in NA012. Refer to the Services section of this document for a list of the services supported on the fiber interface.

Figure 1
ISDN PRI service



Scope

This specification describes the distribution of services across a network, highlighting the connectivity between the network and user. This provides the basis for the definition of ISDN call control and signaling protocol requirements for PRI.

Only the network side of the user-network interface is supported in the DMS-100 for the NTNI PRI.

Structure of document

This specification contains five sections:

- Section 1: Introduction
- Section 2: Layer 1
- Section 3: Layer 2
- Section 4: Layer 3
- Section 5: Supplementary services

Section 1 of this specification contains a brief description of the ISDN primary rate user-network interface on DMS-100, including PRI structure, network configurations and basic connection service.

Section 2 describes layer 1 which is the physical layer. The section contains general information about layer 1 plus a detailed description of the electrical specification, frame formats, maintenance, and connector arrangements.

Section 3 describes layer 2 which is the data link layer. The section includes a general description of layer 2, frame structure, elements of procedures, layer-to-layer communications, peer-to-peer communications, and error indications.

Section 4 describes layer 3 which is the network layer. The layer 3 section is divided into an introduction, an overview of call control, a message and information element format description, call control procedure details, D-channel and B-channel maintenance, and a list of layer 3 parameters. Annexes, located at the rear of section 4, contain additional layer 3 information such as SDL diagrams, compatibility checking, back-up D-channel service, and cause definitions.

Section 5 describes the supplementary services.

Service compatibility

The ISDN Primary Rate service and signaling protocol described in this document is based on the requirements of National ISDN-2 as specified in SR-NWT-002120, TR-TSY-001268, GR-892-CORE and on the emerging North American (ANSI/ECSA-T1) and International (CCITT) standards.

Chapter 1-1: Overview of PRI

This chapter provides an overview of the primary rate interface (PRI) in the telecommunications network, and describes how PRI interworks with other network facilities.

1.1 PRI structure

The basic PRI structure consists of 23 B-channels and a D-channel, for a total transmission rate of 1544 kbit/s, which is equivalent to a DS-1. Each 64 kbit/s B-channel carries user information, such as voice calls or circuit switched data. The D-channel is a 64 kbit/s channel that is used to carry the call control signaling information and to convey Advanced Intelligent Network (AIN) service information.

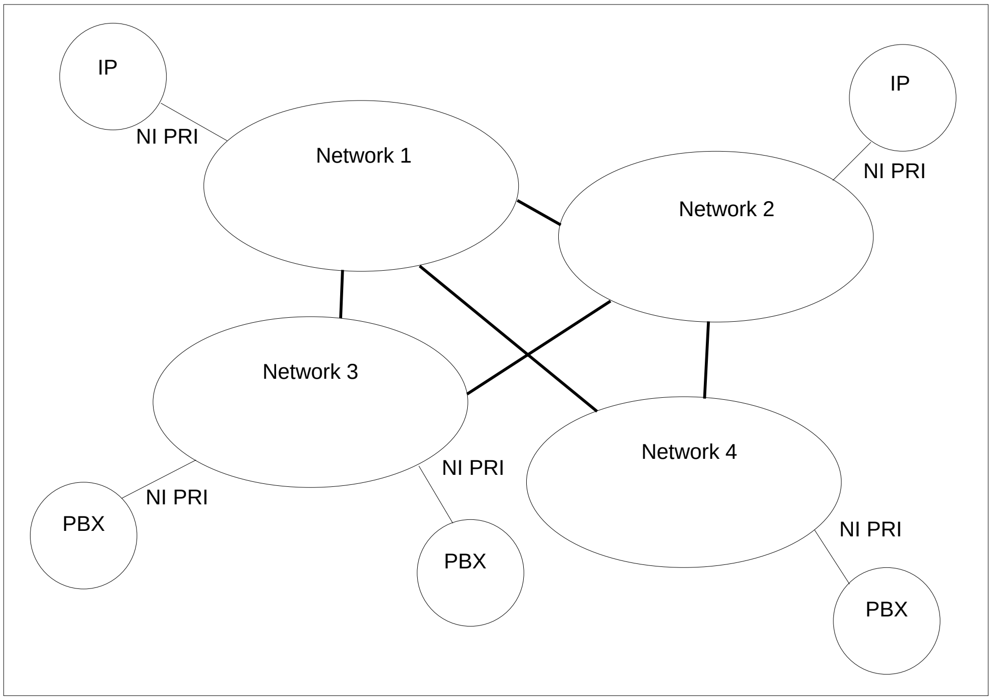
A D-channel may also support the signaling requirements of B-channels on other DS-1 interfaces in addition to the B-channels located on the same DS-1 as the D-channel. This configuration is called non-facility associated signaling. DMS-100 supports a maximum PRI structure that consists of 479 B-channels plus one D-channel (a maximum of 20 DS-1s will be supported per PRI interface), however, heavy call traffic may reduce the configuration size as described in DMS-100 engineering rules. NA012 allows DS-1s controlled by the one D-channel to reside in different peripheral modules. One D-channel provides the signaling for all the B-channels. For increased reliability in larger PRI configurations, a backup D-channel can be assigned. This backup D-channel must exist on a DS-1 different from the one for the primary D-channel. The backup D-channel becomes active if the DS-1 containing the primary D-channel fails, resulting in no loss of service.

Maintenance protocol and procedures for B and D-channels shall include B-channel, DS-1, and D-channel restarts, plus back-up D-channel maintenance procedures and a subset of B-channel availability (as specified in GR-892-CORE).

1.2 Network configurations

Figure 1-1 shows how NI PRI may be used to connect to the public network via a central office (CO). Details of the protocol and services supported over this interface are the subject of this document.

Figure 1-1 PRI provides access to the public switched telephone network



1.3 Connection types

The basic connection service provides two types of connections

- switched
- permanent

1.3.1 Switched connections

Switched connections are set up under control of the user, using D-channel PRI Layer 3 signaling. The user provides the appropriate call establishment information in a connection request, which includes a destination address, the bearer service and the channel associated with each call.

CPE originated public non-call associated signalling connections are supported for Message Service.

1.3.2 Permanent connections

Permanent connections are nailed-up or provisioned connections between a B-channel on a PRI and a trunk or a line interface (including a B-channel on another PRI). For B-Channel Packet service, a permanent connection is provisioned between a B-channel on a PRI and the DMS Link Peripherial Processor (LPP). D-channel call control signaling does not apply to permanent connections.

To establish a permanent connection, the address associated with the connection may not uniquely identify the endpoints of the connection and further qualification is needed (for example, local switch loop numbers and B-channel number in ISDN PRI).

The addresses associated with permanent connections should have a single appearance.

1.4 Bearer services

In ISDN, each connection is associated with a specific bearer service. The bearer service allows the network to reserve the appropriate resources. Bearer services can be generally divided into voice, data, dialable wideband service, and non-call associated signaling categories (see the following sub-sections).

1.4.1 Voice connectivity

For voice connections, the following bearer services are supported

- speech
- 3.1 kHz audio

The default bearer service that is used in the case of interworking with the public network is the 3.1 kHz audio bearer service.

The speech bearer service has the following characteristics

- information transfer rate of 64 kbit/s
- information transfer capability of speech
- user information Layer 1 protocol of μ-law speech

The 3.1 kHz audio bearer service has the following characteristics

- information transfer rate of 64 kbit/s
- information transfer capability of 3.1 kHz audio
- user information Layer 1 protocol of μ-law speech

Layer 1 μ-law coding is in accordance with CCITT Recommendation G.711.

> ***Note:*** The 3.1 kHz audio bearer service can be used to support voice band (analog) data.

1.4.2 Digital data connectivity

For digital data connections, the following bearer services are supported

- unrestricted digital information
- restricted digital information

The unrestricted digital information bearer service has the following characteristics

- information transfer rate of 64 kbit/s
- information transfer capability of “unrestricted digital information”

  This allows the digital data to be routed over facilities that support the B8ZS transmission scheme. This transmission scheme does not require zero code suppression and it allows 64 kbit/s clear data to be transmitted.

  When unrestricted digital information is specified, the user information Layer 1 protocol and user rate may be omitted.
- user information Layer 1 protocol of “CCITT rate adaption”

  This parameter specifies that the 56 kbit/s data rate adaption scheme used is CCITT Recommendation I.463 or V.110) which sets every 8th bit to “1”.

  The advantage of setting the 8th bit to “1” is that it meets the current ZCS ones density requirements, and allows transmission of the user’s data over transmission facilities using in-band A/B bit signaling (which robs bit 8).
- user rate of 56 kbit/s

  The user rate specifies the data transfer rate to be used.

An information transfer capability of “restricted digital information” allows digital data to be routed over T1 facilities with a restricted data transfer capability. The restriction is that some transmission facilities require a certain “ones density” (that is, no more than 15 consecutive zeros) or they may lose synchronization. To avoid losing synchronization they use the Zero Code Suppression (ZCS) coding method which inserts a “1” into the bit stream, as required, which would corrupt the user’s digital data at rates over 56 kbit/s.

When restricted digital information is specified, the user information Layer 1 protocol and user rate are omitted.

1.4.3 Dialable Wideband Service

Dialable Wideband Service (DWS) is also called Switched Fractional DS1 (SWF-DS1) and Multi-rate ISDN by various groups in the industry.

DWS provides the ability to establish PRI, on-demand, nx64 kbps calls. An nx64 kbps call is a call with a rate that is a multiple of 64 kbps. The multiple ’n’ is within the range of 2 to 24.

The characteristics for DWS are:

- information transfer capability of “unrestricted digital information”
- information transfer rate of “H0, H11, or multirate”
- for multirate, the transfer rate multiplier of “2, 3, 4, ... 24”

Note that H0 and H11 represent rates of 384 kbps and 1536 kbps respectively.

1.4.4 Non-Call Associated Signaling

Non-Call Associated Signaling (NCAS) allows the CPE and SPCS to exchange information that is not call related.

An example of the need for NCAS can be seen in Message Service (i.e. voice mail). For example, a CPE providing Message Service needs the ability to activate and deactivate message waiting indicators for their subscribers. These indicators alert subscribers to call their voice mail service. The activation or deactivation typically occurs after the caller has released. Thus, there is no call associated with the signalling.

1.5 Numbering plans and dialing plans

There is a clear distinction between dialing plans and numbering plans. The following definitions will be used throughout this specification:

1.5.1 Numbering plans

A numbering plan defines the network address of a user and is used for routing within the network. Numbering plans are internationally standardized (for instance, CCITT Recommendation E.164).

A numbering plan is identified by a Numbering Plan Identification (NPI).

- NPI of “ISDN/telephony numbering plan E.164/E.163”

  Public network users will be allocated numbers based on the CCITT Recommendation E.164 ISDN numbering plan (see Note). E.163, the pre-ISDN telephony numbering plan, is a subset of E.164.

1.5.2 Dialing plans

A dialing plan defines the digits that a terminal user should dial to establish a connection or to access a service. Dialing plans may include prefix digits and special numbers.

In ISDN signaling, dialing plan digits are carried within information elements. These digits request the functions implied by the digits dialed, and are not necessarily part of the numbering plan. In most cases, users will access the basic connection service by using a dialing plan which contains additional information or special numbers (for example 0, 411, 9+..., etc.) that are not part of the numbering plan.

1.5.3 Conversion of a dialing plan to a numbering plan

It is necessary to convert the dialing plan in use by the user to a network numbering plan to allow the call to be routed by the network.

Figure 1-2 on page 6 shows an example of how a user's dialed digits can be converted to a network numbering plan.

Figure 1-2 Conversion of a dialing plan into a numbering plan

On a typical terminal connected to a CPE, the user dials the digits

10573

The CPE recognizes the customer as a member of Group 1. The Group 1 translation table indicates that the initial **1** in the number should be replaced with the following digits

919-992

Thus, the complete numbering plan number that is used to route the call is

919-992-0573

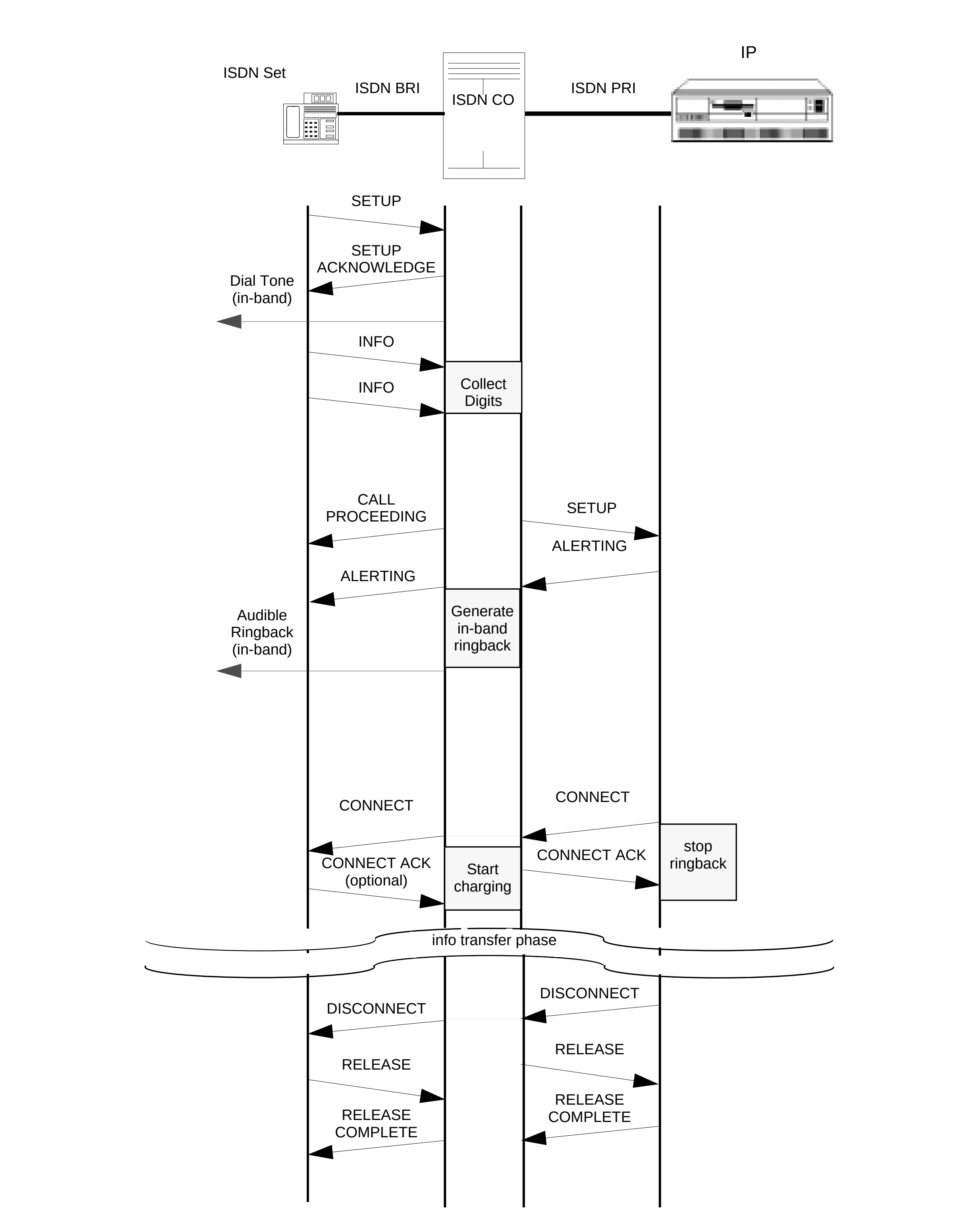
1.6 Basic connection service

The objective of the basic connection service is to connect voice or data CPEs in cooperation with existing public and private networks. The following basic functions are supported to accomplish this goal:

- selection of connection facilities
- progress reporting and cut-through
- conversion between dialing plans and numbering plans
- channel allocation
- interworking with other trunk types, such as analog trunks, digital trunks with A/B-bit signaling and CCS7 trunks

See Figure 1-3 on page 7 for normal message flows associated with the basic connection service, including interworking with ISDN BRI terminals.

Figure 1-3 Basic connection service: normal message flow



1.6.1 Selection of connection facilities

By default, when the called party number has an NPI of “E.164”, public switched network facilities are selected to route the call and support the connection. However, if Network Specific Facilities are requested in the SETUP message, the facilities specified are selected.

1.6.2 Progress reporting and cut-through

The philosophy of the basic connection service is to move, as far as possible, to the target ISDN solution with only out-of-band D-channel and CCS7 signaling. The user interface to terminals is to be driven as close as possible to the user. For example, ISDN terminals will receive the out-of-band signals and generate the appropriate displays, audible tones and announcements, etc. For other terminals, the user interface would be generated from the local switch. This objective allows for customization consistency of the user interface. For example, since the local switch creates the custom user interface, if a call is made to a foreign country, the local switch would receive the out-of-band messages and translate them to locally generated tones, English announcements and English displays (assuming that English is the user’s desired language).

Some exceptions to the rule above have been made to permit interworking with non-ISDN network trunks (for example, DS-1 with A/B-bit signaling) and to overcome engineering problems. These special cases are:

- When a call is set up between an ISDN network and a non-ISDN network, call progress signaling reverts to “far-end” in-band signaling (for example, busy tone, audible ringing, and announcements). A progress report is always sent back to the originating party indicating that interworking with non-ISDN facilities has occurred.
- In order to provide consistent operation to non-ISDN terminals, the local switch translates ISDN messages and progress reports to the appropriate protocol on the terminal access interface. For example, it will translate an ISDN *DISCONNECT* message to a busy tone. The general rule in an ISDN network is that, as a call progresses through the ISDN, the circuit is cut through in both directions at the originating and intermediate switches. In addition, it shall always be the case that there is early cut-through at the terminating switch when the call progresses to it.

  However, a major clipping problem is introduced if near-end audible “ringback” is generated on receipt of the D-channel *ALERTING* message. The circuit cannot be cut-through to the far-end if the near-end supplies a ringback generator. The *CONNECT* message has to be forwarded across the ISDN network, to switch out the ringback generator, before cut-through is achieved. For this reason, audible ringback, when needed, will always be generated in-band from the far end.

To allow the generation of tones and announcements from the terminating switch, the intermediate switches cut through the B-channel on successful B-channel selection.

1.6.3 Conversion of a dialing plan into a network numbering plan

CPE users and Centrex or CO users that have simple terminals supply routing and destination information to the basic connection service by supplying digit strings in conformance to the network dialing plan. The dialed digits must be converted into information elements in a *SETUP* message for routing and conveyance through the ISDN network. This conversion is done by the originating node (CPE or CO) supporting the non-ISDN user access interface. Some conversion from an ISDN BRI interface at the originating switch may also be required (for example, converting dialing plan to numbering plan).

The following fields are provisioned in the CPE to allow the user to define how the dialing plan is converted into ISDN information:

- Number, address, directory number: a string of digits conforming to a standardized numbering plan (for example, E.164).
- Numbering plan identification (NPI): E.164 numbering plan.
- Type of number: “local number”, “national number”, “international number”, or “unknown”.
- Transit Network Selection (TNS): specifies which carrier to use for routing, when required.

The following rules are used by the network for calls received from PRI users to determine numbering plan and routing information. The PRI user should encode the *SETUP* message for outgoing calls according to these requirements for desired services.

Digit strings are encoded in the number digits field of the *Called party number* information element. It is assumed that 6 and 9 digits select private and public numbering plans, respectively. In practice, the actual digits used are assigned by the customer through service orders/changes. Details of the encoding of the referenced information elements can be found in Section 4.

- Numbering Plan Identification (NPI)

  The NPI is in the *Called party number* information element.

  — First digit is “6” or “9”: NPI is “E.164”

  — Otherwise: NPI is “Unknown”

- Type of Number (TON)

  The TON is in the *Called party number* information element.

  When the NPI is “E.164”, the TON is set to “Local”.

  When the NPI is “Unknown”, the TON is set to “Unknown”.

- Carrier Identification Code (CIC)

  For equal access public calls (NPI of “E.164”), the PRI user can explicitly specify a carrier. The carrier identification code can appear in the *Transit network selection* information element. The CIC may be 3 or 4 digits long in order that it comply with North American Carrier Identification Code expansions.

1.6.4 Channel allocation

Where there is a choice of channels to be allocated, the equipment routing the call (for example, the terminal or switch) allocates the outgoing channel. That is, the CPE usually allocates channels on the PRI for calls originating from the CPE, and the CO allocates channels on calls terminating to the CPE.

In the event of “glare” (channel contention) one end of the channel or trunk must be preconfigured as the “master”. The master is set to win all contentions.

To minimize the possibility of glare, both ends should allocate channels in a complementary fashion. For example, the “master” should allocate channels in ascending order and the “slave” in descending order. In this specification, the CO is always the “master”. Note that B-channel negotiation procedures are not supported by the DMS.

1.7 Supplementary services

In addition to the basic connection service, PRI supports a number of supplementary services. These consist of both call processing and administration/maintenance services. Call processing services are associated with establishing and clearing calls. Administration/maintenance services are associated with provisioning and maintaining the PRI infrastructure.

Call processing services supported in this specification are

- calling number delivery
- equal access (inter-LATA)
- special number services
- two B-channel transfer
- call by call service selection

- redirecting number
- calling name delivery
- dialable wideband service
- message service
- B-channel packet service

Administration/maintenance services supported in this specification are

- backup D-channel
- restart signaling
- B-channel availability

Detailed descriptions of the supplementary services are in Section 5 of this specification.

Chapter 2-1: Layer 1 Introduction

In addition to the existing layer 1 wire interface described in this chapter, Nortel offers NTNI PRI on an OC-3 fiber in NA012. The fiber interface will contain the equivalent of 84 DS-1 PRI interfaces.

This section defines the physical layer of the ISDN primary rate interface (PRI) between a central office (CO) and a private branch exchange (PBX). The physical layer consists primarily of a standard DS-1 interface; however there are some configuration differences caused by regulatory conditions attached to the CPE functionality, that is, the need for Network Circuit Terminating Equipment (NCTE). There are a number of DS-1 options which have to be specified for this application.

This specification is based on ANSI T1.408, which describes the PRI layer 1 characteristics. Various annotations and additions are included herein which reflect Northern Telecom's implementation of the applicable standards.

This section includes

- a general description of the interface and configuration
- an electrical definition including formats for the data link (DL)
- a physical definition of connectors

1.1 Conformance

All products which fully conform to this specification implement DS-1 with the following schemes:

- bipolar coding with 8-zero suppression (B8ZS)
- zero code suppression (ZCS), with bit insertion

  Note: Although the ISDN PRI standard requires the support of 64 kbit/s unrestricted/clear information transfer for a DS-0 channel (which requires B8ZS), the current ZCS scheme is also supported since many existing DS-1 transmission facilities do not yet support B8ZS. Provision of ZCS avoids the need for the telephone company to have to replace the ZCS equipment. It also avoids restricting PRI to a clear channel service.

Bit-robbed signaling (for example, A/B bits) are supported on a per DS-0 channel basis, allowing ISDN PRI DS-0 channels (that is, B- and D-channels) to be intermixed on the same DS-1 facility as conventional trunks.

Additionally, a DS-0 nominated as the ISDN PRI D-channel must be able to transmit data at 56 kbit/s (by setting bit 8 to “1”) or at 64 kbit/s clear.

Note: A D-channel with a transmission rate of 56 kbit/s (by setting bit 8 to “1”) is needed for ISDN PRI configurations where the deployed transmission facilities require the use of ZCS coding.

1.2 Standards Compatibility

The network interface is based on

- ANSI T1.403, Carrier to customer installation — DS-1 metallic interface specification, 1989
- ANSI T1.408, ISDN primary rate — customer installation metallic interfaces Layer 1 specification, 1990
- FCC Part 68 Subpart D
- EIA PN 1378 Section 4.13 Page 204, Synchronization
- “Digital Synchronous Network Plan”, Bell Labs Technical Reference PUB60110.
- “High Capacity Digital Service Channel Interface Specification”, Bell Labs Technical Reference PUB62411

The interface does not support the following features (for further information, see the following chapters)

- extended super frame data link message-oriented code words
- extended super frame data link bit-oriented code words other than remote alarm indication (RAI)
- line and payload loopbacks

Chapter 2-2: Layer 1 General Information

2.1 Architecture

This specification defines the physical DS-1 interface including the DS-0 channels used by the ISDN B-channels, D-channels and conventional bit-robbing trunks to transmit information. Figure 2-1 shows the ISDN PRI functional architecture.

Figure 2-1 ISDN PRI architecture

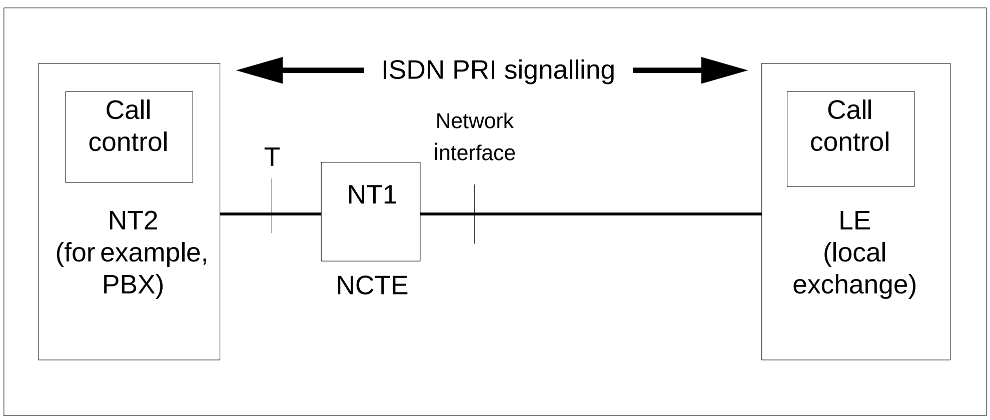
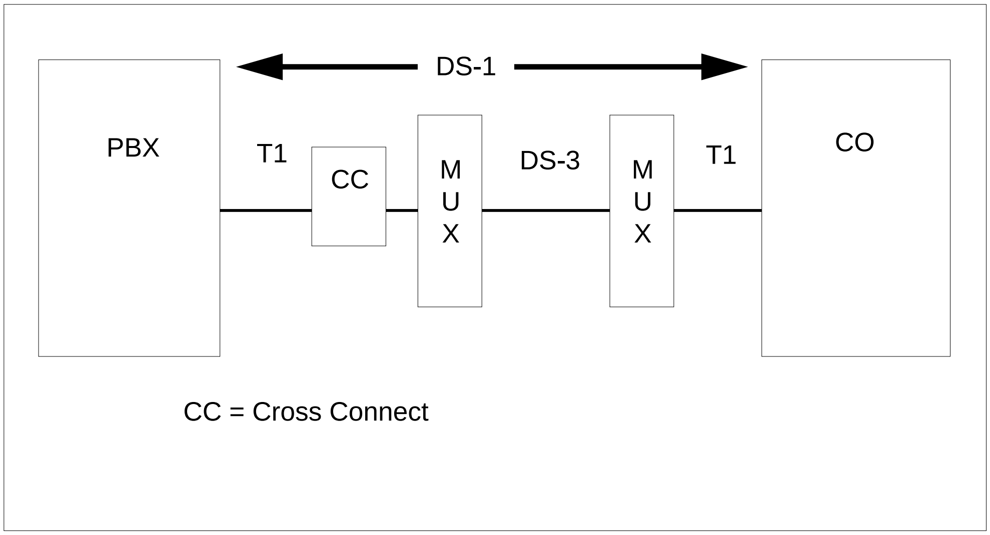


Figure 2-1 shows a network view of the physical architecture.

Figure 2-2 Network view of ISDN PRI functionality



2.2 Layer 1 Services

The physical layer DS-1 facility provides the following services to the higher layers. These services are dependent on the DS-1 facility options being used.

- DS-1 with B8ZS and extended superframe (ESF)

  This DS-1 option set conforms to the ISDN PRI standard as defined in ANSI T1.408, ISDN primary rate—customer installation metallic interfaces Layer 1 specification. The DS-0 channels may be used for ISDN PRI (B-channels or D-channels) or for conventional bit robbing signaling trunks with A/B/C/D bit signaling or A/B signaling. The DS-0 channels used for ISDN PRI have the capability to support an information transfer rate of 64 kbit/s unrestricted. An end-to-end 64 kbit/s connection requires the access and network connections to support the 64 kbit/s capability.

  Note: The use of the ESF format also provides a special data link which may be used for link management (for example, alarm indication, loopback set up, performance reporting).

- DS-1 with ZCS and standard framing (SF)

  This DS-1 option set permits DS-0 channels to be used for ISDN PRI (D-channels or B-channels) with an information transfer rate of up to 56 kbit/s (by setting bit 8 of each byte to “1”), and for conventional trunking with A/B bit signaling.

Note: In general, the ISDN PRI DS-0 channels may be used for a restricted 64 kbit/s information transfer service provided that “1”s density requirements of current ZCS are met to prevent “1”s insertion, and out-of-band signaling is used.

2.3 Layer 1 Signaling

This section defines the characteristics of the metallic interface between a carrier and customer installation (CI), referred to as the network interface (NI), at the DS-1 level. It establishes requirements at the NI necessary for compatible operation between the Carrier and the CI.

The signals at the network interface, described in the following chapters, are of two types:

- normal operating signals
- maintenance signals

Signals that appear as a result of the environment (for example, voltages and currents induced by lightning hits) are not covered.

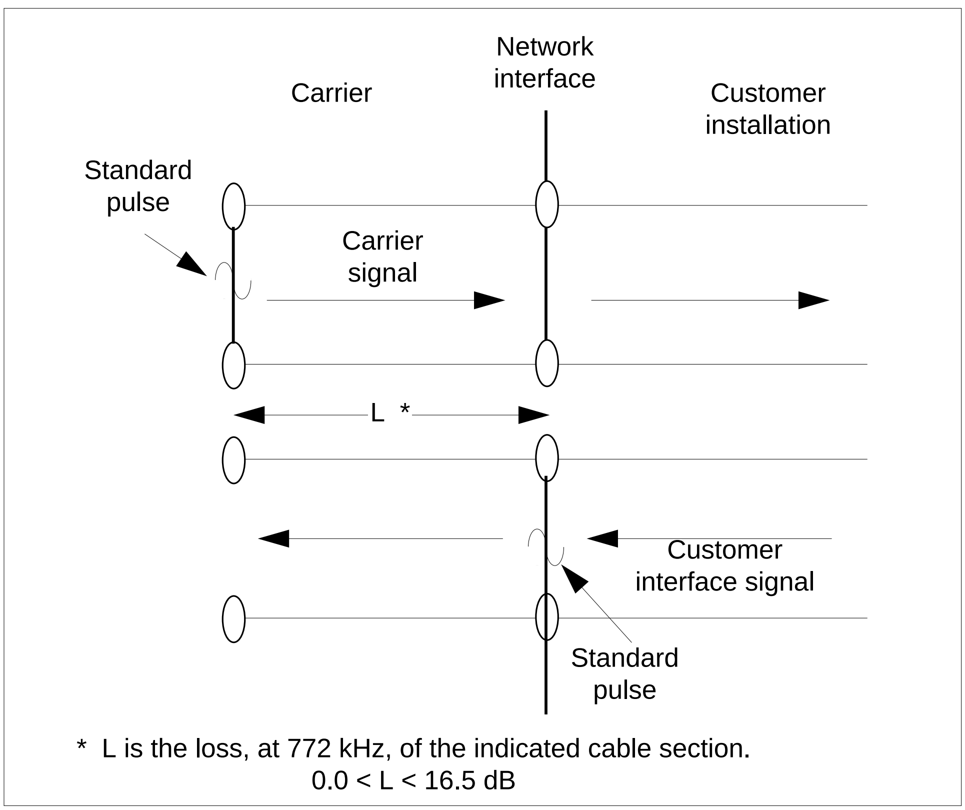
The specification covers the 4-wire DS-1 interface based on the various digital facilities currently in use. Physical arrangements, electrical parameters, signal formats and maintenance protocols are described.

Chapter 2-3: Layer 1 Electrical Specification

3.1 Introduction

The Layer 1 electrical specification describes the DS-1 signals delivered to the carrier and to the customer installation (CI) at the network interface (NI). The NI is shown in Figure 2-3. The signal delivered to the NI by the carrier is identified as the carrier signal, and the signal delivered to the NI by the CI is identified as the CI signal. The NI, as defined in this document, is not symmetrical. That is, at the NI, some of the electrical requirements of the carrier signal differ from those of the CI signal.

Figure 2-3 Network interface



3.2 Impedance matching

Exchange cables generally used by the carriers in the loop plant are non-loaded, staggered-twist paired cables. The characteristic impedance of these cable pairs and the impedance of their associated terminations at 772 kHz is nominally 100 ohms[1].

3.3 Signal specifications

The following signal specifications describe characteristics for all signals at the NI. Differences between the carrier and the CI signals are identified in sections 3.4 and 3.5.

3.3.1 Transmission rate

The transmission rate of the DS-1 signal is 1.544 Mbit/s ± 50 bit/s. Older equipment has rate variations of ±200 bit/s.

3.3.2 Line codes

The line code for the DS-1 signal is bipolar, except where intentional bipolar violations are introduced by B8ZS.

3.3.3 Test load

A termination of 100 ohms ± 5% resistive is used at the network interface for the evaluation of signal characteristics.

3.3.4 Standard pulse characteristics

3.3.4.1 Pulse shape

An isolated pulse, both positive and inverted negative, has an amplitude between 2.4 V and 3.6 V and fits the normalized template shown in Figure 2-4 when scaled by a constant factor. Table 2-1 and Table 2-2 define the corner points of the pulse template.

3.3.4.2 Power levels

For an all “1”s transmitted pattern, the power in the 3 kHz band centered at 772 kHz is in the range of 12.0 to 19.0 dBm and the power in the 3 kHz band centered around 1544 kHz is at least 25 dB less.

3.3.4.3 Pulse imbalance

In any window of 17 consecutive bits, the maximum variation in pulse amplitudes is less than 200 mV, and the maximum variation in pulse width (half amplitude) is less than 20 nsec.

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[1] There may be a small number of low capacitance-type cables in the carrier’s plant. The characteristic impedance of these cables ranges from 120 to 145 ohms at 772 kHz. These cables are non-standard for this interface and, if used, must be tested on an individual basis to ensure that impedance discontinuities do not result in interface reflection losses great enough to affect the stated performance objectives.

Figure 2-4 Isolated pulse template

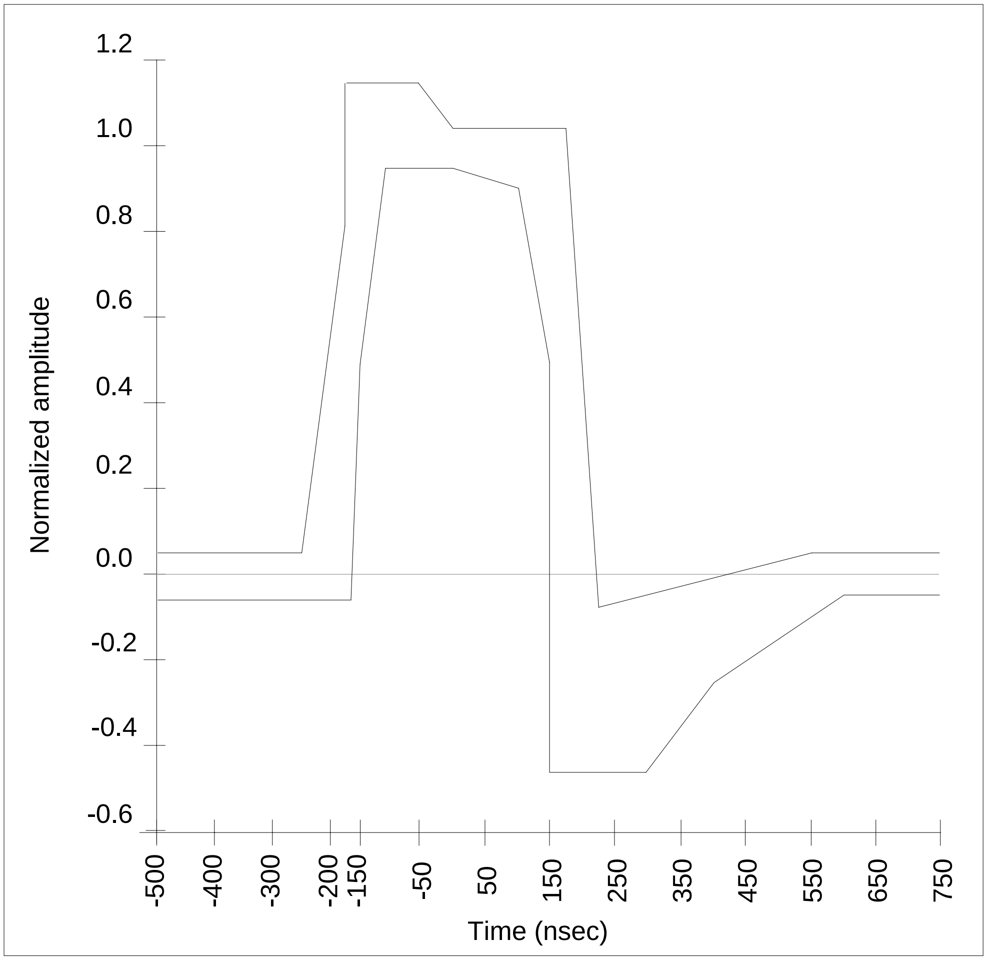


Table 2-1 Pulse template corner points: maximum curve

Time	**nanoseconds**	-500	-250	-175	-175	-75	0	175	228	500	750
	time slots	-0.77	-0.39	-0.27	-0.27	-0.12	0	0.27	0.35	0.77	1.16
Normalized amplitude		0.05	0.05	0.80	1.15	1.15	1.05	1.05	-0.07	0.05	0.05

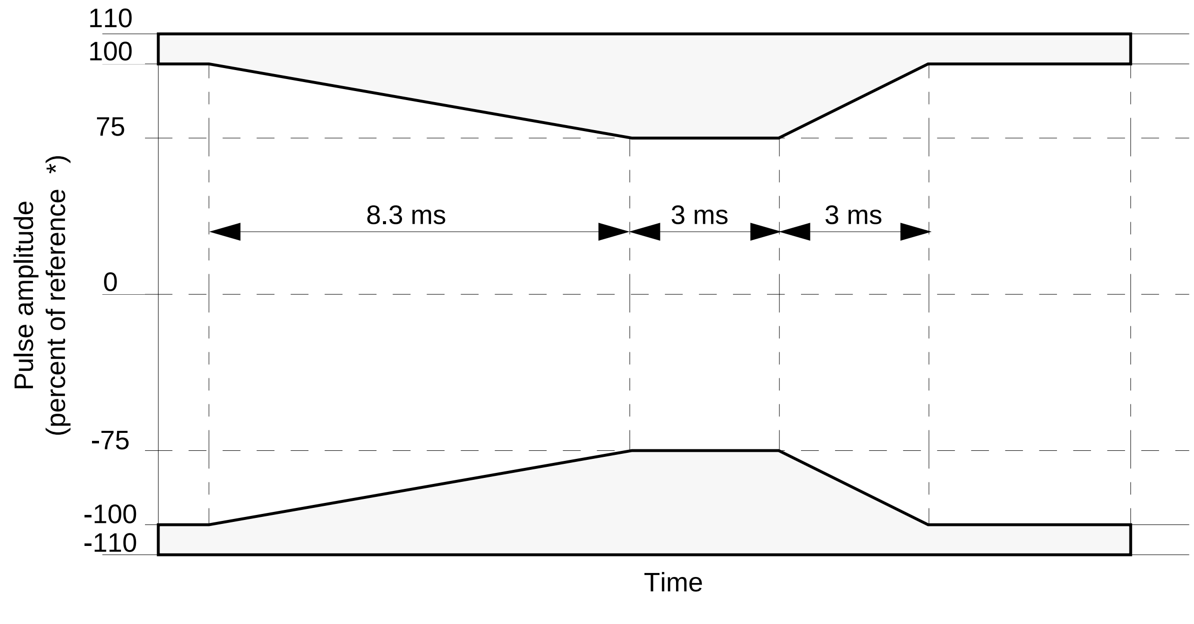
Table 2-2 Pulse template corner points: minimum curve

Time	**nanoseconds**	-500	-150	-100	0	100	150	300	390	600	750
	time slots	-0.77	-0.23	-0.15	0	0.15	0.23	0.46	0.66	0.93	1.16
Normalized amplitude		-0.05	-0.50	0.95	0.95	0.90	-0.45	-0.45	-0.26	-0.05	-0.05

3.3.5 60 Hz variations in pulse amplitude

Pulse amplitude may vary at a 60 Hz rate as a result of the presence of 60 Hz longitudinal currents in the powering loops of T1 repeaters. In such cases, the envelope of pulse amplitudes is limited as shown in Figure 2-5. Any pulse amplitude in the range of 2.4 V to 3.45 V may be used as the 100 per cent point in the figure.

Figure 2-5 Pulse amplitude envelope



Envelope of pulse amplitudes lies within the shaded areas

3.4 Signal from the carrier (carrier signal)

The carrier signal at the network interface meets the signal specifications identified in section 3.3, except that

- the pulse characteristics are those of a standard pulse (see section 3.3.4) transmitted through a cable pair with a loss in the range of 0.0 to 16.5 dB at 772 kHz between 100 ohm terminations
- the lower limit on the standard pulse amplitude is 2.25 V rather than 2.4 V

The variable length and characteristics of installed cable pairs make it impractical to define a pulse template for the carrier signal at the NI. However, the standard pulse template may be used with the appropriate mathematical procedures to construct representative hypothetical signals (see Figure 2-4). These signal constructions should be based on the approximate electrical characteristics of 100 ohm cables as shown in Appendix A of T1.403 “Carrier to Customer Installation — DS-1 Metallic Interface Specification”, 1989.

3.5 Signal from the customer installation (CI signal)

The CI should not apply voltages to the NI other than those described in this specification.

The CI signal at the NI should meet all the specifications defined in section 3.3.

3.6 Pulse density

The CI signal at the NI must contain at least one pulse in each eight-bit time slot.

3.7 Jitter and wander

The following specification provides a quantitative measurement for jitter and wander.

Jitter is defined as the short-term variations of the significant instants of a DS-1 signal from their ideal positions in time. Wander is the long-term variation of the same instants. The boundary between long-term and short-term is a frequency of 10 Hz. The magnitudes of jitter and wander are specified in terms of unit intervals (UIs). One UI is equal to 648 nsec (one pulse period).

3.7.1 Jitter

Timing jitter is specified in two frequency bands: Band 1 and Band 2. The characteristics of the weighting functions which define these bands are provided in Figure 2-6.

3.7.1.1 Carrier signal

At the NI, the jitter of the carrier signal does not exceed the following limits:

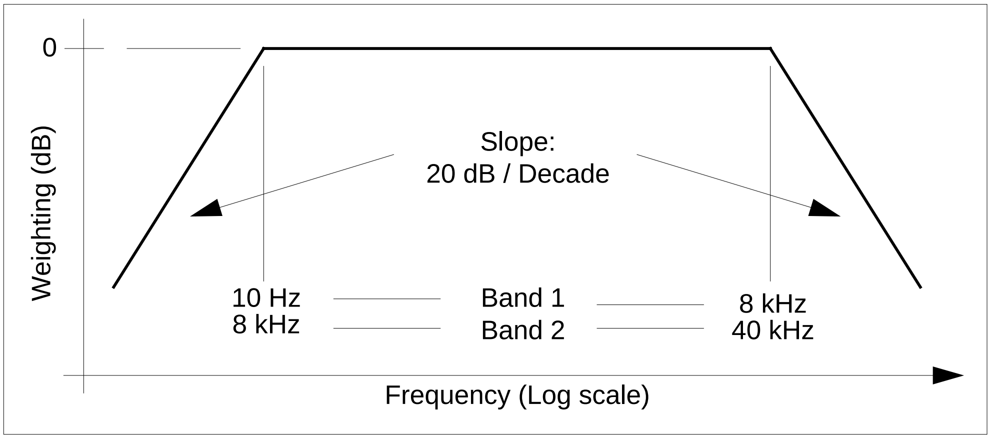
- Band 1: 5.0 UI, peak-to-peak
- Band 2: 0.1 UI, peak-to-peak

3.7.1.2 CI signal

At the NI, the jitter of the CI signal must not exceed the following limits:

- Band 1: 0.5 UI, peak-to-peak
- Band 2: 0.05 UI, peak-to-peak

Figure 2-6 Frequency weighting function for jitter



3.7.2 Wander

Wander is specified in frequency band 3. The characteristics of the weighting function which define this band are shown in Figure 2-7.

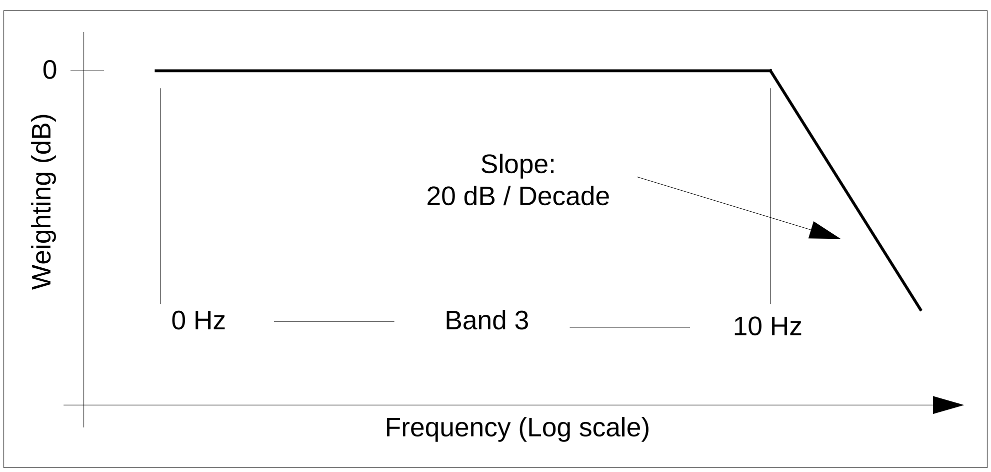
3.7.2.1 Carrier signal

At the NI, the wander of the carrier signal does not exceed 28 UI, peak-to-peak.

3.7.2.2 CI Signal

At the NI, the wander of the CI signal also must not exceed 28 UI, peak-to-peak.

Figure 2-7 Frequency weighting function for wander



3.8 Powering arrangements

Direct-current power is not delivered to the NI.

Chapter 2-4: Layer 1 Frame Formats

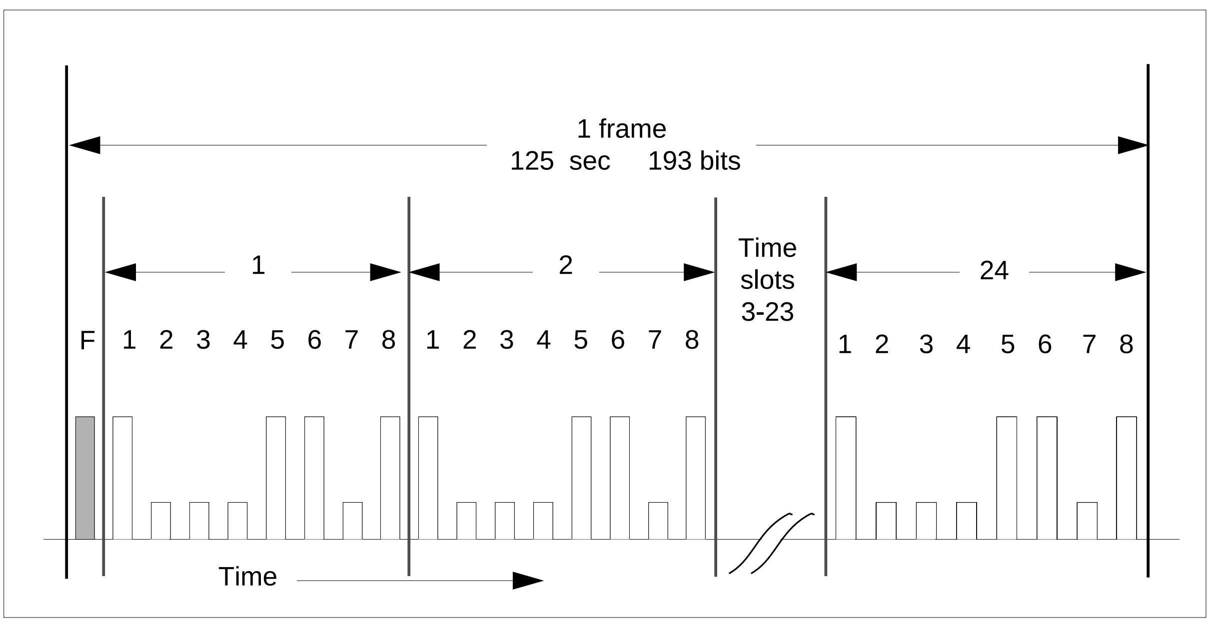
4.1 Introduction

The carrier and the CI signals at the NI are in either the superframe (SF) or the extended superframe (ESF) format. The same framing format is used in both directions of transmission.

4.2 Frame format definition

A frame is a set of 192 information digit time slots preceded by a one-digit time slot containing a framing bit (F bit), for a total of 193 digit time slots. The 192 information digit time slots may be partitioned into 24 eight-bit time slots, as shown in Figure 2-8.

Figure 2-8 DS-1 frame bit assignment



4.3 Superframe format definition

A superframe consists of twelve consecutive frames as shown in Table 2-3. The superframe format is a structure in which the F bits are used for framing only. In the superframe format, the F bits are divided into two groups

- terminal framing (Ft) bits, used to identify frame boundaries
- signaling framing (Fs) bits, used to identify superframe boundaries. (When the 192 digit time slots are channelized, the Fs bits are used to identify the robbed-bit signaling frames and associated signaling channels A and B.)

The F-bit position, with respect to every group of 192 information bits is always maintained from NI to NI or from NI to central office (CO).

Table 2-3 Superframe format

Frame no.	F bits			Bit use in each time slot		Signaling bit use options	
	Bit no.	Terminal framing bit (Ft)	Signaling framing bit (Fs)	Traffic	Signaling	T	Signaling channel
1	0	1	-	1-8	-		
2	193	-	0	1-8	-		
3	386	0	-	1-8	-		
4	579	-	0	1-8	-		
5	772	1	-	1-8	-		
6	965	-	1	1-7	8	-	A
7	1158	0	-	1-8	-		
8	1351	-	1	1-8	-		
9	1544	1	-	1-8	-		
10	1737	-	1	1-8	-		
11	1930	0	-	1-8	-		
12	2123	-	0	1-7	8	-	B

Note 1: Frame 1 is transmitted first.

Note 2: Frames 6 and 12 are called signaling frames.

Note 3: Option T - traffic (bit 8 is not used for signaling).

4.4 Extended superframe format

An extended superframe (ESF) consists of twenty-four consecutive frames. The ESF is a structure in which the F bits are used as shown below and in Table 2-4

- A 2 kbit/s framing pattern sequence (FPS) channel is used to identify the frame and the extended superframe boundaries. (When the 192 information digit time slots are channelized, the FPS bits are used to identify the robbed-bit signaling frames and the associated signaling channels, A, B, C and D.)
- A 4 kbit/s data link (DL) channel. When idle, the DL channel contains continuous repetitions of the data link idle code — 0111 1110.
- A 2 kbit/s cyclic redundancy check (CRC) channel which carries the CRC-6 code. The CRC-6 bits from ESF frame N that are transmitted in ESF frame (N+1) are determined as follows:
  - — For the purpose of CRC-6 calculation only, every F bit is set to “1” in ESF(N), that is, the ESF just preceding ESF(N+1). ESF(N) is altered in no other way.
  - — The resulting 4632 bits of ESF(N) are used, in order of occurrence, to construct a polynomial in “x” such that bit 0 of ESF(N) is the coefficient of the term x^{4631} and bit 4631 of ESF(N) is the coefficient of the term x^0 .
  - — The polynomial is multiplied by the factor x^6, and the result is divided, modulo 2, by the generator polynomial x^6+x+1. The coefficients of the remainder polynomial are used, in order of occurrence, as the ordered set of check bits, C1 through C6, for ESF(N+1). The ordering is such that the coefficient of the term x^5 in the remainder polynomial is check bit C1 and the coefficient of the term x^0 in the remainder polynomial is check bit C6.
  - — The check bits C1 through C6 contained in any ESF frame are always those associated with the content of the ESF frame immediately preceding the one in which the check bits occur. When there is no immediately preceding ESF frame, the check bits may be assigned any value.

Table 2-4 Extended superframe format

Frame no.	F bits				Bit use in each time slot		Signaling bit use options	
	Bit no.	FPS	DL	CRC	Traffic	Signal'g	T	Signal'g channel
1	0	-	m	-	1-8	-		
2	193	-	-	C1	1-8	-		
3	386	-	m	-	1-8	-		
4	579	0	-	-	1-8	-		
5	772	-	m	-	1-8	-		
6	965	-	-	C2	1-7	8	-	A
7	1158	-	m	-	1-8	-		
8	1351	0	-	-	1-8	-		
9	1544	-	m	-	1-8	-		
10	1737	-	-	C3	1-8	-		
11	1930	-	m	-	1-8	-		
12	2123	1	-	-	1-7	8	-	B
13	2316	-	m	-	1-8	-		
14	2509	-	-	C4	1-8	-		
15	2702	-	m	-	1-8	-		
16	2895	0	-	-	1-8	-		
17	3088	-	m	-	1-8	-		
18	3281	-	-	C5	1-7	8	-	A
19	3474	-	m	-	1-8	-		
20	3667	1	-	-	1-8	-		
21	3860	-	m	-	1-8	-		
22	4053	-	-	C6	1-8	-		
23	4246	-	m	-	1-8	-		
24	4439	1	-	-	1-7	8	-	B

Note 1: Frame 1 is transmitted first.

Note 2: Frames 6, 12, 18, and 24 are denoted signaling frames.

Note 3: FPS is the Framing Pattern Sequence (...001011...).

Note 4: DL is the 4 kbit/s Data Link (“m” bits).

Note 5: CRC is the CRC-6 Cyclic Redundancy Check (bits C1 to C6).

Note 6: Option T is traffic (bit 8 is not used for signaling).

4.5 Idle codes

4.5.1 Codes for idle channels and idle slots

A keep-alive signal is applied to idle channels to ensure that no more than 8 consecutive “0”s are transmitted. The keep alive signal is removed when the pulse density returns to the requirements described in section 3.6.

The keep alive signal is an unframed, continuous repetition of the channel idle code — 0111 1111.

4.5.2 Interframe (layer 2) timefill

Contiguous HDLC flags are transmitted on the D-channel when its layer 2 has no frames to send.

Chapter 2-5:
Layer 1 Clear Channel Capability

5.1 Clear Channel Capability

To provide DS-1 clear channel capability (CCC), a DS-1 signal with unconstrained information bits is altered by some method to meet the pulse density requirements specified in section 3.6. The method used to provide DS-1 CCC is the same in both directions of transmission. The long-term method of providing DS-1 CCC will be B8ZS. DS-1 CCC is a necessary, but not a sufficient condition for providing clear channel capabilities end-to-end for customers.

Chapter 2-6: Layer 1 Maintenance

Maintenance messages and signals are transmitted in-band in the superframe format (SF) and in the data link layer in the extended superframe (ESF) format.

6.1 Remote Alarm Indication

The remote alarm indication (RAI) signal — also called the Yellow Alarm — is transmitted in the outgoing direction when a DS-1 terminal determines that it has lost the incoming signal. The RAI signal is transmitted to the interface as follows:

- In the superframe format, the RAI signal is transmitted for the duration of the alarm condition or for at least one second, whichever is greater. For the duration of the alarm, bit 2 in every eight-bit time slot is a “0”.
- In the extended superframe format, the RAI signal is transmitted for the duration of the alarm condition or for at least one second, whichever is greater. For the duration of the alarm, a repeating 16-bit pattern consisting of eight “1”s followed by eight “0”s (1111 1111 0000 0000) is transmitted continuously on the ESF data link.
- For either framing format, the minimum time between the end of one transmission and the beginning of another transmission is one second. Certain services provided by the network may require longer time intervals than these minimum values, and may require unequal “on” and “off” intervals, or both.

6.2 Alarm indication signal (AIS)

An alarm indication signal (AIS) should be transmitted forward upon a loss of an originating signal, or when any action is taken that would cause a service disruption. The AIS is removed when the condition triggering the AIS is terminated. The AIS is an unframed, all “1”s signal. The presence of the AIS signal may indicate the loss of network synchronization.

6.3 Loopback

Customers have the option to use the CI with or without loopback.

The protocol currently in use by the carriers for network access to the CI loopback feature is in-band signaling control. This protocol may also be used for CI-to-CI testing. Only the CI may respond to the in-band control loopback codes described in this section.

With in-band signaling control, the loopback operates upon receipt of specific framed pulse patterns. The loopback pulse codes and functions are:

- Activate: A framed DS-1 signal consisting of repetitions of four “0”s followed by a “1” (00001), lasting for at least 5 seconds, with the frame alignment bits overwriting the pattern.
- Deactivate: A framed DS-1 signal consisting of repetitions of two “0”s following by a “1” (001), lasting for at least 5 seconds, with the frame alignment bits overwriting the pattern[1].

The loopback also operates upon receipt of the patterns described above without framing to accommodate imbedded equipment which sends unframed (non-standard) in-band control signals. With the CI loopback feature activated, the customer's signal is interrupted and the DS-1signal received from the network is transmitted back to the network. The looped signal must be regenerated by the CI without change in framing format or removal of bipolar violations.

Line loopbacks and payload loopbacks as described in ANSI T1.408 are not supported by the network. Loopback on a DMS-100 is activated and deactivated from a MAP terminal.

6.4 ESF maintenance

6.4.1 Introduction

The extended superframe format incorporates a block error detection code (CRC-6) and a data link (DL) channel that allow carrier maintenance of DS-1 transmission facilities. The following sections specify the functions that are necessary in the CI to support monitoring of digital circuits.

Errors in the transmission received by the CI may be detected by

- detecting CRC violations, by comparing a locally calculated CRC with the CRC encoded in the received signal
- detecting errors in the framing bit pattern, or detecting the loss of a frame
- detecting line code violations (non-B8ZS bipolar violations)

[1]It should be noted that embedded network equipment exists which may be activated by the loopback code and block the code from reaching the CI, requiring manual intervention to deactivate the loopback.

- detecting controlled slips (for CIs that are components of a synchronized network)

The presence of all or a subset of these error types can indicate the location of the impairment, and thus is required maintenance information. The CI monitors the incoming signal for these conditions.

Once each second, the CI reports the parameters over the DL channel as specified in the following sections. These reports ensure that the quality of transmission, as received at the CI, is reported. The reports are sent over the DL channel using bit-oriented signals.

6.4.2 Transmission measurement parameters

During periods of ideal transmission, none of these events occur. If the CI detects, or does not detect, any of these conditions, it shall report as specified in section 6.4.3. The reports are based on one-second intervals.

The one-second timing intervals may be derived from the DS-1 signal, or from a separate, equally accurate (± 32 ppm) source. The phase of the one-second periods with respect to the occurrence of error events is arbitrary. That is, the one-second timing does not depend on the time of occurrence of any error event. These events identify details of transmission errors received at the CI.

The events that are detected and reported are

- no event
- CRC error
- severely-errored frames

The events that may be detected and reported are

- frame synchronization bit error
- line code violation
- controlled slip

These are defined as follows:

6.4.2.1 CRC error event

A CRC error event is reported if the received CRC code for a particular frame is not identical to the corresponding locally calculated code.

6.4.2.2 Severely errored framing event

A severely errored framing event is reported if two or more framing bit pattern errors occur within a 3 ms period. Contiguous 3 ms intervals are examined. The 3 ms period may coincide with the extended superframe period.

6.4.2.3 Frame synchronization bit error event

A frame synchronization bit error event is the occurrence of a received framing-bit-pattern error.

6.4.2.4 Line code violation event

A line code violation event occurs when a bipolar violation is received for an AMI-coded signal. For a B8ZS-coded signal, a line code violation event occurs when a bipolar violation is received and this violation is not part of an associated zero-substitution code.

6.4.2.5 Controlled slip event

A controlled slip event is the occurrence of a replication or deletion of DS-1 frames by the receiving terminal. A controlled slip occurs when there is a difference between the timing of a synchronous receiving terminal and that of the received signal of such a magnitude as to exhaust the buffer capability of the synchronous terminal.

6.4.3 ESF data link

There are two categories of bit-oriented messages — priority messages, and command and response messages.

Message-oriented codewords are used to carry performance monitoring information (see ANSI T1.408, ISDN primary rate—customer installation metallic interfaces Layer 1 specification, 1990). Message-oriented codewords based on LAPD protocol are not supported by the network.

6.4.3.1 Priority messages

Priority messages indicate a service-affecting condition. The only priority message generated by the network is an RAI — a yellow alarm. It is transmitted continuously until the cause no longer exists.

6.4.3.2 Command and response messages

Command and response messages are transmitted to perform various functions. The various command and response messages include

- loopback activate
- loopback deactivate
- protection switch line “x” (0 < x < 28)
- protection switch acknowledge
- protection switch release

These are currently not supported by the network although it is recommended that user equipment support these for future compatibility.

6.4.4 ESF bit-oriented data link communication

Data link bit-oriented messages shall be of the format:

0xxx xxx0 1111 1111

with the rightmost bit transmitted first. Table 2-5 lists two categories of bit-oriented message functions and their associated 16-bit codewords. Codewords for priority messages are repeated continually until the condition which initiated the message is removed. The minimum duration is as specified for RAI in section 6.1. Command/response codewords are repeated at least 10 times.

6.4.4.1 Protection switching codewords

The "switch line" codes in Table 2-5 use the five least significant "x" bits in the second octet of the codeword to indicate the number of the line, 1 through 27, to be switched to a protection line.

Table 2-5 Assigned Bit-oriented data-link messages

Priority Messages	Codeword	
RAI (Yellow alarm)	000 0000	0111 11111
Loopback retention	001 0101	0111 11111

Command and Response Messages	Codeword	
Line loopback (Ia) activate	000 0111	0111 11111
Line loopback (Ia) deactivate	001 1100	0111 11111
Line loopback (Ib) activate	001 0000	0111 11111
Payload loopback activate	000 1010	0111 11111
Payload loopback deactivate	001 1001	0111 11111
Network use loopback activate	000 1001	0111 11111
Universal loopback deactivate	001 0111	0111 11111
CI loopback activate	001 0111	0111 11111
Protection switch line 1	010 0001	0111 11111
Protection switch line 2	010 0010	0111 11111
Protection switch line 3	010 0011	0111 11111
....	...	...
Protection switch line 27	011 1011	0111 11111
Protection switch acknowledge	000 1100	0111 11111
Protection switch release	001 0011	0111 11111
Synchronization	001 1000	0111 11111
Synchronization	000 0110	0111 11111
Synchronization	001 0001	0111 11111
Synchronization	001 0100	0111 11111

Note 1: The rightmost bit in each code word is transmitted first.

Note 2: The protection switch line codes of the form 01x xxxx 0111 1111 use the five x-bits to indicate the number of the line (1 to 27) to be switched to a protection line.

Note 3: Only RAI is supported by the network; other values are reserved.

Chapter 2-7:
Layer 1 Connector Arrangements

7.1 Connector Arrangements

All connections at the network interface use one of three Universal Service Ordering Code (USOC) connectors (RJ48C, RJ48X, or RJ48M) (FCC Rules and Regulations, Sub-part F of Part 68, supplemented by Public Notice 2526, February 10, 1986). The physical arrangement of these connectors is shown in Figure 2-9, Figure 2-10, and Figure 2-11.

Figure 2-9 Connector pin assignment (RJ48C)

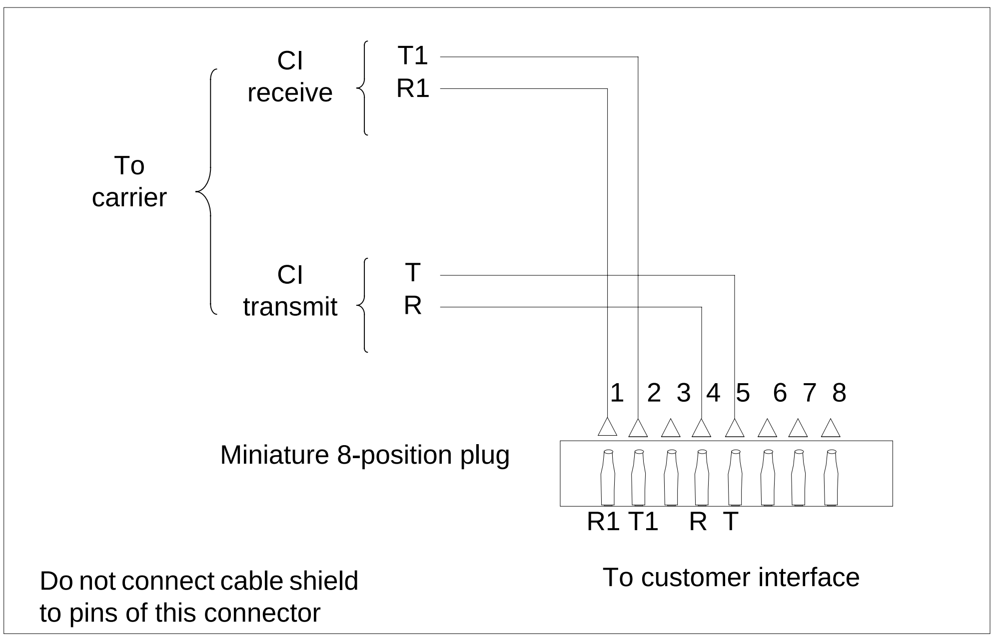


Figure 2-10 Connector pin assignment (RJ48X)

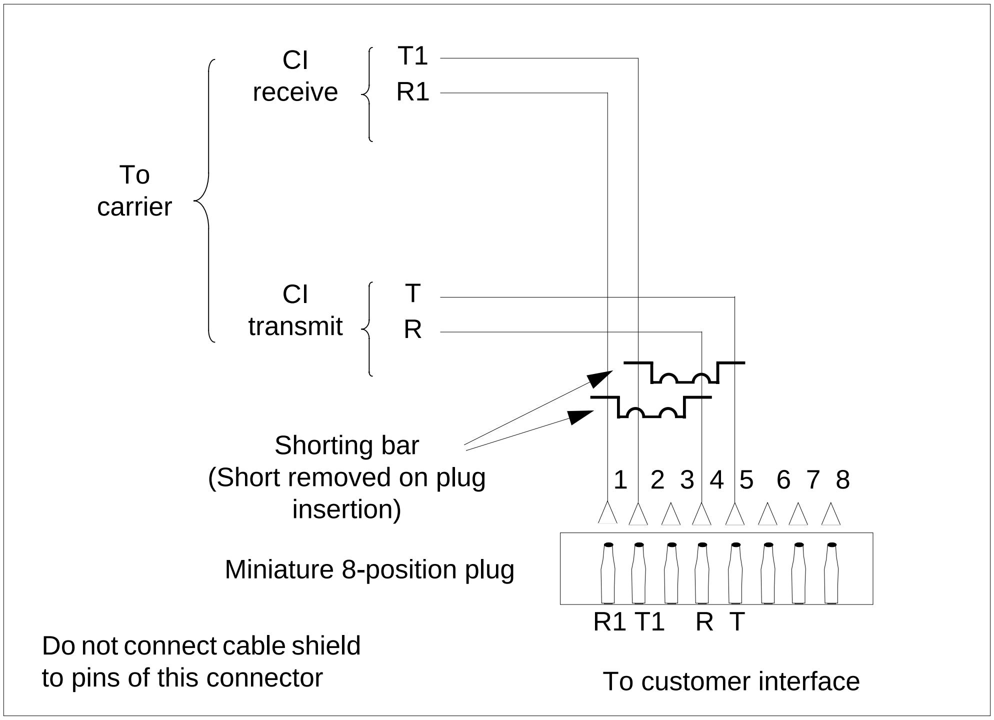
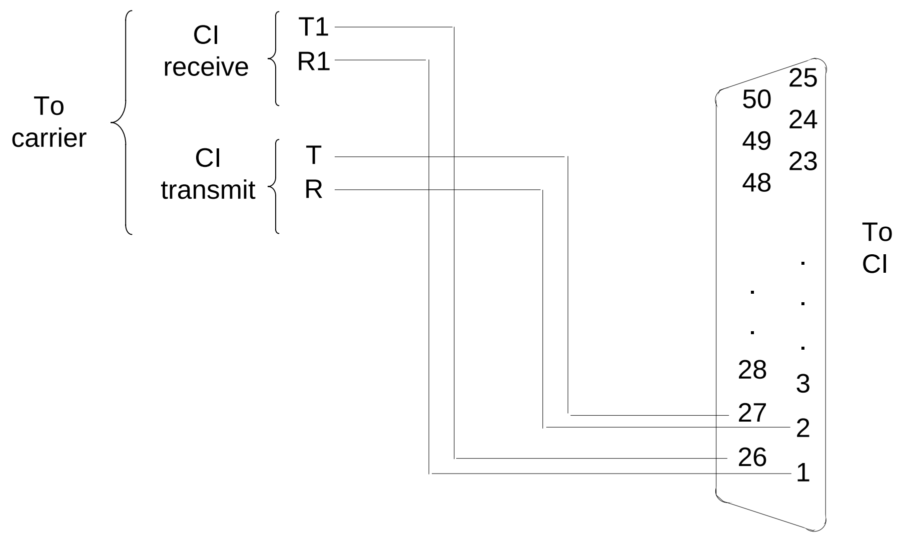


Figure 2-11 Connector pin assignment (RJ48M)



Connector pin number				
Line	**T1**	**R1**	**T**	**R**
1	26	1	27	2
2	29	4	30	5
3	32	7	33	8
4	35	10	36	11
5	38	13	39	14
6	41	16	42	17
7	44	19	45	20
8	47	22	48	23

Do not connect cable shield
to pins of this connector

Chapter 3-1: Layer 2 Introduction

1.1 Scope

This section defines the link access protocol for the D channel (LAPD) of the ISDN primary rate interface (PRI).

In particular, it specifies:

- the peer-to-peer protocol for the transfer of information and control between any pair of service access points on the data link layer
- the interactions between the data link layer[1] and Layer 3, and between the data link layer and the physical layer (Layer 1).

LAPD, in the Open Systems Interconnection (OSI) reference model, is the Layer 2 protocol for the interface. It is independent of transmission rate, and requires a duplex, bit-transparent D-channel. The purpose of LAPD is to convey information between Layer 3 entities across the ISDN primary rate interface using the D-channel. The protocol defines the procedures required to establish, maintain, and disconnect the link.

The LAPD procedures in this section are suitable for all applications of the ISDN primary rate interface. For example, private branch exchange (PBX) to central office (CO).

1.2 Feature summary

The LAPD features that are supported are:

- Point-to-point, acknowledged, multiple frame information transfer.

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[1]The term "data link layer" is used in the main text of this specification. However, the terms "Layer 2"and "L2"are used as abbreviations. Similarly, in accordance with Recommendations Q.930 (I.450) and Q.931 (I.451), the term "layer 3"is used to indicate the layer above the data link layer.

All references to "layer management entity" or "connection management entity" refer to those entities at the data link layer.

- Service access point identifier (SAPI) of 0, and terminal endpoint identifier (TEI) of 0 (fixed TEI).
- TEI administration procedures are limited to those interactions that do not involve peer entities. For example, assignment of a TEI value by the user-side management entity to the user-side data link layer entity do not involve interactions with the network side.
- Default parameter values.

Features in ANSI T1.602 that are not supported are as follows:

- Unnumbered information (UI) commands, and the *DL-Unit-Data* primitive.
- Broadcast procedures (that is, TEI 127 is not supported).
- Management information transfer (that is SAPI 63, Identity Remove message, and *MDL-Unit-Data* primitive).
- TEI removal procedure (the network and user can not request that the other end remove its TEI).
- Exchange identification (XID) procedures.
- MPH primitives (used for communication between the management entity and Layer 1).
- Deactivation procedures.

1.3 Standards compatibility

This data link layer specification is based on *ANSI T1.602, ISDN signaling specification for application at the user-network interface — Layer 2 specification*, and is a subset of the *CCITT Recommendation Q.920(I.440), ISDN user-network interface data link layer — general aspects*, and the *CCITT Recommendation Q.921(I.441), ISDN user-network interface data link layer specification.*

1.4 Overview description of LAPD functions and procedures

The purpose of LAPD is to convey information between Layer 3 entities across the ISDN PRI using the D-channel.

All data link layer messages are transmitted in frames which are delimited by flags. A flag is a unique bit pattern.

LAPD includes functions for:

- Provisioning of one or more data link connections on a D-channel. Discrimination between the data link connections is by means of a data link connection identifier (DLCI) contained in each frame.

- Frame delimiting, alignment, and transparency, that allows a sequence of bits transmitted over a D-channel to be recognized as a frame.
- Sequence controlling, to maintain the sequential order of frames across a data link connection.
- Detection of transmission, format, and operational errors on a data link connection.
- Recovery from detected transmission, format, and operational errors.
- Notification to the management entity of unrecoverable errors.
- Flow control.

Data-link-layer functions provide the means for information transfer between multiple combinations of data link connection endpoints. In the case of PRI, the information is transferred through point-to-point data link connections in which each frame is directed to a single endpoint.

1.5 Protocol service definition

The data link layer provides services to Layer 3 and the management of the data link layer (Layer 2). It uses the services provided by the physical layer (Layer 1) and by layer management.

1.5.1 Services provided to Layer 3

The specification of the interactions with Layer 3 (primitives) provides a description of the services that the data link layer, plus the physical layer offer to Layer 3, as viewed from Layer 3.

The information transfer service is based on acknowledged information transfer at the data link layer.

The characteristics of the service are as follows:

- provision of a data link connection between Layer 3 entities for acknowledged information transfer of Layer 3 message units
- identification of data link connection endpoints
- sequence integrity of data link layer message units in the absence of malfunctions
- notification to the peer entity in the case of errors; for example, loss of sequence
- notification to the management entity of unrecoverable errors detected by the data link layer
- flow control

The primitives associated with the acknowledged information transfer services are:

- *DL-Data-Request* and *-Indication* — for transferring data
- *DL-Establish-Request* and *-Indication* — for establishing multiple-frame operation
- *DL-Release-Request*, *-Indication*, and *-Confirm* — for terminating multiple-frame operation

1.5.2 Administrative services

The administrative services functions are:

- assignment and removal of TEI values
- notification of errors

These services are considered to be provided conceptually by layer management either on the user side or on the network side. The primitives associated with these services are:

- *MDL-Assign-Request* and *-Indication* — for assigning TEI value

  These primitives are used to send a TEI value obtained from the layer manager. The layer manager passes the TEI value to the data link layer in order that the user data-link-layer entities can begin to communicate with the network data-link-layer entities.
- *MDL-Remove-Request* — for removing TEI value

  This primitive is used to send a layer manager request for removal of a TEI value that has previously been assigned using the *MDL-Assign* primitives.
- *MDL-Error-Indication* and *-Response* — used for error notification.

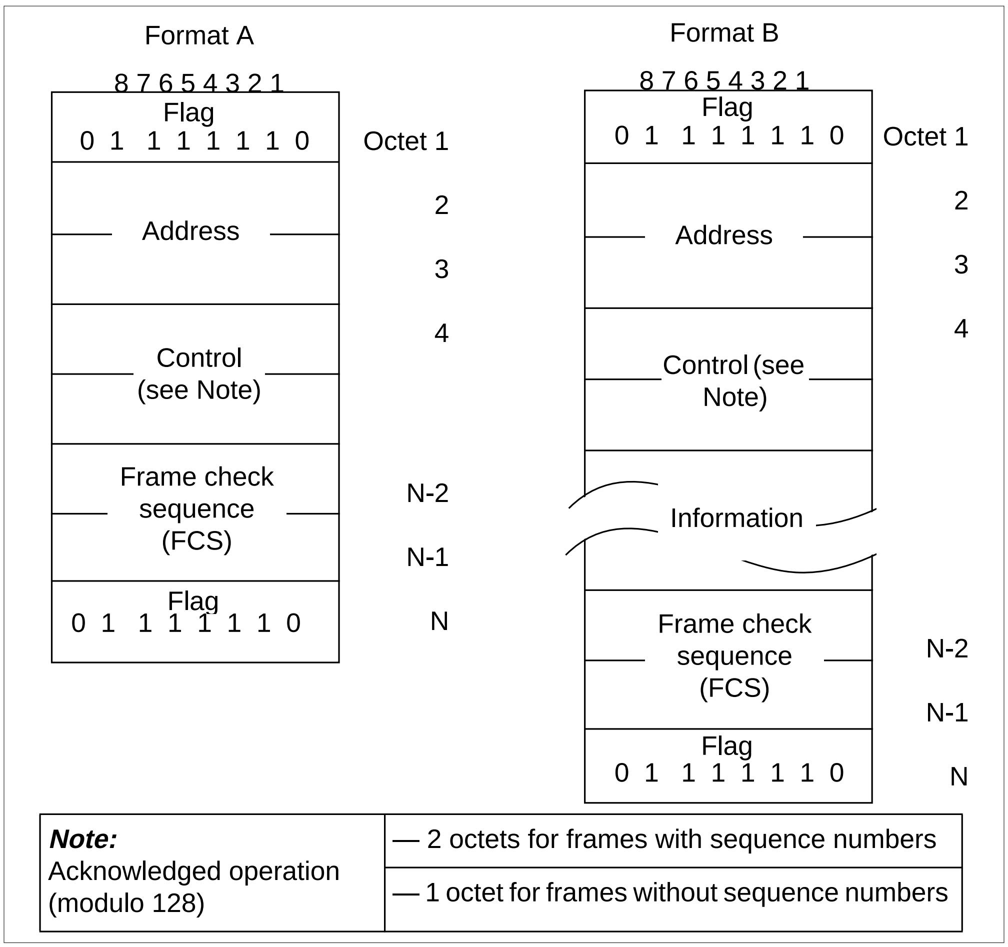
  These primitives are used to report errors between the layer manager and the data-link-layer entities.

Chapter 3-2: Layer 2 Frame Structure

2.1 Introduction

All peer-to-peer exchanges at the data link layer conform to one of the formats shown in Figure 3-1. Format A is used for frames that do not have an information field. Format B is used for frames that do contain an information field.

Figure 3-1 Frame formats



2.2 Flag sequence

All frames start and end with a flag sequence that consists of one “0” bit followed by six contiguous “1” bits and one “0” bit (0111 1110). The flag preceding the address field is called the opening flag. The flag following the Frame Check Sequence (FCS) field is called the closing flag. The closing flag may also serve as the opening flag of the next frame in some applications.

When the layer 2 entity has no frames to transmit, it sends contiguous HDLC flag sequences (0111 1110). The receiving equipment should also be capable of receiving an interframe abort. This consists of one “0” bit followed by seven contiguous “1” bits (0111 1111).

2.3 Address field

The address field consists of 2 octets as shown in Figure 3-1. The address field identifies the intended receiver of a command frame and the transmitter of a response frame. The format of the address field is defined in section 3.2 on page 53.

2.4 Control field

Depending on the type of operation, the control field consists of 1 or 2 octets as shown in Figure 3-1. This field is used to identify the type of command and response. The format of the control field is defined in section 3.4 on page 55.

2.5 Information field

The information field of a frame, when present, follows the control field and precedes the frame check sequence as shown in Figure 3-1. The contents of the information field consist of an integral number of octets which hold a message from layer 3.

The maximum number of octets in the information field is a system parameter, which is described in section 5.9.3 on page 91.

2.6 Transparency

A transmitting data-link-layer entity examines the frame content between the opening and closing flag sequences, (address, control, information and FCS fields). It inserts a “0” bit after all sequences of five contiguous “1” bits (including the last five bits of the FCS) to ensure that a flag or an abort sequence is not simulated within the frame.

At the receiving end, a similar data-link-layer entity examines the frame contents between the opening and closing flag sequences and discards any “0” bit which directly follows five contiguous “1” bits.

2.7 Frame checking sequence (FCS) field

The FCS field is a 16-bit sequence. It is the “1”s complement of the sum (modulo 2) of the following formulas:

- the remainder of $(x^k)(x^{15} + x^{14} + x^{13} + x^{12} + x^{11} + x^{10} + x^9 + x^8 + x^7 + x^6 + x^5 + x^4 + x^3 + x^2 + x + 1)$ 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
- the remainder of the division (modulo 2) by the generator polynomial $x^{16} + x^{12} + x^5 + 1$, of the product of x^{16} by 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 the transmitter, the initial content of the register of the device computing the remainder of the division is preset to all “1”s. This is modified by division by the generator polynomial (as described above) of the address, control and information fields; the “1”s complement of the resulting remainder is transmitted as the16-bit FCS.

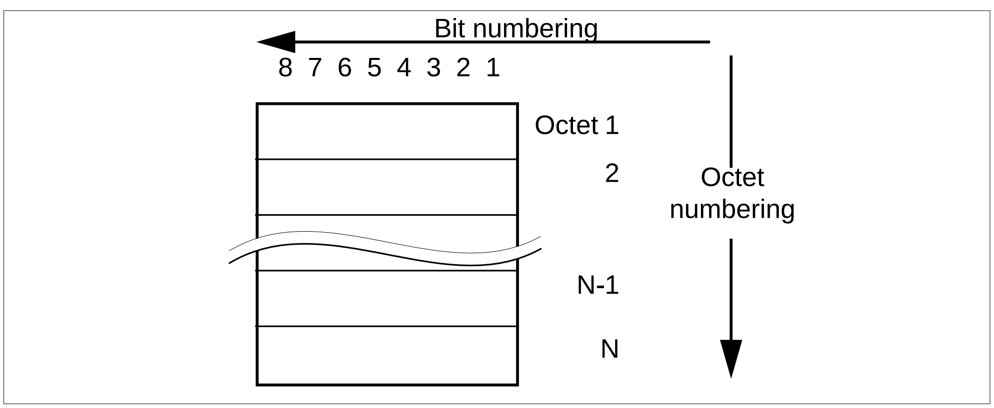
As a typical implementation at the receiver, the initial content of the register of the device computing the remainder is preset to all “1”s. The final remainder, after multiplication by x and division (modulo 2) by the generator polynomial $x^{16} + x^{12} + x^5 + 1$ of the serial incoming protected bits and the FCS, is ‘0001 1101 0000 1111’(x^{15} through x^0, respectively) in the absence of transmission errors.

2.8 Format convention

2.8.1 Numbering convention

The basic frame numbering convention used is shown in Figure 3-2. The bits are grouped into octets.

Figure 3-2 Format convention



2.8.2 Order of bit transmission

The octets are transmitted in ascending numerical order. Within an octet, bit 1 is the first bit to be transmitted.

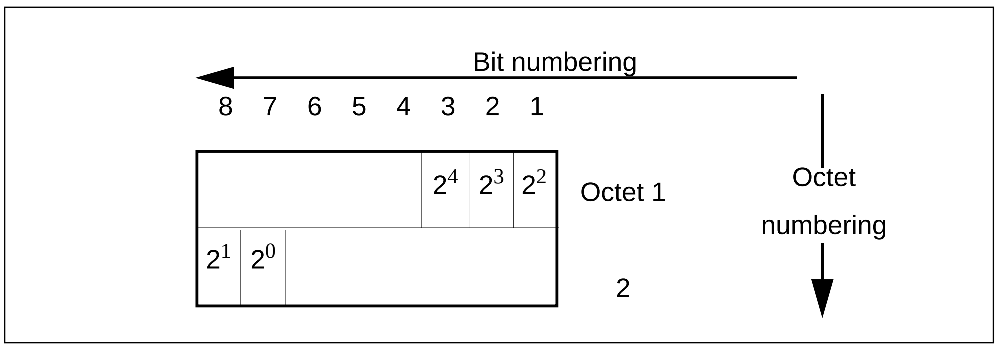
2.8.3 Field mapping convention

When a field is contained within a single octet, the lowest bit number of the field represents the lowest order value.

When a field spans more than one octet, the order of bit values progressively decreases as the octet number increases within each octet. The lowest bit number associated with the field represents the lower order value.

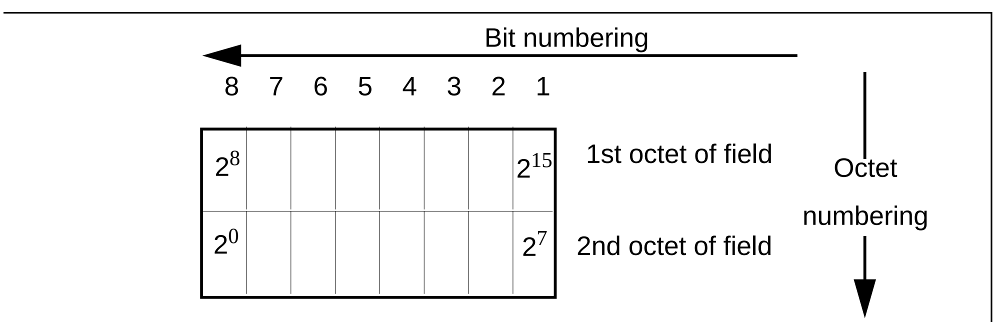
For example, a bit number can be identified as a couple (o, b) where “o” is the octet number and “b” is the relative bit number within the octet. Figure 3-2 shows a field that spans from bit (1, 3) to bit (2, 7). The high order bit of the field is mapped on bit (1, 3) and the low order bit is mapped on bit (2, 7).

Figure 3-3 Field mapping convention



An exception to the preceding field mapping convention is the data-link-layer frame check sequence (FCS) field, which spans two octets. In this case, bit 1 of the first octet is the high order bit and bit 8 of the second octet is the low order bit (see Figure 3-5).

Figure 3-4 FCS mapping convention



2.9 Invalid frames

An invalid frame is a frame which has one or more of the following properties:

- it is not properly bounded by two flags
- it has fewer than 6 octets between flags of frames that contain sequence numbers and fewer than 5 octets between flags of frames that do not contain sequence numbers
- it does not consist of an integral number of octets prior to zero bit insertion or following zero bit extractions
- it contains a frame-check sequence error
- it contains a single octet address field
- it contains a service access point identifier (SAPI) which is not supported by the receiver

Invalid frames are discarded without notification to the sender. No action is taken as the result of the invalid frame.

2.10 Frame abort

Receipt of seven or more continuous “1” bits is interpreted as an abort message and the data-link-layer entity ignores the frame currently being received.

Chapter 3-3: Layer 2 Elements of Procedures

3.1 Introduction

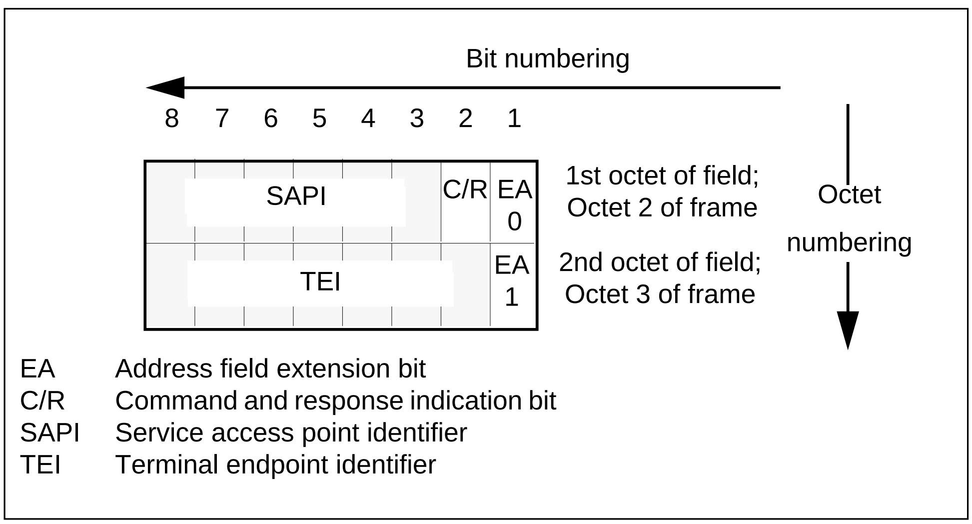
This chapter defines the elements that are used on the data link connections carried on the D-channel.

Procedures are derived from these elements and are described in “Chapter 3-5: Layer 2 Peer to Peer Communication on page 73”.

3.2 Address field format

The address field format shown in Figure 3-5 contains the address field extension bits, a command and response indication bit (C/R), a data-link-layer Service Access Point Identifier (SAPI) subfield, and a Terminal Endpoint Identifier (TEI) subfield.

Figure 3-5 Address field format



3.3 Address field variables

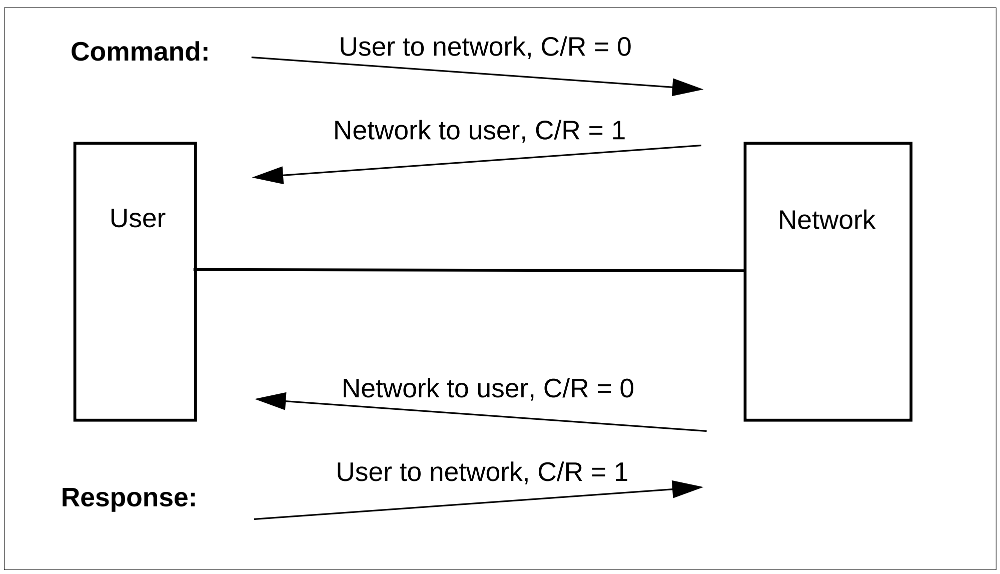
3.3.1 Address field extension bit (EA)

The address field range is extended by reserving the first transmitted bit of the address field octets to indicate the final octet of the address field. The presence of a "1" in the first bit of an address-field octet signals that it is the final octet of the address field. The double-octet address field for LAPD operation has bit 1 of the first octet set to "0" and bit 1 of the second address octet set to "1".

3.3.2 Command response field bit (C/R)

The C/R bit identifies a frame as either a command or a response. The user side sends commands with the C/R bit set to "0", and responses with the C/R bit set to "1". The network side does the opposite; that is commands are sent with the C/R bit set to "1", and responses are sent with the C/R bit set to "0". The combinations for the network side and user side are shown in Figure 3-6.

Figure 3-6 C/R field bit usage



3.3.3 Service access point identifier (SAPI)

The SAPI identifies an endpoint at which data-link-layer services are provided by a data-link-layer entity to a Layer 3 or management entity. Consequently, the SAPI specifies a data-link-layer entity that should process a data-link-layer frame and also a Layer 3 or management entity which is to receive information carried by the data-link-layer frame.

The SAPI allows 64 (2^5) service access points to be specified. In the address field octet containing the SAPI, bit 3 is the least significant binary digit and bit 8 is the most significant. The SAPI values are allocated as shown in Figure 3-7.

Figure 3-7 Allocation of SAPI values

SAPI value	Related Layer 3 or management entity
0	Call control procedures
All others	Reserved for future standardization

3.3.4 Terminal end-point identifier (TEI)

The TEI for a point-to-point data link connection may be associated with a single item of terminal equipment (TE). A TE contains one TEI for point-to-point data transfer. The TEI subfield allows 128 (2^6)values to be specified. where bit 2 of the address field octet containing the TEI is the least significant binary digit and bit 8 is the most significant binary digit.

The TEI values from 0 to 126 are used for the point-to-point data link connections associated with the addressed SAP. The TEI subfield bit pattern “111 1111” (127) is reserved for assignment to the broadcast data link connection. This value is not supported.

The user side is assigned one TEI value, that is, the value of 0. The TEI is assigned at the time of subscription (and consequently described also as fixed or non-automatic TEI equipment), and may be entered into the TE, for example, by the user or manufacturer.

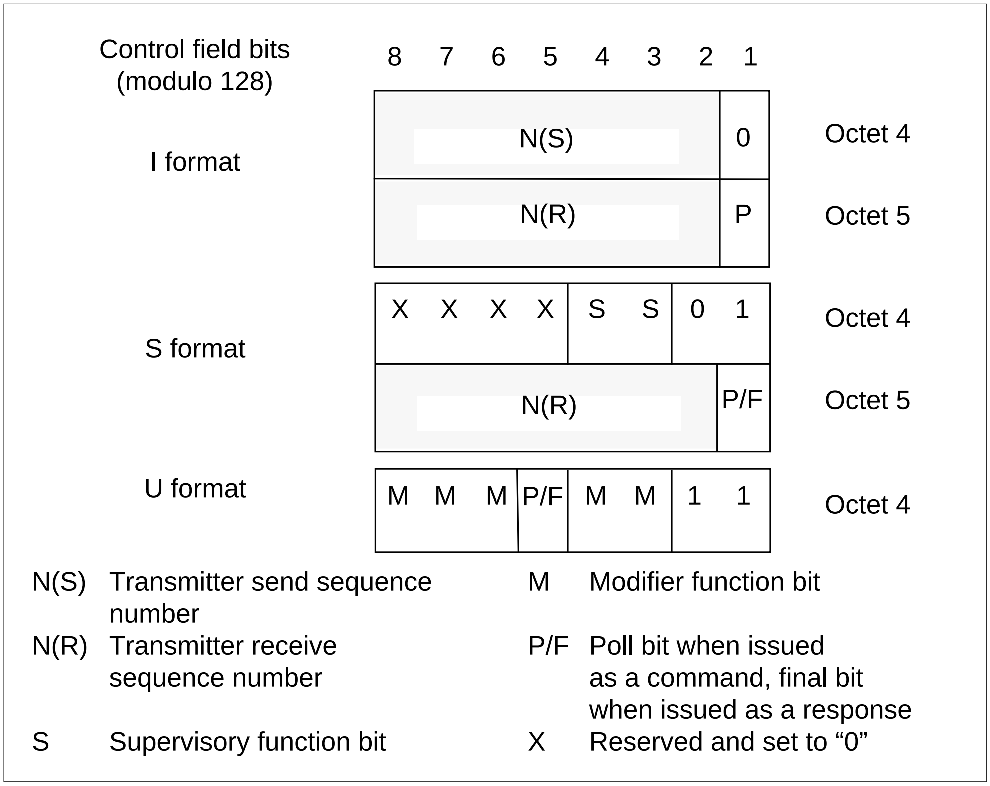
3.4 Control field formats

The control field identifies the type of frame. It can be either a command or a response frame. The control field contains sequence numbers where applicable. Three types of control field formats are specified:

- numbered information transfer (I format)
- supervisory function (S format)
- unnumbered information transfers and control functions (U format).

The control field formats are shown in Figure 3-8.

Figure 3-8 Control field formats



3.4.1 Information transfer format — I

The I format is used for frames that transfer information between Layer 3 entities. The functions of N(S), N(R) and P (defined in section 3.5) are independent. Each I frame has an N(S) sequence number and an N(R) sequence number which may or may not acknowledge additional I frames received by the data-link-layer entity and a P bit that may be set to “0” or “1”.

The use of N(S), N(R), and P bits are defined in “Chapter 3-5: Layer 2 Peer to Peer Communication on page 73”.

3.4.2 Supervisory format — S

The S format is used for frames to perform data link supervisory control functions such as

- acknowledging I frames
- requesting retransmission of I frames
- requesting a temporary suspension of transmission of I frames

The functions of N(R) and P/F are independent. Each supervisory frame has an N(R) sequence number which may or may not acknowledge additional I frames received by the data-link-layer entity and a P/F bit that may be set to “0” or “1”.

3.4.3 Unnumbered format — U

The U format is used for frames that provide additional data link control functions. This format does not contain any sequence numbers. It includes a P/F bit that may be set to “0” or “1”. Unnumbered frames have a one-octet-sized control field.

3.5 Control field parameters and associated state variables

The various parameters associated with the control field formats are described in this section.

The coding of the bits within these parameters is such that the lowest numbered bit within the parameter field is the least significant bit.

3.5.1 Poll/final (P/F) bit

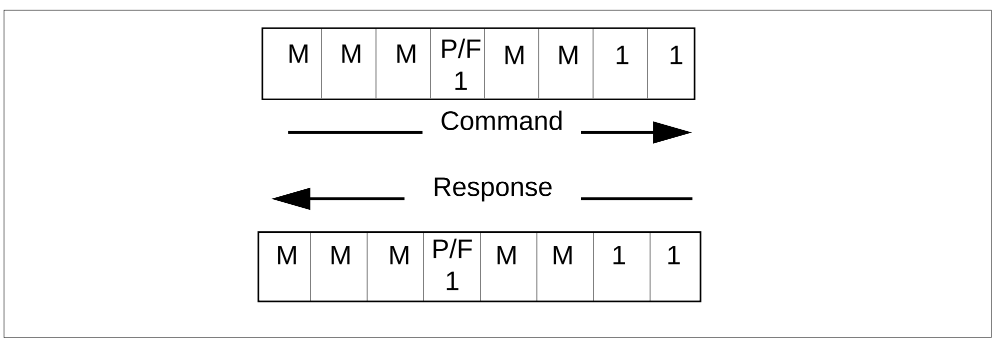
All frames contain a poll/final (P/F) bit. The P/F bit is used in both command and response frames. In command frames, the P/F bit is called the P bit. In response frames it is called the F bit.

The P bit set to ‘1’ is used by a data link layer entity to solicit (poll) a response frame from the peer data link layer entity.

When the F bit set to “1”, this indicates that the frame is a response from a data-link-layer entity sent as a result of a soliciting (poll) command.

The use of the P/F bit is fully described in “Chapter 3-5: Layer 2 Peer to Peer Communication on page 73”.

Figure 3-9 Example of P/F bit for U-format frames



3.5.2 Multiple frame operation — variables and sequence numbers

This section describes all the variables and sequence numbers that are used when frames are transmitted. Figure 3-10 shows how these numbers progress as different frames are sent.

3.5.2.1 Modulus

Each I frame is sequentially numbered and may have a value 0 through modulus minus 1. The modulus is 128, and the sequence numbers cycle through the entire range, 0 through 127.

3.5.2.2 Send state variable, V(S)

When using I-frame commands, each point-to-point data link connection endpoint has an associated send state variable [V(S)]. The send state variable denotes the sequence number of the next in-sequence I frame that the end point transmits.

The send state variable can take on the value 0 through modulus minus 1. The value of the send state variable is incremented by 1 with each successive I-frame transmission. It cannot exceed V(A) by more than the maximum number of outstanding I frames, “k”. The value of “k” ranges from 1 through 127.

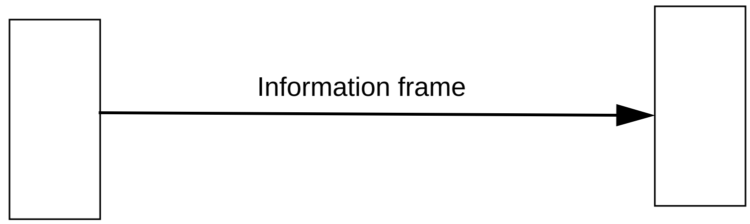
3.5.2.3 Acknowledge state variable, V(A)

When using I-frame commands and Supervisory frame commands and responses, each point-to-point data link connection endpoint has an associated acknowledge state variable [V(A)]. The acknowledge state variable identifies the last frame that has been acknowledged by its peer.

N(S) of last acknowledged I frame = V(A) - 1

The acknowledge state variable can take on the value 0 through modulus minus 1. The value of the acknowledge state variable is updated whenever a frame with a valid receive sequence number [N(R)] is received from its peer. A valid N(R) has a value in the range $V(A) \le N(R) \le V(S)$.

Figure 3-10 Variable and sequence number progression



First frame sent

V(S) = 1	In frame 1	Assume k = 2 in this example
V(A) = 1	N(S) = 1	
V(R) = 1	N(R) = 1	

Second frame sent

V(S) = 2	In frame 2
V(A) = 1	N(S) = 2
V(R) = 1	N(R) = 1

Third frame to be sent

V(S) = 3	In frame 3	
V(A) = 1	N(S) = 3	Frame cannot be sent until
V(R) = 1	N(R) = 1	an acknowledge is returned

because
V(S) [=3] - V(A) [=1]   k [=2]

When 1st acknowledge frame returned:	When 2nd acknowledge frame returned for both frames sent:
V(S) = 2	V(S) = 2
V(A) = 2	V(A) = 3
V(R) = 1	V(R) = 1

3.5.2.4 Send sequence number, N(S)

Only I frames contain send sequence numbers [N(S)]. When an in-sequence I frame is transmitted, the value of the send sequence number [N(S)] in the frame is set equal to the value of the send state variable [V(S)].

3.5.2.5 Receive state variable, V(R)

When using I frame commands and supervisory frame commands and responses, each point-to-point data link connection endpoint has an associated receive state variable [V(R)].

The receive state variable [V(R)] denotes the sequence number of the next in-sequence I frame expected to be received. The receive state variable can take on the value 0 through modulus minus 1. The value of the receive state variable is incremented by one when each error free, in-sequence I frame is received provided its N(S) value equals the receive state variable [V(R)].

Figure 3-11 Layer 2 commands and responses

Format	Commands	Responses	Encoding 8 7 6 5 4 3 2 1	Octet No.
Information transfer	I (Information)		N(S) | 0	4
			N(R) | P	5
Supervisory	RR (Receive ready)	RR	0 0 0 0 0 0 0 1	4
			N(R) | P/F	5
	RNR (Receive not ready)	RNR	0 0 0 0 0 0 0 1	4
			N(R) | P/F	5
	REJ (Reject)	REJ	0 0 0 0 1 0 0 1	4
			N(R) | P/F	5
Unnumbered	SABME*		0 1 1 P 1 1 1 1	4
		DM (Disconnect mode)	0 0 0 F 1 1 1 1	4
	DISC (Disconnect)		0 1 0 P 0 0 1 1	4
		UA (Unnumbered acknowledge)	0 1 1 F 0 0 1 1	4
		FRMR (Frame reject)	1 0 0 F 0 1 1 1	4

*Set asynchronous balanced mode extended

3.5.2.6 Receive sequence number, N(R)

All I frames and supervisory frames contain N(R), the expected send sequence number of the next received I frame. When any I or S frame is transmitted, the value N(R) in that frame is set equal to the current value of the receive state variable [V(R)]. N(R) indicates that the data-link-layer entity transmitting the N(R) has correctly received all I frames numbered up to and including N(R) - 1.

3.6 Frame types

3.6.1 Commands and responses

This section describes the commands and responses that are used by either the user or the network data-link-layer entities. Each data link connection supports all the commands and responses identified below.

Only point-to-point, acknowledged, multiple frame information transfer is supported. Frame types associated with other information transfer modes are discarded. No other action is taken.

A supervisory or unnumbered frame that is encoded different than what is shown in Figure 3-11 is treated as an undefined command and response control field.

3.6.2 Information (I) command

The information (I) command is used to transfer, across a data link connection, sequentially numbered frames containing information fields provided by layer 3. This command is used in the multiple frame operation on point-to-point data link connections.

3.6.3 Set asynchronous balanced mode extended (SABME) command

The SABME unnumbered command is used to place the addressed user side or network side into modulo 128 multiple frame acknowledged operation.

No information field is permitted with the SABME command. A data link layer entity confirms acceptance of a SABME command by the transmission at the first opportunity of a UA or DM response. Upon acceptance of this command, the data link layer entity's send state variable V(S), acknowledge state variable V(A), and receive state variable V(R) are cleared (set to zero). The transmission of an SABME command indicates the clearance of all exception conditions.

Previously transmitted I frames that are unacknowledged when this command is processed remain unacknowledged and are discarded. It is the responsibility of a higher level (for example, Layer 3) or the management entity to recover any such loss of information.

3.6.4 Disconnect (DISC) command

The DISC unnumbered command is transmitted to terminate multiple frame operation.

No information field can be present in the DISC command frame. The data-link-layer entity receiving the DISC command confirms the acceptance of a DISC command by transmitting a UA response. The data-link-layer entity sending the DISC command terminates the multiple frame operation when it receives an acknowledging UA or DM response.

Previously transmitted I frames that are unacknowledged when this command is processed remain unacknowledged and are discarded. It is the responsibility of a higher level (for example, Layer 3) or the management entity to recover any such loss of information.

3.6.5 Unnumbered information (UI) command

Not supported in this specification.

3.6.6 Receive ready (RR) command and response

The RR supervisory frame is used by a data-link-layer entity to

- indicate it is ready to receive an I frame
- acknowledge previously received I frames numbered up to and including N(R) - 1
- clear a busy condition that was indicated by the earlier transmission of an RNR frame by that same data-link-layer entity

In addition to indicating the status of a data-link-layer entity, the RR command, with the P bit set to “1” is used by the data-link-layer entity to ask for the status of its peer data-link-layer entity.

3.6.7 Reject (REJ) command and response

The REJ supervisory frame is used by a data-link-layer entity to request retransmission of I frames starting with the frame numbered N(R). The value of N(R) in the REJ frame acknowledges that I frames numbered up to and including N(R) - 1 have been received. New I frames pending initial transmission are transmitted following the retransmitted I frame(s).

Only one REJ exception condition for a given direction of information transfer is established at a time. The REJ exception condition is reset when an I frame with an N(S) equal to the N(R) of the REJ frame is received.

The transmission of a REJ frame also indicates that the busy condition has cleared on a sending data-link-layer entity. The busy state would normally have been signalled by the transmission of an RNR frame by that same data-link-layer entity.

In addition to indicating the status of a data-link-layer entity, the REJ command (with the P bit set to “1”) is used by the data-link-layer entity to ask for the status of its peer data-link-layer entity.

3.6.8 Receive not ready (RNR) command and response

The RNR supervisory frame is used by a data-link-layer entity to indicate a busy condition. That is, a temporary inability to accept additional incoming I frames. The value of the receive sequence number [N(R)] in the RNR frame acknowledges I frames numbered up to and including [N(R) - 1].

In addition to indicating the status of a data-link-layer entity, the RNR command — with the P bit set to “1” — may be used by the data-link-layer entity to enquire about the status of its peer data-link-layer entity.

3.6.9 Unnumbered acknowledgment (UA) response

The UA response is used by a data-link-layer entity to acknowledge the receipt and acceptance of the mode-setting commands, SABME or DISC. Received mode-setting commands are not processed until the UA response is transmitted. The UA response frame does not contain an information field.

The transmission of the UA response is also used to indicate the clearance of any busy condition that was reported by the earlier transmission of an RNR frame by that same data-link-layer entity.

3.6.10 Disconnected mode (DM) response

The DM response is used by a data-link-layer entity to report to its peer that the data link layer is in a state such that multiple frame operation cannot be performed. The DM response frame is not numbered and does not contain an information field.

3.6.11 Frame reject (FRMR) response

The FRMR unnumbered response may be received by a data link layer entity as a report of an error condition not recoverable by retransmission of the identical frame; that is, at least one of the following error conditions, resulting from the receipt of a valid frame:

- A frame containing a command or response control field that is not defined or is not implemented.An undefined or unimplemented control or response field is any control field code not identified in Figure 3-11.
- A supervisory or unnumbered frame of incorrect length. A frame containing an information field that is not permitted, with exception to the following message types; SABME, DISC, UA, RR, RNR, and REJ. For these messages, the frame is simply ignored.
- A frame received with an invalid receive sequence number [N(R)]. A valid N(R) value is one that is in the range $V(A) \leq N(R) \leq V(S)$.

If such an error occurs, an information field immediately following the control field is returned, consisting of five octets. This response provides the reason for the FRMR response. This information field format is shown in Figure 3-12.

Figure 3-12 FRMR information field format for extended (modulo 128) operation

8	7	6	5	4	3	2	1	
Rejected frame control field								Octet 5
								Octet 6
V(S)							0	Octet 7
V(R)							C/R	Octet 8
0	0	0	0	Z	Y	X	W	Octet 9

- The rejected frame control field is the control field of the received frame which causes rejection. When the rejected frame is not numbered, the control field of the rejected frame is positioned in octet 5, with octet 6 set to “0000 0000”.
- V(S) is the value of the current send state variable (on the user side or network side) that is reporting the rejection condition.
- C/R is set to “1” if the rejected frame is a response
- V(R) is the value of the current receive state variable (on the user side or network side) that is reporting the rejection condition.
- W set to “1” indicates that the control field received and returned in octets 5 and 6 is undefined or not implemented.
- X set to “1” indicates that the control field received and returned in octets 5 and 6 is considered invalid because the frame contained an information field which is not permitted with this frame, or the frame is a supervisory or unnumbered frame of incorrect length. Bit W is set to “1” in conjunction with this bit.
- Y set to “1” indicates that the information field received exceeds the maximum established information field length (N201) of the user side or network side reporting the rejection condition.
- Z set to “1” indicates that the control field received and returned in octets 5 and 6 contains an invalid N(R).
- Octet 7, bit 1, and octet 9, bits 5 through 8, are set to “0”.

Note: DMS implementation does not generate FRMR frame under any conditions. However, it responds to a received FRMR frame as specified in this document.

3.6.12 Exchange identification (XID) command/response

Not supported in this specification.

Chapter 3-4: Layer to Layer Communication

4.1 Introduction

Communication between layers and between the data link layer and the management entity is accomplished by means of primitives.

Primitives represent, in an abstract way, the logical exchange of information and control between the data link layer and adjacent layers. They do not specify or constrain implementations.

Primitives consist of commands and their respective responses associated with the services requested of a lower layer. The general syntax of a primitive is:

Interface- Generic name - Type: Parameters

4.2 Interface

The interface part of the primitive determines the interface across which the primitive flows. For ISDN PRI, the following interfaces are defined:

- DL defines communication between Layer 3 and the data link layer
- PH defines communication between the data link layer and the physical layer
- MDL defines communication between the layer management and the data link layer

4.3 Generic names

The generic name specifies the activity that should be performed by the primitive. Table 3-1 illustrates the primitives defined in this chapter. (Note that some of the primitives do not have associated parameters.) A list of all the primitives and their uses follows Table 3-1.

Table 3-1 Primitives associated with the data link layer

Generic name	Type				Parameters		Message unit contents
	Request	Indication	Response	Confirm	Priority indicator	Message unit	
Layer 3-to-Layer 2 boundary							
DL-Establish	X	X	-	X	-	-	
DL-Release	X	X	-	X	-	-	
DL-DM-Release	X	-	-	-	-	-	
DL-Data	X	X	-	-	-	X	Layer 3 peer-to-peer message
Management entity-to-Layer 2 boundary							
MDL-Assign	X	X	-	-	-	X	TEI value - CES
MDL-Remove	X	-	-	-	-	X	TEI value - CES
MDL-Error	-	X	X	-	-	X	Reason for error
Later 2-to-Layer 1 boundary							
PH-Data	X	X	-	-	X	X	Layer 2 peer-to-peer message

4.3.1 DL-Establish

The *DL-Establish* primitives are used to request, indicate, and confirm the outcome of the procedures used to establish multiple-frame operation.

4.3.2 DL-Release

The *DL-Release* primitives are used to request, indicate, and confirm the outcome of the procedures for terminating a previously established multiple-frame operation. These primitives are also used to report unsuccessful attempts to establish multiple-frame operation.

4.3.3 DL-DM-Release

The *DL-DM-Release* primitives are equivalent to a *DL-Release* request. These primitives cause the Layer-2 entity to respond to a SABME command with a DM response. This primitive is used in the D-channel backup procedures (see “9.3 Annex C - Backup D-channel service on page 272”).

4.3.4 DL-Data

The *DL-Data* primitives are used to request and indicate layer-3 messages which are to be transmitted, or have been received by the data link layer. These primitives are only used if the Layer-3 messages are transmitted using the acknowledged information transfer service.

4.3.5 MDL-Assign

The *MDL-Assign* primitives are used by the layer management entity to request that the data link layer associate the TEI value contained within the message portion of the primitive with the specified connection endpoint suffix (CES), across all SAPIs.

In addition, an *MDL-Assign* primitive is used by the data link layer to indicate to a layer management entity that a TEI value needs to be associated with the CES specified in the primitive message unit.

4.3.6 MDL-Remove

The *MDL-Remove* primitives are used by the layer management entity to request that the data link layer remove the association of the specified TEI value with the specified CES, across all SAPIs. The TEI and CES are specified in the *MDL-Remove* primitive message unit.

4.3.7 MDL-Error

The *MDL-Error* primitives are used to indicate to the connection management entity that one of the following has been detected:

- an error associated with a previous management function request
- an error in a communication with the data link layer peer entity, which cannot be corrected by the data link layer

4.3.8 PH-Data

The *PH-Data* primitives are used to request and indicate message units containing frames used for data link layer peer-to-peer communications passed to and from the physical layer.

4.4 Primitive types

The primitive types defined in this specification are defined in the following sections.

4.4.1 Request

The *Request* primitive type is used when a higher layer or a management entity is requesting a service from the next lower layer.

4.4.2 Indication

The *Indication* primitive type is used by a layer providing a service to inform the next higher layer or layer management.

4.4.3 Response

The *Response* primitive type is used by layer management as a consequence of the *Indication* primitive type.

4.4.4 Confirm

The *Confirm* primitive type is used by the layer providing the requested service to confirm that the activity has been completed.

4.5 Parameter definition

4.5.1 Priority indicator

Since several service access points (SAPs) may exist on the network side or on the user side, protocol message units sent by one SAP may contend with those of other SAPs for the physical resources available for message transfer.

The priority indicator is used to determine which message unit has greater priority when contention exists. The priority indicator is only needed on the user side. It is used to distinguish message units sent by the SAP (with a SAPI value of “0”) from all other message units.

4.5.2 Message unit

The message unit contains additional layer-to-layer information concerning actions and results associated with requests. For *Data* primitives, the message unit contains the requesting layer peer-to-peer messages. For example, the *DL-Data* message unit contains Layer 3 information. The *PH-Data* message unit contains the data link frame.

> ***Note:*** The operations across the Layer 2-to-Layer 3 boundary are such that the layer sending the *DL-Data* primitive assumes a temporal order of the bits within the message unit. It is also assumed that the layer receiving the primitive can reconstruct the message with its assumed temporal order.

4.6 Primitive procedures

Primitive procedures specify the interactions used (between adjacent layers of the protocol) to invoke and provide a service. The service primitives represent the elements of the procedures. This section specifies the interactions between Layer 3 and the data link layer.

The states of a data link connection endpoint may be derived from the internal states of the data link layer entity supporting this type of a data link connection.

The data link connection endpoint states for point-to-point data link connection endpoints are as follows:

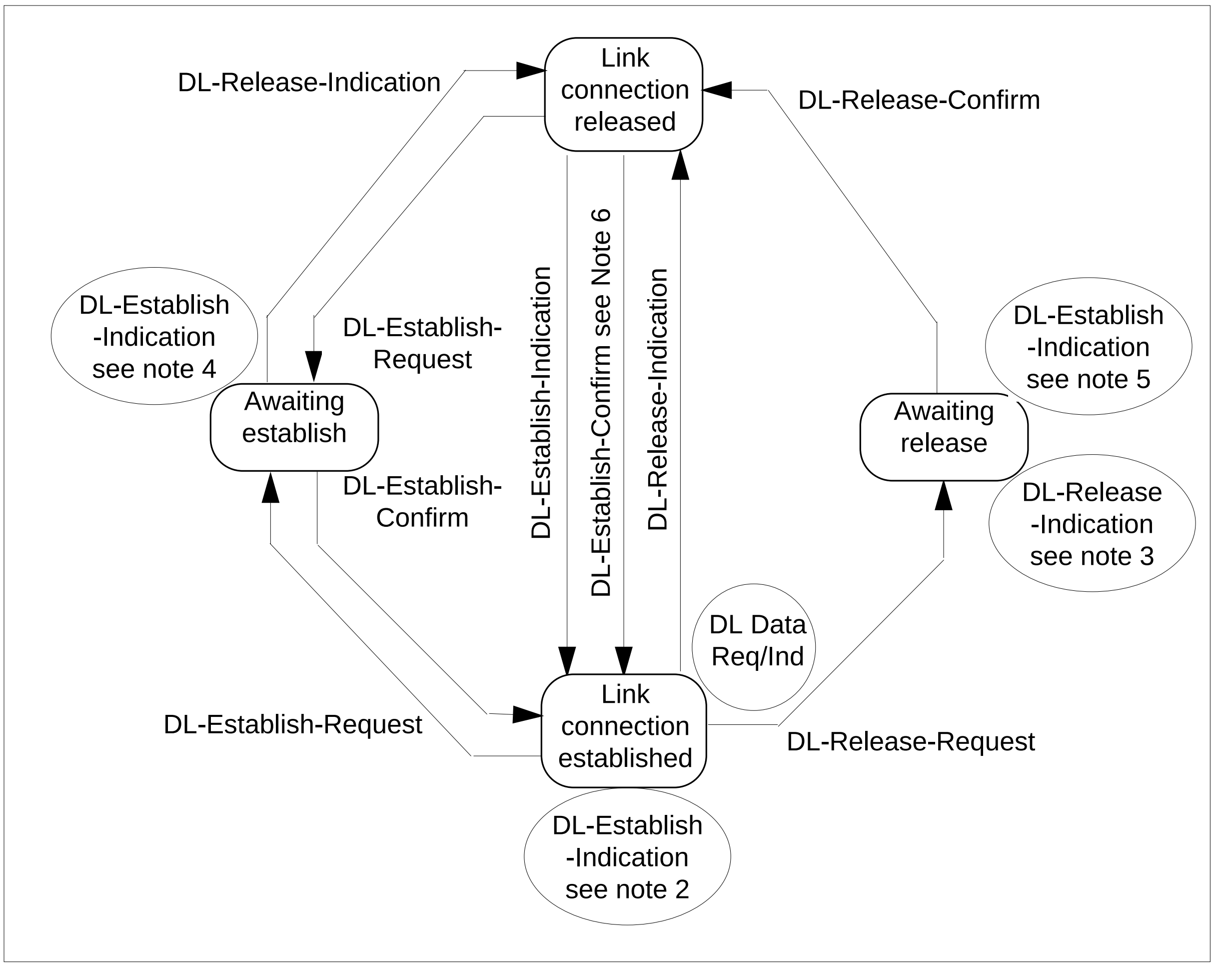
- link connection released
- awaiting establish
- awaiting release
- link connection established

The primitives provide the procedures to specify, conceptually, how a data link service user can invoke a service.

The possible overall sequences of primitives at a point-to-point data link connection endpoint are shown in the state transition diagram (Figure 3-13) The sequences are related to the states at one point-to-point data link connection endpoint.

The *Link connection released* and *Link connection established* states are stable states. The *Awaiting establish* and *Awaiting release* states are transition states.

Figure 3-13 State transition diagram as seen by Layer 3



Note 1: If the data link layer entity issues a *DL-Establish-Indication* primitive, (for instance, if the data link layer is initiated or the peer system initiated re-establishment), a *DL-Release-Confirm* primitive, or a *DL-Release-Indication* primitive, all the data link service data units representing *DL-Data-Request*s are discarded.

Note 2: This primitive notifies Layer 3 that the link is re-established.

Note 3: This primitive is generated if a *DL-Release-Request* collides with a *DL-Release-Indication*.

Note 4: This primitive is generated if a *DL-Establish-Request* collides with a *DL-Establish-Indication*.

Note 5: This primitive is generated if a *DL-Release-Request* collides with a *DL-Establish-Indication*.

Note 6: This primitive is generated if a *DL-Establish-Request* (generated if Layer 3 attempts to re-establish the link) collides with a *DL-Release-Indication*. Since this *DL-Release-Indication* is not related to the *DL-Establish-Request*, the data link layer establishes the link and issue a *DL-Establish-Confirm*.

Chapter 3-5: Layer 2 Peer to Peer Communication

This chapter specifies the procedures used by the data-link-layer entities.

The elements of procedure (frame types) which apply to point-to-point, acknowledged, and multiple-frame information transfer are:

- Set asynchronous balanced mode extended (SABME) command
- Unnumbered acknowledgment (UA) response
- Disconnected mode (DM) response
- Disconnect (DISC) command
- Receive ready (RR) command and response
- Receive not ready (RNR) command and response
- Reject (REJ) command and response
- Information (I) command
- Frame reject (FRMR) response

5.1 Procedure for use of the P/F bit

5.1.1 Unacknowledged information transfer

Not supported in this specification.

5.1.2 Acknowledged multiple-frame information transfer

A data-link-layer entity receiving an SABME, DISC, RR, RNR, REJ, or I-frame with the P bit set to “1”, sets the F bit to “1” in the next response frame it transmits, as shown in Table 3-2.

Table 3-2 Immediate response operation of the P/F bit

Command received with P bit = “1”	**Response transmitted with F bit = “1”**
SABME, DISC	UA, DM
I, RR, RNR, REJ	RR, RNR, REJ

5.2 Procedures for unacknowledged information transfer

Not supported in this specification.

5.3 Terminal endpoint identifier (TEI) management procedures

User equipment in the TEI-unassigned state enters the TEI-assigned state when layer management assigns a TEI value of “0” to that equipment. The state change is carried out when layer management issues an *MDL-Assign-Request* primitive.

User equipment in the TEI-assigned state enters the TEI-unassigned state when layer management removes the TEI from that equipment. The TEI is removed when layer management issues an *MDL-Remove-Request* primitive.

5.4 Automatic negotiation of data-link-layer parameters

Not supported in this specification.

5.5 Procedures for establishment and release of multiple frame operation

5.5.1 Establishment of multiple frame operation

Only the extended multiple-frame operation (modulo 128 sequencing) is supported for PRI.

The following procedures are used to establish multiple-frame operation between the network and a designated user entity.

Layer 3 requests establishment of multiple frame operation by the using the *DL-Establish-Request* primitive. Re-establishment may be initiated by the data-link-layer procedures defined in section 5.7 on page 87. All frames (other than unnumbered frames) received during the establishment procedures are ignored.

5.5.1.1 Establishment procedures

A data-link-layer entity initiates a request for multiple frame operation by transmitting the set asynchronous balanced mode extended (SABME) command. The SABME command:

- clears all existing exception conditions
- resets the retransmission counter to zero

- starts timer T200. (Timer T200 is defined in section 5.9.1 on page 91.) All mode setting commands are transmitted with the P bit set to “1”

Establishment procedures initiated by Layer 3 imply that all outstanding *DL-Data-Requests* and all I-frames in queues are discarded.

Having received a SABME command, and provided it can enter the multiple frame established state, the data-link-layer entity

- responds with an unnumbered acknowledgment (UA) response with the F bit is set to the same binary value (“0” or “1”) as the P bit in the received SABME command
- sets the send state variable V(S), the receive state variable V(R), and the acknowledge state variable V(A) to “0”
- enters the multiple-frame established state and inform Layer 3 using the *DL-Establish-Indication* primitive
- clears all existing exception conditions
- clears any existing peer receiver busy condition
- starts timer T203. (Timer T203 is defined in section 5.9.8 on page 91.)

If the data-link-layer entity cannot enter the multiple-frame established state, it responds to the SABME command with a Disconnected mode (DM) response. The F bit is set to the same binary value (“0” or “1”) as the P bit in the received SABME command.

If a UA response with the F bit set to “1” is received by the originator of the SABME command, the originator:

- resets timer T200
- starts timer T203
- sets the send state variable V(S), the receive state variable V(R), and the acknowledge state variable V(A) to “0”
- enters the multiple-frame established state and informs Layer 3 using the *DL-Establish-Confirm* primitive

If a DM response with the F bit set to “1” is received by the originator of the SABME command, the originator:

- informs Layer 3 that it has received this command, using the *DL-Release-Indication* primitive
- resets timer T200
- enters the TEI-assigned state

If a DM response with the F bit set to “0” is received by the originator of the SABME command, the originator ignores the response.

If a *DL-Release-Request* primitive is received during re-establishment of the data link layer, it is serviced on completion of the establishment mode-setting operation.

5.5.1.2 Procedure on expiry of timer T200

If timer T200 expires before the UA or DM response (with the F bit set to “1”) is received, the data-link-layer entity

- retransmits the SABME command
- restarts timer T200
- increments the retransmission counter

After retransmission of the SABME command N200 time, the data link layer entity indicates this to Layer 3 and the connection management entity by using the *DL-Release-Indication* and *MDL-Error-Indication* primitives, respectively. After discarding all outstanding *DL-Data-Request* primitives and all I-frames in the queue, the data-link-layer entity enters the TEI-assigned state.

The value of N200 is defined in section 5.9.2 on page 91.

5.5.2 Information transfer

I-frames and supervisory frames are transmitted and received (according to the procedures described in section 5.6 on page 79) if

- UA is transmitted in response to a received SABME command, or
- UA response is received in response to a transmitted SABME command.

If a SABME command is received while in the multiple-frame established state, the data-link-layer entity goes through the re-establishment procedures described in section 5.7 on page 87.

5.5.3 Termination of multiple frame operation

5.5.3.1 General

The following procedures are used to terminate the multiple-frame operation between the network and a designated user entity.

A Layer-3 entity can request termination of the multiple frame operation by using the *DL-Release-Request* primitive.

All frames, other than the unnumbered frames received during the release procedures, are ignored. All outstanding *DL-Data-Request* primitives, and all I-frames in the queue, are discarded.

If there is a persistent Layer 1 failure, the data-link-layer entity

- discards all I queues
- delivers a *DL-Release-Confirm* primitive to Layer 3, if a *DL-Release-Request* primitive is outstanding, otherwise it delivers a *DL-Release-Indication* primitive to Layer 3

5.5.3.2 Release procedure

A data-link-layer entity can initiate a request for release of the multiple-frame operation by transmitting the Disconnect (DISC) command with the P bit set to “1”. Timer T200 is started and the retransmission counter is reset to zero.

If a data-link-layer entity receives a DISC command while in the multiple-frame established state, or the timer recovery state, it transmits a UA response with the F bit set to the same binary value (“0” or “1”) as the P bit in the received DISC command. A *DL-Release-Indication* primitive is passed to Layer 3 and the entity enters the TEI-assigned state.

If the originator of the DISC command receives one of the following, it enters the TEI-assigned state and timer T200 is reset:

- a UA response with the F bit set to “1”
- a DM response with the F bit set to “1” (indicating that the peer data-link-layer entity is already in the TEI-assigned state)

The data-link-layer entity which issued the DISC command notifies Layer 3 that it is now in the TEI-assigned state using the *DL-Release-Confirm* primitive. The conditions relating to the TEI-assigned state are defined in section 5.5.4 on page 78.

5.5.3.3 Procedure on expiry of timer T200

If timer T200 expires before a UA or DM response with the F bit set to “1” is received, the originator of the DISC command

- retransmits the DISC command as defined above
- restarts the retransmission timer (T200)
- increments the retransmission counter.

If the data link layer entity has not received the correct response as defined in section 5.5.3.2 on page 77 after N200 attempts to recover, the data link layer

- sends an *MDL-Error-Indication* primitive to the managemnet entity
- enters the TEI-assigned state
- notifies layer 3 by means of the *DL-Release-Confirm* primitive

5.5.4 TEI-assigned state

While in the TEI-assigned state, the data link layer responds to the various commands, as follows:

- DISC command received: A disconnected mode (DM) response is transmitted with the F bit set to the binary value (“0” or “1”) of the received P bit.
- SABME command received: The entity tries to enter the multiple-frame operation state as described in section 5.5.1 on page 74.
- Unsolicited DM response (with the F bit set to “0”) received: The entity tries to enter the multiple-frame operation state as described in section 5.5.1 on page 74, or, if it cannot, it ignores the DM response.
- Unsolicited UA response received: The entity issues an *MDL-Error-Indication* primitive.

All other frame types are ignored by the entity and are discarded.

5.5.5 Collision of unnumbered commands and responses

5.5.5.1 Identical transmitted and received commands

If the transmitted and received unnumbered commands (SABME or DISC) are the same, the data-link-layer entities send the UA response at the earliest possible opportunity.

The entity receiving the UA response enters the indicated state. The data-link-layer entities each notify their respective Layer 3 entity using the appropriate *Confirm* primitive.

5.5.5.2 Different transmitted and received commands

If the transmitted and received unnumbered commands (SABME or DISC) are different, the data-link-layer entities issue a DM response at the earliest possible opportunity.

The entity receiving a DM response (with the F bit set to “1”) enters the TEI-assigned state and notifies its Layer 3 using the appropriate primitive.

The entity receiving the DISC command issues a *DL-Release-Indication* primitive while the other entity issues a *DL-Release-Confirm* primitive.

5.5.6 Unsolicited DM response and SABME or DISC command

When a DM response (with the F bit set to “0”) is received by a data-link-layer entity, a collision between a transmitted SABME or DISC command and the unsolicited DM response may have occurred. This is caused (typically) when the user equipment applies a protocol procedure according to X.25 LAPB to ask for a mode-setting command. (See the reference *CCITT Recommendation X.25, Interface between data terminal equipment (DTE) and data circuit* *terminating equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit*.)

In order to avoid misinterpretation of the DM response received, a data-link-layer entity always sends the SABME or DISC command with the P bit set to “1”.

If a DM response (with the F bit set to “0”) collides with a SABME or DISC command, the DM response is ignored.

5.6 Procedures for information transfer in multiple frame operation

The procedures for transmitting I-frames are defined in the following sections. The term “transmission of an I-frame” and its equivalents, refer to the delivery of an I frame by the data link layer to the physical layer.

5.6.1 Transmitting I-frames

Information is received by the data-link-layer entity from Layer 3 using the *DL-Data-Request* primitive. This information is transmitted between peer entities in an I-frame. The control field parameters N(S) and N(R) in the I-frame are assigned the values of the send and receive state variables V(S) and V(R), respectively. The value of the send state variable V(S) is incremented by one at the end of the transmission of the I-frame.

If the retransmission timer, T200, is not running at the time of transmission of an I-frame, it is started. If the timer T200 expires before an acknowledgment is received by the sending entity, the procedures defined in section 5.6.7 on page 86 are followed.

If:
Send state variable V(S) = Acknowledge state variable V(A)
+ k (where k is the maximum number of outstanding I-frames),
the data-link-layer entity does not transmit any new I-frames. It may retransmit an I-frame as a result of the error recovery procedures described in section 5.6.4 on page 81 and section 5.6.7 on page 86.

When the network side or user side is in the own-receiver busy[1] condition, it may still transmit I-frames, provided that a peer-receiver busy condition does not exist.

> ***Note:*** Any *DL-Data-Request* primitives received while in the timer recovery condition are queued.

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[1]The term own- or peer-receiver busy refers to the peer-to-peer flow control state in the data-link-layer entities.

5.6.2 Receiving I-frames

Independent of a timer recovery condition, when a data-link-layer entity is not in an own-receiver busy condition, and receives a valid I-frame, whose send sequence number N(S) is equal to the current receive state variable V(R), the data-link-layer entity

- passes the information field of this frame to Layer 3 using the *DL-Data-Indication* primitive.
- increments its receive state variable V(R) by one.

The following actions are performed depending on the value of the P bit.

5.6.2.1 P bit set to “1”

If the P bit of the received I-frame is set to “1”, the data-link-layer entity responds to its peer in one of the following ways:

- If the data-link-layer entity receiving the I-frame is still not in an own receiver busy condition, it sends an RR response (with the F bit set to “1”).
- If the data-link-layer entity receiving the I-frame enters an own receiver busy condition upon receipt of the I-frame, it sends an RNR response (with the F bit set to “1”).

5.6.2.2 P bit set to “0”

If the P bit of the received I-frame is set to “0” and

- if the data-link-layer entity is still not in an own-receiver busy condition:
  - — if no I-frame is available for transmission, or if an I-frame is available for transmission but a peer receiver busy condition exists, the data-link-layer entity transmits an RR response (with the F bit set to “0”).
  - — if an I-frame is available for transmission and no peer receiver busy condition exists, the data-link-layer entity transmits the I-frame with the value of N(R) set to the current value of V(R).
- if, on receipt of this I-frame, the data-link-layer entity is now in an own-receiver busy condition, it transmits an RNR response (with the F bit set to “0”).

When the data-link-layer entity is in an own receiver busy condition, it processes any received I-frame according to the procedures defined in section 5.6.6 on page 85.

5.6.3 Sending and receiving acknowledgments

5.6.3.1 Sending acknowledgments

Whenever a data-link-layer entity transmits an I-frame or a supervisory frame, the value of N(R) is set equal to the value of V(R).

5.6.3.2 Receiving acknowledgment

On receipt of a valid I-frame or supervisory frame (RR, RNR, or REJ) — even in the own receiver busy or timer (T200) recovery condition — the data-link-layer entity treats the receive sequence number [N(R)] contained in this frame as an acknowledgment for all the I-frames it has transmitted with a send sequence number [N(S)] up to and including the received N(R)-1.

The value of the acknowledge state variable V(A) is set to the value of N(R).

The data-link-layer entity resets timer T200 on receipt of one of the following

- a valid I-frame
- a supervisory frame with the receive sequence number [N(R)] higher than V(A) (actually acknowledging some I-frames)
- a REJ frame with an N(R) equal to V(A)

  Note 1: If a supervisory frame with the P bit set to “1” has been transmitted and not acknowledged, timer T200 is not reset.

  Note 2: Upon receipt of a valid I-frame, timer T200 is not reset if the data-link-layer entity is in the peer receiver busy condition.

If timer T200 has been reset by the receipt of an I, RR, or RNR frame, and if there are outstanding I-frames still unacknowledged, the data-link-layer entity restarts timer T200. If the timer then expires, the data-link-layer entity attempts to recover as defined in section 5.6.7 on page 86.

If timer T200 has been reset by the receipt of a REJ frame, the data-link-layer entity retransmit any outstanding frames as described in section 5.6.4 on page 81.

5.6.4 Receiving REJ frames

On receipt of a valid REJ frame, the data-link-layer entity carries out the following

- if the data-link-layer entity is not in the timer recovery condition, the data-link-layer entity
  - — clears any existing peer receiver busy condition
  - — sets its send state variable V(S) and its acknowledge state variable V(A) to the value of the N(R) contained in the REJ frame control field
  - — stops timer T200
  - — starts timer T203
  - — if it was a REJ command frame with the P bit set to “1”, it transmits an appropriate supervisory response frame[1] with the F bit set to “1”

- — transmits the corresponding I-frame as soon as possible, as defined in section 5.6.1 on page 79, taking into account the conditions in section 5.6.4.1 on page 83
- — notifies the management entity that a protocol violation has occurred by use of the *MDL-Error-Indication* primitive, if it was a REJ response frame with the F bit set to "1".

- If the data-link-layer entity is in the timer recovery condition and it was a REJ response frame with the F bit set to "1", the data-link-layer entity
    - — clears any existing peer receiver busy condition
    - — sets its send state variable V(S) and its acknowledge state variable V(A) to the value of N(R) contained in the REJ frame control field
    - — stops timer T200
    - — starts timer T203
    - — enters the multiple-frame-established state
    - — transmits the corresponding I-frame as soon as possible, as defined in section 5.6.1 on page 79, taking into account the conditions in section 5.6.4.1 on page 83
- If the data-link-layer entity is in the timer recovery condition and it was a REJ frame, other than a REJ response frame with the F bit set to "1", the data-link-layer entity
    - — clears any existing peer receiver busy condition
    - — sets its acknowledge state variable V(A) to the value of the N(R) contained in the REJ frame control field
    - — if it was a REJ command frame with the P bit set to "1", it transmits an appropriate supervisory response frame with the F bit set to "1". See footnote 1 on page 3-82 for a definition of the appropriate supervisory frame.

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[1]If the data-link-layer entity is not in an own receiver busy condition and is in a Reject exception condition (that is, an N(S) sequence error has been received, and a REJ frame has been transmitted, but the requested I-frame has not been received), the appropriate supervisory frame is the RR frame.

If the data-link-layer entity is not in an own receiver busy condition, but is in an N(S) sequence error exception condition, (that is, an N(S) sequence error has been received but a REJ frame has not been transmitted), the appropriate supervisory frame is the REJ frame.

If the data-link-layer entity is in its own receiver busy condition, the appropriate supervisory frame is the RNR frame.

Otherwise, the appropriate supervisory frame is the RR frame.

5.6.4.1 Transmission of I-frames

When I-frames are transmitted the following conditions are taken into account:

- If the data-link-layer entity is transmitting a supervisory frame when it receives the REJ frame, it completes that transmission before commencing transmission of the requested I-frame.
- If the data-link-layer entity is transmitting a SABME command, a DISC command, a UA response, or a DM response when it receives the REJ frame, it ignores the request for retransmission.
- If the data-link-layer is not transmitting a frame when the REJ frame is received, it immediately commences transmission of the requested I-frame.

All outstanding unacknowledged I-frames, commencing with the I-frame identified in the received REJ frame are transmitted. Other I-frames not yet transmitted may be transmitted following the retransmitted I-frames.

5.6.5 Receiving RNR

If the data-link-layer entity is not engaged in a mode setting operation, after receiving a valid RNR command or response, it sets a peer receiver busy condition and then

- if it was an RNR command (with the P bit set to “1”) and the data-link-layer entity is *not* in an own receiver busy condition, it responds with an RR response (with the F bit set to “1”)
- if it was an RNR command (with the P bit set to “1”) and the data-link-layer entity *is* in an own receiver busy condition, it responds with an RNR response (with the F bit set to “1”)
- if it was an RNR response (with the F bit set to “1”) any existing timer recovery condition is cleared and the receive sequence number [N(R)] contained in the RNR response is used to update the send state variable [V(S)]

The data-link-layer entity takes note of the peer receiver busy condition and does not transmit any I-frames to the peer which has indicated the busy condition.

> ***Note:*** The receive sequence number [N(R)] in any RR or RNR command frame — irrespective of the setting of the P bit — is *not* used to update the send state variable [V(S)].

The data-link-layer entity then

- treats the receive sequence number [N(R)] contained in the received RNR frame as an acknowledgment for all the I-frames that have been (re)transmitted with an N(S) up to and including N(R) - 1. It sets its acknowledge state variable [V(A)] to the value of the N(R) contained in the RNR frame.
- restarts timer T200 unless a supervisory response frame (with the F bit set to “1”) is still expected

If timer T200 expires, the data-link-layer entity

- if it is not yet in a timer recovery condition, enters the timer recovery condition, and resets the retransmission count variable,,
- if it is already in a timer recovery condition, adds one to its retransmission count variable.

The data-link-layer entity then

- if the value of the retransmission count variable is less than N200:
  - — transmits an appropriate supervisory command (with the P bit set to “1”). See footnote 1 on page 3-82 for a definition of the appropriate supervisory frame.
  - — restarts timer T200
- If the value of the retransmission count variable is equal to N200, the data-link-layer entity
  - — initiates a re-establishment procedure as described in section 5.7 on page 87.
  - — indicates re-establishment is occurring by sending the *MDL-Error-Indication* primitive to the management entity.

The data-link-layer entity receiving the supervisory frame (with the P bit set to “1”) responds, at the earliest opportunity, with an appropriate supervisory response frame (with the F bit set to “1”), to indicate whether or not its own receiver busy condition still exists. See footnote 1 on page 3-82 for a definition of the appropriate supervisory frame.

When the supervisory response frame (with the F bit set to “1”) is received, the data-link-layer entity resets timer T200 and

- if the response is an RR or REJ response, the peer receiver busy condition is cleared and the data link entity may transmit new I-frames or retransmit I-frames
- if the response is an RNR response, the data-link-layer entity receiving the response proceeds as indicated in the first paragraph of this description

If a supervisory command (RR, RNR, or REJ, with the P bit set to “0”or “1”) or a supervisory response frame (RR, RNR, or REJ, with the F bit set to “0”) is received during the enquiry process, the data-link-layer entity carries out one of the following:

- If the supervisory frame is an RR or REJ command frame or an RR or REJ response frame (with the F bit set to “0”) the data-link-layer entity clears the peer receiver busy condition. I-frames are not (re)transmitted until the appropriate supervisory response frame (with the F bit set to “1”) is received, or timer T200 expires.
- If the supervisory frame is an RR or REJ command frame (with the P bit set to “1”) the data-link-layer entity transmits the appropriate supervisory response frame (with the F bit set to “1”). See footnote 1 on page 3-82 for a definition of the appropriate supervisory frame. I-frames are not (re)transmitted until the appropriate supervisory response frame (with the F bit set to “1”) is received, or timer T200 expires.
- If the supervisory frame is an RNR command frame or an RNR response frame (with the F bit set to “0”) the data-link-layer entity retains the peer receiver busy condition.
- If the supervisory frame received is an RNR command (with the P bit set to “1”) the data-link-layer entity transmits the appropriate supervisory response frame (with the F bit set to “1”). See footnote 1 on page 3-82 for a definition of the appropriate supervisory frame.

When a SABME command is received, the data-link-layer entity clears the peer receiver busy condition.

5.6.6 Data link layer own receiver busy condition

When the data-link-layer entity enters an own receiver busy condition, it transmits a receiver not ready (RNR) frame at the earliest opportunity.

> ***Note:*** The DMS-100 supports receiving RNR but does not send RNR.

The RNR frame may be one of the following:

- an RNR response (with the F bit set to “0”)
- an RNR response (with the F bit set to “1”) if the busy condition occurs when a command frame (with the P bit set to “1”) is received
- an RNR command (with the P bit set to “1”) if the busy condition occurs when timer T200 expires

All I-frames (with the P bit set to “0”) that are received, are discarded after the acknowledge state variable [V(A)] is updated.

All supervisory frames (with the P/F bit set to “0”) that are received are processed, including updating the acknowledge state variable [V(A)].

All I-frames (with the P bit set to “1”) that are received are discarded, after the acknowledge state variable [V(A)] is updated. An RNR response frame (with the F bit set to “1”) is transmitted.

All supervisory frames (with the P bit set to “1”) that are received are processed including updating the acknowledge state variable [V(A)]. An RNR response (with the F bit set to “1”) is transmitted.

To indicate to the peer data-link-layer entity that the own receiver busy condition has been cleared, the data-link-layer entity transmits one of the following:

- an RR frame
- if a previously detected N(S) sequence error has not been reported, an REJ frame with the N(R) set to the current value of the receive state variable [V(R)]

The transmission of a SABME command or a UA response (in reply to a SABME command) also indicates to the peer data-link-layer entity that the own receiver busy condition has been cleared.

5.6.7 Waiting acknowledgment

The data-link-layer entity maintains an internal retransmission count variable.

If timer T200 expires, the data-link-layer entity

- if it is *not* in the timer recovery condition, enters the timer recovery condition and resets the retransmission count variable
- if it *is* in the timer recovery condition, adds one to its retransmission count variable,

The data-link-layer entity then

- if the value of the retransmission count variable is less than N200:
  - — restarts timer T200, and, either
    - – transmits an appropriate supervisory command (with the P bit set to “1”) (see footnote 1 on page 3-82 for a definition of the appropriate supervisory frame)
    - – retransmits the last transmitted I-frame [V(S) - 1] (with the P bit set to “1”)
- if the value of the retransmission count variable is equal to N200
  - — initiates a re-establishment procedure as defined in section 5.7 on page 87
  - — indicates this to the management entity by issuing the *MDL-Error-Indication* primitive

The timer recovery condition is cleared when the data-link-layer entity receives a valid supervisory frame response (with the F bit set to “1”).

If the receive sequence number [N(R)] of the received supervisory frame is within the range from its current acknowledge state variable [V(A)] to its current send state variable [V(S)] inclusive, it sets its send state variable [V(S)] to the value of the received N(R).

Timer T200 is reset if the received supervisory frame response is an RR or REJ response. After the timer is reset, the data-link-layer entity resumes I-frame (re)transmission, as appropriate.

Timer T200 is reset and restarted if the received supervisory response is an RNR response. This allows the enquiry process, described in section 5.6.5 on page 83, to proceed.

5.7 Re-establishment of multiple frame operation

5.7.1 Criteria for re-establishment

To re-establish the multiple-frame mode of operation, one or more of the following conditions must be satisfied:

- while in the multiple-frame mode of operation, a SABME command is received
- a *DL-Establish-Request* primitive is received from Layer 3
- while in the timer recovery condition, the occurrence of N200 retransmission failures
- the occurrence of a frame rejection condition as identified in section 5.8.5 on page 89
- while in the multiple-frame mode of operation, an FRMR response frame is received
- while in the multiple-frame mode of operation, an unsolicited DM response (with the F bit set to “0”) is received
- while in a timer recovery condition, a DM response (with the F bit set to “1”) is received

5.7.2 Procedures

In all re-establishment situations, the data-link-layer entity follows the procedures defined in section 5.5.1 on page 74. Any locally generated condition that causes re-establishment procedures to be started, causes a SABME command to be transmitted.

For data-link-layer- and peer-initiated re-establishment, the data-link-layer entity also

- issues an *MDL-Error-Indication* primitive to the management entity

- if the send state variable [V(S)] > acknowledge state variable [V(A)], issues a *DL-Establish-Indication* primitive to Layer 3, and discards all I queues prior to re-establishing the call

For Layer 3-initiated re-establishment, or if a *DL-Establish-Request* primitive occurs before re-establishment, the *DL-Establish-Confirm* primitive is used.

5.8 Exception condition reporting and recovery

Exception conditions may occur as the result of physical layer errors or data-link-layer procedural errors.

The error recovery procedures which are available to effect recovery following the detection of an exception condition at the data link layer are defined in the following sections.

5.8.1 Send sequence number [N(S)] sequence error

A send sequence number [N(S)] sequence error exception condition occurs in the receiver when a valid I-frame is received in which the send sequence number [N(S)] is not equal to the receive state variable [V(R)].

All information fields of all I-frames whose N(S) does not equal V(R) are discarded.

The receiver does not acknowledge the I-frame causing the sequence error or increment its receive state variable [V(R)]. It does not acknowledge any I-frames which may follow. Recovery from this condition is indicated when an I-frame with the correct send sequence number [N(S)] is received.

A data-link-layer entity which receives one or more I-frames having sequence errors which are otherwise error free, or subsequent supervisory frames (RR, RNR, and REJ), uses the control field information contained in the N(R) field and the P or F bit to perform data link control functions. For example, it receives acknowledgment of previously transmitted I frames and causes the data-link-layer entity to respond if the P bit is set to “1”. Therefore, the retransmitted I-frame may contain an N(R) field value and P bit that are updated from (and different from) those contained in the originally transmitted I-frame.

The REJ frame is used by a receiving data-link-layer entity to initiate an exception condition recovery (retransmission) following the detection of an N(S) sequence error. Only one REJ exception condition for a given direction of information transfer can be established at any one time.

When a data-link-layer entity receives a REJ command or response it initiates sequential transmission (retransmission) of all I-frames starting with the I frame indicated by the N(R) contained in the REJ frame.

A REJ exception condition is cleared when the requested I-frame is received or when a SABME or DISC command is received.

5.8.2 Receive sequence number [N(R)] sequence error

A receive sequence number [N(R)] sequence error exception condition occurs in the transmitter when a valid supervisory frame or I-frame is received which contains an invalid receive sequence number [N(R)] value.

A valid N(R) is one that is in the range: $V(A) \leq N(R) \leq V(S)$

The information field contained in an I-frame that is in sequence and is error-free may be delivered to Layer 3 using the *DL-Data-Indication* primitive.

The data-link-layer entity informs the management entity of this exception condition using the MDL-*Error-Indication* primitive, and initiates re-establishment according to the procedures defined in section 5.7 on page 87.

5.8.3 Timer recovery condition

If a data-link-layer entity, due to a transmission error, does not receive a single I-frame or the last I-frame(s) in a sequence of I-frames, it cannot detect an out-of-sequence exception condition and therefore, does not transmit a REJ frame.

The data-link-layer entity which transmitted the unacknowledged I-frame(s), on the expiry of timer T200 takes the recovery action defined in section 5.6.7 on page 86 to determine which I-frame(s) must be re-transmitted.

5.8.4 Invalid frame condition

Any frame received which is invalid is discarded. No other action is taken as a result of that frame being received. Invalid frames are defined in section 2.9 on page 51 and section 3.6 on page 61.

5.8.5 Frame rejection condition

A frame rejection condition occurs when undefined commands or response frames are received. See section 3.6.1 on page 61 and section 3.6.11 on page 63 for a listing of such commands and responses

When a frame rejection condition occurs while in multiple-frame mode of operation, the data-link-layer entity

- issues an *MDL-Error-Indication* primitive
- initiates re-establishment, as described in section 5.7 on page 87

5.8.6 Receipt of an FRMR response frame

When an FRMR response frame is received, while in the multiple-frame mode of operation, the data-link-layer entity

- issues an *MDL-Error-Indication* primitive

- initiates re-establishment as described in section 5.7 on page 87

5.8.7 Unsolicited response frames

The action taken on the receipt of an unsolicited response frame is defined in Table 3-3.

5.8.8 Multiple assignment of a TEI value

Not supported in this specification.

Table 3-3 Action on receipt of an unsolicited response frame

Unsolicited response frame	TEI assigned	Awaiting estab-lishment	Awaiting release	Multiple frames modes of operation	
				Established mode	Timer recovery condition
UA response: F = 1	Issue MEI	Solicited	Solicited	Issue MEI	Issue MEI
UA response: F = 0	Issue MEI	Issue MEI	Issue MEI	Issue MEI	Issue MEI
DM response: F = 1	Ignore	Solicited	Solicited	Issue MEI	Re-establish Issue MEI
DM response: F = 0	Establish	Ignore	Ignore	Re-establish Issue MEI	Re-establish Issue MEI
Supervisory response: F = 1	Ignore	Ignore	Ignore	Issue MEI	Solicited
Supervisory response: F = 0	Ignore	Ignore	Ignore	Solicited	Solicited

Key:

Issue MEI	Issue *MDL-Error-Indication* primitive to Layer 3
Ignore	Ignore response
Establish	Establish multiple-frame mode of operation
Re-establish	Re-establish multiple-frame mode of operation

5.9 List of system parameters

The system parameters listed below are associated with each individual service access point (SAP).

The parameter values are assigned when the data link is configured. Only default values of the parameters are supported by the network.

5.9.1 Timer T200

The default value for timer T200, at the end of which transmission of a frame may be initiated according to the procedures described in section 5.6 on page 79, is one second.

> ***Note:*** The proper operation of the procedure requires that the time-out for timer T200 be set greater than the maximum time between transmission of command frames and the reception of their corresponding response or acknowledgment frames.

5.9.2 Maximum number of retransmissions, N200

The default value of N200 is 3.

5.9.3 Maximum number of octets in an information field, (N201)

The maximum number of octets that can be inserted into a frame is set using the system parameter N201.

The default value of N201 is 260 octets.

5.9.4 Maximum number of transmissions of an identity request message, (N202)

Not supported in this specification.

5.9.5 Maximum number of outstanding I-frames, k

The maximum number (k) of sequentially numbered I-frames that may be outstanding (that is, unacknowledged) at any given time is a system parameter that does not exceed 127.

The default value is 7.

5.9.6 TEI identity check timer, T201

Not supported in this specification.

5.9.7 Timer, T202

Not supported in this specification.

5.9.8 Data link verification timer, T203

The data link verification timer, T203, is used to set the maximum period that the data link is allowed to remain active without frames being exchanged.

The default value of timer T203 is 10 seconds.

5.10 Data-link-layer monitor function

5.10.1 General

The procedural elements defined in this chapter allow for the supervision of the data-link-layer resource. This section describes procedures which may be used to provide this supervision function.

5.10.2 Data link layer supervision in the multiple-frame-established state

The following procedures propose a solution which is already identified in the HDLC classes of procedures. Connection verification is a service provided by the data link layer to Layer 3. This implies that Layer 3 is informed in case of a failure only. Furthermore, the procedure may be incorporated in the "normal" exchange of information and may become more efficient than a procedure based on the involvement of Layer 3.

The procedure is based on supervisory command frames (RR command, RNR command) and the data link verification timer (T203). It operates in the multiple-frame-established state as follows.

If there are no frames being exchanged on the data link connection (neither new or outstanding I-frames, or supervisory frames with the P bit set to "1") there is no means to detect a faulty data link connection condition, or to detect if the user equipment has been unplugged. The data link verification timer (T203) represents the maximum time allowed without frames being exchanged.

If timer T203 expires, a supervisory command (with the P bit set to "1") is transmitted.

Such a procedure is protected against transmission errors by making use of the procedures associated with the timer T200 and the maximum number of retransmissions, N200.

5.10.3 Connection verification procedures

5.10.3.1 Start of data link verification timer, T203

The data link verification timer, T203 is started

- when the multiple-frame-established state is entered
- AND, whenever timer T200 is stopped while in the multiple-frame established state (that is, T200 and T203 are never running concurrently)

When an I or supervisory frame is received, timer T203 is restarted if timer T200 is not to be started.

5.10.3.2 Stop of data link verification timer, T203

The data link verification timer, T203, is stopped

- when in the multiple-frame established state, timer T200 is started (see note), *and*
- when leaving the multiple-frame established state.

  Note: These two conditions mean that timer T203 is only started whenever T200 is stopped and not restarted.

5.10.3.3 Expiry of timer T203

If timer T203 expires — and timer T200 is neither running or expired — the data-link-layer entity

- sets the retransmission count variable to zero
- enters the timer recovery state
- transmits a supervisory-type command (with the P bit set to “1”) as follows:
  - — if there is *not* a receiver busy condition (own receiver not busy), it transmits an RR command
  - — if there *is* a receiver busy condition (own receiver busy), it transmits an RNR command
- starts timer T200
- sends an *MDL-Error-Indication* primitive to layer management after N200 retransmissions

Chapter 3-6: Occurrence of *MDL-Error-Indication*

6.1 Introduction

The *MDL-Error-Indication* primitive is used to notify the management entity of the data link layer of error situations. The error situations for which this primitive is generated are shown in Table 3-4.

The associated error parameter contains the error code that describes the unique error conditions. The table also identifies the associated management actions that are taken by the network and should be taken by the user side, for the various types of error reported.

The following paragraphs provide a key to the information contained in Table 3-4.

Error code

The *Error code* column gives the identification value for each error situation that is included as a parameter with the *MDL-Error-Indication* primitive.

Error condition and affected states

The *Error condition* column together with the *Affected states* column describes the unique protocol error events and the state of the data link layer entity at the time that the *MDL-Error-Indication* primitive is generated.

Network management action

For each error condition, the *Network management action* column describes the preferred action taken by the network management entity.

User management action

This column describes the preferred action taken by the user side management entity on a given error condition.

6.2 Preferred management actions

The various preferred management actions on an error situation may be described as one of the following:

- Error Log
  - — This suggests that the network side management entity has the preferred action of logging the event in an error counter. The length and the operation of the counter mechanisms for the error situations are implementation dependent.
- TEI Remove
  - — This suggests that the user side layer management entity may directly remove its TEI value from service.

In most of the described error situations, there is either no action to be taken on the user side layer management or the action to be taken by the user side is implementation dependent. It is therefore a user side option to incorporate any form of error counter to log or store the reported event.

If action is taken, the layer management entity has to take into account that the data link layer has initiated a recovery procedure.

Table 3-4 Management entity actions for MDL-Error-Indications.

Error code	Error condition	Affected states *	Network management action	User management action
Receipt of unsolicited response (error codes A through E)				
A	Supervisory frame (F = 1)	7	Error log	Implementation dependent
B	DM frame (F = 1)	7, 8	Error log	Implementation dependent
C	UA frame (F = 1)	4, 7, 8	Error log	Implementation dependent
D	UA frame (F = 0)	4, 5, 6, 7, 8	Error log	Implementation dependent
E	Receipt of DM response (F =0)	7, 8	Error log	Implementation dependent
Peer initiated re-establishment (error code F)				
F	SABME frame	7, 8	Error log	Implementation dependent
Unsuccessful retransmission (after N200 retries) (error codes G through I)				
G	SABME frame	5	Error log	Implementation dependent
H	DISC frame	6	Error log	Implementation dependent
I	Status enquiry	8	Error log	Implementation dependent
Other errors (error codes J through O)				
J	N(R) error	7, 8	Error log	Implementation dependent
K	Receipt of FRMR response	7, 8	Error log	Implementation dependent
L	Receipt of non-implemented frame	4, 5, 6, 7, 8	Error log	Implementation dependent
M	Receipt of I field not permitted	4, 5, 6, 7, 8	Error log	Implementation dependent
N	Receipt of frame with wrong size	4, 5, 6, 7, 8	Error log	Implementation dependent
O	N201 error	4, 5, 6, 7, 8	Error log	Implementation dependent

Chapter 4-1: Introduction

1.1 Scope

Section 4 defines the call associated and non-call associated signaling protocol for DMS-100 to CPE applications using an Integrated Services Digital Network (ISDN) Primary Rate Interface (PRI). The call associated signaling is based on the general format and procedures found in CCITT Recommendation Q.931 (I.451), ISDN user-network interface Layer 3-specification and ANSI T1.607, Layer 3 signaling specification for circuit switched bearer services. The public non-call associated signaling is based on the format and procedures found in GR-2823-CORE. The PRI interface provides a subset of compatibility with Bellcore's ISDN PRI (as detailed in TR-NWT-001268).

Section 4 specifies the procedures for establishing, maintaining, and clearing network connections at the ISDN user-network interface for support of circuit-switched calls. These procedures are defined in terms of messages exchanged over the D-channel of a PRI. This part also describes the protocol structure on which supplementary services are based. Procedures for the operation of supplementary services are defined in section 5.

Section 4 also contains descriptions of single D-channel maintenance procedures, B-channel maintenance procedures, and system parameters. Annexes A through D, at the rear of section 4, contain layer 3 SDL diagrams, compatibility checking, backup D-channel service procedures, and cause definitions, respectively.

References in the text to "network side" equipment are to be understood as relating to a DMS-100 Central Office (CO).

1.2 Conformance

Products conforming to this specification must support all mandatory procedures and information elements outlined in this section of the specification.

Chapter 4-2: Layer 3 overview of call control

In this chapter, call states are defined for call associated and non-call associated signaling calls in paragraph 2.1 on page 101 and for the interface in paragraph 2.2 on page 104.

In paragraph 2.1 on page 101, the basic call control states that individual calls may have are defined. These definitions do not apply to the state of the interface itself, any attached equipment, the D-channel, or the logical links used for signaling on the D-channel. Because several calls may exist simultaneously at a user-network interface, and each call may be in a different state, the state of the interface itself cannot be unambiguously defined.

Detailed descriptions of the procedures for call control are given in Chapter 4-5: "Layer 3 Call Control Procedures" in terms of:

- The messages which are transferred across the user-network interface (defined in Chapter 4-3: "Layer 3 message functional definitions").
- The information processing and actions that take place at the user side and the network side.

Overview and detailed specification and description language (SDL) diagrams for call control of circuit-switched calls are contained in Annex A "Annex A: Layer 3 SDL diagrams".

In this specification, the terms “incoming” and “outgoing” are used to describe the call as viewed by the user side of the interface.

2.1 Circuit switched calls

This section defines the basic call control states for circuit switched call associated and non-call associated signaling calls. Note that non-call associated signaling (NCAS) introduced in NA011 supports only calls that originate at the user side (i.e. toward the network). NCAS supports only the following states; (0) null, (1) call initiated, (3) outgoing call proceeding, (10) active, and (19) release request.

2.1.1 Call states on the network or user side of the interface

The states which may exist on the network side of the user-network interface are defined in Table 4-1. The user side states are included for completeness.

Table 4-1 Call states

State no.	State name	User side	Network side	Definition
0	Null	U0	N0	No call exists.
1	Call initiated	U1	N1	This state exists for an outgoing call, when the user requests call establishment from the network, but the network has not responded. On the network side, this state exists when the network has received a call establishment request, but has not yet responded.
3	Outgoing call proceeding	U3	N3	This state exists for an outgoing call when the user has received acknowledgement that the network has received all call information necessary to effect call establishment. On the network side, this state exists when the network has sent acknowledgement that it has received all call information necessary to effect call establishment.
4	Call delivered	U4	N4	This state exists for an outgoing call when the calling user has received an indication that the remote user has been alerted. On the network side, this state exists for an outgoing call when the network has indicated that the remote user has been alerted.
6	Call present	U6	N6	This state exists for an incoming call when the user has received a call establishment request but has not yet responded. On the network side, this state exists when the network has sent a call establishment request, but has not yet received a satisfactory response.
7	Call received	U7	N7	This state exists for an incoming call when the user has initiated alerting but has not yet answered. On the network side, this state is entered when the network receives an indication that the user has initiated alerting, but has not yet answered.
8	Connect request	U8	N8	This state exists for an incoming call when the user has answered the call and is waiting to be awarded the call. On the network side, this state exists when the network has received an answer but the network has not awarded the call.

Table 4-1 Call states (Continued)

State no.	State name	User side	Network side	Definition
9	Incoming call proceeding	U9	N9	This state exists for an incoming call when the user has sent acknowledgement that the user has received all call information necessary to effect call establishment. On the network side, this state exists when the network has received acknowledgement that the user has received all call information necessary to effect call establishment.
10	Active	U10	N10	This state exists for an incoming call when the user has received an acknowledgement from the network that the user has been awarded the call. This state exists for an outgoing call when the user has received an indication that the remote user has answered the call. That is, the call is in an end-to-end communication mode.
11	Disconnect request	U11	N11	This state exists when the user has requested the network to clear the end-to-end connection (if any) and is waiting for a response. This state exists on the network from the time that the network has received the call clearing request from the user.
12	Disconnect indication	U12	N12	This state exists when the user has received an invitation to disconnect because the network has disconnected the end-to-end connection (if any). On the network side, this state is entered when the network has disconnected the call, and sent an invitation to disconnect to the user-network connection.
19	Release request	U19	N19	This state exists when the user has requested the network to release the call and is waiting for a response. On the network side, this state exists when the network has requested the user to release and is waiting for a response

NCAS supports only the following states; (0) null, (1) call initiated, (3) outgoing call proceeding, (10) active, and (19) release request.

2.2 States associated with the global call reference

This section defines the states that the protocol may adopt using the global call reference. The procedures for use of the global call reference for restart procedures are contained in paragraph 5.7 on page 200.

There is only one global call reference per interface.

The states which may exist on the network side of the user-network interface are defined in Table 4-2. The user side states are included for completeness.

Table 4-2 Call states associated with global call reference

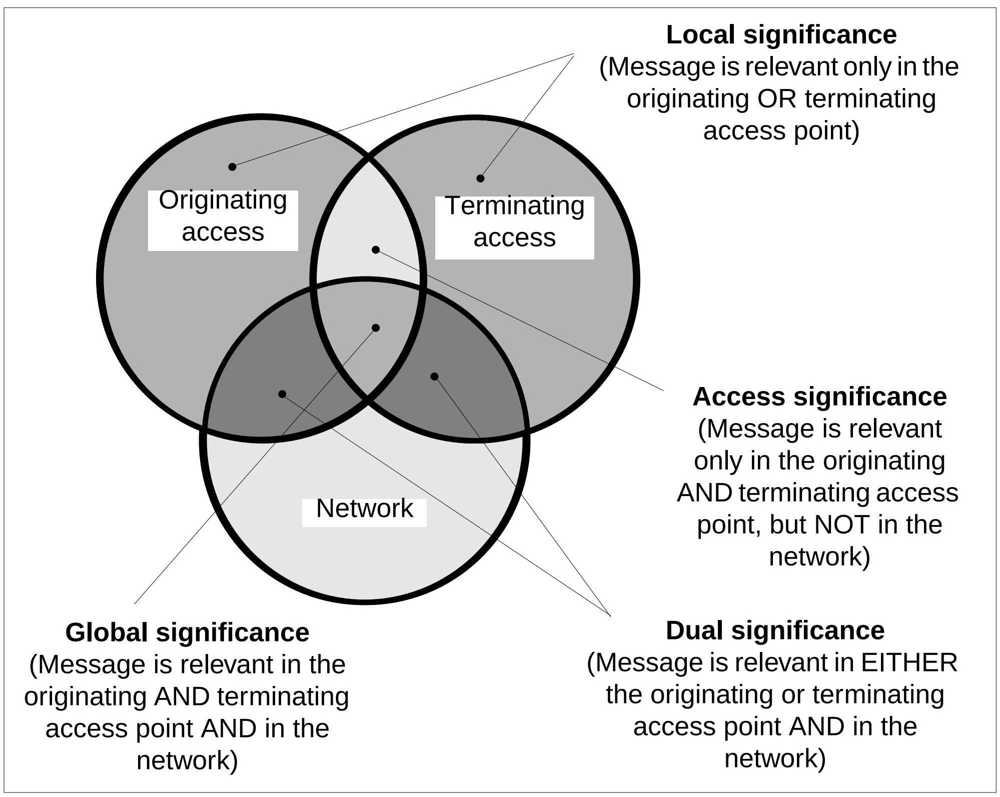
State no.	State name	User side	Network side	Definition
0	Null	Rest 0	Rest 0	No transaction exists.
1	Restart request	Rest 1	Rest 1	On the user side, this state exists for a restart transaction when the user has sent a restart request but has not yet received an acknowledgement response from the network. On the network side, this state exists when the network has sent a restart request, but has not yet received an acknowledgement response from the user.
2	Restart	Rest 2	Rest 2	On the user side, this state exists when a request for a restart has been received from the network and responses have not yet been received from all locally active call references. Similarly, on the network side, this state exists when a request for a restart has been received from the user, but a response has not yet been received from all locally active call references.

Chapter 4-3: Layer 3 message functional definitions

This chapter provides an overview of the Layer 3 message structure, providing the functional definition and information content (that is, the semantics) of each message. Each definition includes:

- A brief description of the message direction and use, including the significance of the message with respect to the originating access point, the terminating access point and the network, as shown in Figure 4-1.

Figure 4-1 Message significance within the network



- A table listing the codeset 0 in the order of their appearance in the message. The relative order of information elements is the same for all message types. For each information element the table indicates
  - — the reference to the section where the information element is described
  - — the direction in which the information element may be sent, that is, user to network (“u->n”), network to user (“n->u”), or “both” directions
  - — whether inclusion is mandatory (“M”) or optional (“O”), with a reference to notes explaining the circumstances under which the information element is included
  - — the length of the information element (or permissible range of lengths), in octets
- Further explanatory notes, as necessary.

3.1 Messages for circuit mode connection control

Table 4-3 summarizes the messages for circuit-mode connection control. Note that non-call associated signaling supports only calls in the user to network direction and supports only Call Proceeding, Connect, Facility, Release, Release Complete, Setup, Status, and Status Enquiry messages.

Table 4-3 Messages for circuit-mode connection control

Call establishment messages	Reference
ALERTING	paragraph 3.1.1 on page 108
CALL PROCEEDING	paragraph 3.1.2 on page 109
CONNECT	paragraph 3.1.3 on page 110
CONNECT ACKNOWLEDGE	paragraph 3.1.4 on page 111
PROGRESS	paragraph 3.1.7 on page 114
SETUP	paragraph 3.1.10 on page 117
Call clearing messages	
DISCONNECT	paragraph 3.1.5 on page 112
RELEASE	paragraph 3.1.8 on page 115
RELEASE COMPLETE	paragraph 3.1.9 on page 116
Miscellaneous messages	
FACILITY	paragraph 3.1.6 on page 113
STATUS	paragraph 3.1.11 on page 119
STATUS ENQUIRY	paragraph 3.1.12 on page 120

3.1.1 ALERTING

This message is sent by the network or the user to indicate that called user alerting has been initiated.

Table 4-4 *ALERTING* **message content**

Message type: *ALERTING* **Significance:** Global **Direction:** Both				
Information element	**Reference**	**Direction**	**Type**	**Length**
Protocol discriminator	paragraph 4.2 on page 130	both	M	1
Call reference	paragraph 4.3 on page 130	both	M	2 - 3
Message type	paragraph 4.4 on page 133	both	M	1
Channel identification	paragraph 4.5.10 on page 156	both	O (see Note 1)	3 - 8
Progress indicator	paragraph 4.5.16 on page 177	both	O (see Note 2)	2 - 4

Note 1: Mandatory if this message is the first message in response to *SETUP.*

Note 2: Included in connection with the provision of in-band information and patterns. The progress descriptor of the progress indicator shall be coded as #8, “Inband information or pattern is now available”.

3.1.2 CALL PROCEEDING

This message is sent by the network to the calling user to indicate that the requested call establishment has been initiated and no more call establishment information can be accepted. This message is sent by the called user to the network to indicate that more time is needed to begin alerting or accept the call.

Table 4-5 *CALL PROCEEDING* **message content**

Message type: *CALL PROCEEDING* **Significance:** Local **Direction:** Both				
Information element	**Reference**	**Direction**	**Type**	**Length**
Protocol discriminator	paragraph 4.2 on page 130	both	M	1
Call reference	paragraph 4.3 on page 130	both	M	2 - 3
Message type	paragraph 4.4 on page 133	both	M	1
Channel identification	paragraph 4.5.10 on page 156	both	M	3 - 8

3.1.3 CONNECT

This message is sent by the network or user to indicate call acceptance by the called user.

Table 4-6 *CONNECT* **message content**

Message type: *CONNECT* **Significance:** Global **Direction:** Both				
Information element	**Reference**	**Direction**	**Type**	**Length**
Protocol discriminator	paragraph 4.2 on page 130	both	M	1
Call reference	paragraph 4.3 on page 130	both	M	2 - 3
Message type	paragraph 4.4 on page 133	both	M	1
Channel identification	paragraph 4.5.10 on page 156	both	O (see Note 1)	3 - 8
Progress Indicator	paragraph 4.5.16 on page 177	both	O (see Note 2)	2 - 4

Note 1: Mandatory if this message is the first message in response to *SETUP.*

Note 2: The Progress Indicator #2 is included if the call is answered by a non-ISDN terminal.

3.1.4 CONNECT ACKNOWLEDGE

This message is sent by the network to the called user to indicate the user has been awarded the call. This message may optionally be sent by the calling user to the network after the calling user receives the connect message.

Table 4-7 *CONNECT ACKNOWLEDGE* **message content**

Message type: *CONNECT ACKNOWLEDGE* **Significance**: Local **Direction:** Both				
Information element	**Reference**	**Direction**	**Type**	**Length**
Protocol discriminator	paragraph 4.2 on page 130	both	M	1
Call reference	paragraph 4.3 on page 130	both	M	2 - 3
Message type	paragraph 4.4 on page 133	both	M	1

3.1.5 DISCONNECT

This message is sent by the network to indicate that the end-to-end connection is cleared. This message is sent by the user to initiate call clearing.

Table 4-8 *DISCONNECT* **message content**

Message type: *DISCONNECT* **Significance**: Global **Direction:** Both				
Information element	**Reference**	**Direction**	**Type**	**Length**
Protocol discriminator	paragraph 4.2 on page 130	both	M	1
Call reference	paragraph 4.3 on page 130	both	M	2 - 3
Message type	paragraph 4.4 on page 133	both	M	1
Cause	paragraph 4.5.8 on page 150	both	M	4 - 10 (see Note 1)
Facility	paragraph 4.5.11 on page 159	both	O	see Note 2

Note 1: The network does not generate more than two octets of diagnostics.

Note 2: The length depends upon the service. The DMS receive maximum is 115 octets and the send maximum is 113 octets.

3.1.6 FACILITY

The *FACILITY* message is used to transfer higher layer protocols (for example, ROSE) using connection-oriented or connectionless signaling (see Note 1).

Table 4-9 *FACILITY* **message content**

Message type: *FACILITY*

Significance: Global

Direction: Both

Information element	Reference	Direction	Type	Length
Protocol discriminator	paragraph 4.2 on page 130	both	M	1
Call reference	paragraph 4.3 on page 130	both	M	2 - 3
Message type	paragraph 4.4 on page 133	both	M	1
Facility	paragraph 4.5.11 on page 159	both	M	(see Note 2)

Note 1: Connectionless signaling is not implemented.

Note 2: The length depends upon the service. The DMS receive maximum is 115 octets and the send maximum is 113 octets.

Note 3: FACILITY is used over a non-call associated signaling connection for Message Service.

3.1.7 PROGRESS

This message is sent by the network to indicate the progress of a call in the event of interworking or in relation with the provision of in-band information or patterns. This message is sent by the user to the network to indicate interworking with a non-ISDN circuit, call routing to an inband tone or announcement, or reporting call progress delay at the destination interface.

Table 4-10 *PROGRESS* **message content**

Message type: *PROGRESS* **Significance**: Global **Direction:** Both				
Information element	**Reference**	**Direction**	**Type**	**Length**
Protocol discriminator	paragraph 4.2 on page 130	both	M	1
Call reference	paragraph 4.3 on page 130	both	M	2 - 3
Message type	paragraph 4.4 on page 133	both	M	1
Cause	paragraph 4.5.8 on page 150	both	O (see Note 1)	2 - 10 (see Note 2)
Progress indicator	paragraph 4.5.16 on page 177	both	M	4

Note 1: Included by the network to provide additional information concerning the provision of in-band information or patterns.

Note 2: The network does not generate more than two octets of diagnostics.

3.1.8 RELEASE

This message is sent by the network or by the user to indicate that the equipment sending the message has disconnected the channel (if any) and intends to release the channel and the call reference, and that the receiving equipment should release the channel and prepare to release the call reference after sending a *RELEASE COMPLETE* message.

Table 4-11 *RELEASE* **message content**

Message type: *RELEASE* **Significance:** Local (see Note 1) **Direction:** Both				
Information element	**Reference**	**Direction**	**Type**	**Length**
Protocol discriminator	paragraph 4.2 on page 130	both	M	1
Call reference	paragraph 4.3 on page 130	both	M	2 - 3
Message type	paragraph 4.4 on page 133	both	M	1
Cause	paragraph 4.5.8 on page 150	both	O (see Note 2)	2 - 10 (see Note 3)

Note 1: This message has local significance. However, it may carry information of global significance when used as the first call clearing message.

Note 2: Mandatory in the first call clearing message, including when the *RELEASE* message is sent as a result of an error handling condition.

Note 3: The network does not generate more than two octets of diagnostics.

3.1.9 RELEASE COMPLETE

This message is sent by the network or the user to indicate that the equipment sending the message has released the channel (if any) and call reference. The channel is available for reuse, and the receiving equipment releases the call reference.

Table 4-12 *RELEASE COMPLETE* **message content**

Message type: *RELEASE COMPLETE*

Significance: Local (see Note 1)

Direction: Both

Information element	**Reference**	**Direction**	**Type**	**Length**
Protocol discriminator	paragraph 4.2 on page 130	both	M	1
Call reference	paragraph 4.3 on page 130	both	M	2 - 3
Message type	paragraph 4.4 on page 133	both	M	1
Cause	paragraph 4.5.8 on page 150	both	O (see Note 2)	2 - 10 (see Note 3)
Facility	paragraph 4.5.11 on page 159	both	O	Note4

Note 1: This message has local significance. However, it may carry information of global significance when used as the first call clearing message.

Note 2: Mandatory in the first call clearing message, including when the *RELEASE COMPLETE* message is sent as a result of an error handling condition.

Note 3: The network does not generate more than two octets of diagnostics.

Note 4: The length depends upon the service. The DMS receive maximum is 115 octets and the send maximum is 113 octets.

3.1.10 SETUP

This message is sent by the network or the user to initiate call establishment.

Table 4-13 *SETUP* **message content**

Message type: *SETUP*

Significance: Global

Direction: Both

Information element	**Reference**	**Direction**	**Type**	**Length**
Protocol discriminator	paragraph 4.2 on page 130	both	M	1
Call reference	paragraph 4.3 on page 130	both	M	2 - 3
Message type	paragraph 4.4 on page 133	both	M	1
Bearer capability	paragraph 4.5.4 on page 139	both	M	4 - 8
Channel identification	paragraph 4.5.10 on page 156	both	M	3 - 8
Facility	paragraph 4.5.11 on page 159	both	O (see Note 1)	(see Note 2)
Progress indicator	paragraph 4.5.16 on page 177	both	O (see Note 3)	2 - 4
Network Specific Facilities	paragraph 4.5.11 on page 159	both	O (see Note 4	4 - 7
Calling party number	paragraph 4.5.7 on page 148	both	O (see Note 5)	2 - 17
Called party number	paragraph 4.5.6 on page 146	both	O (see Note 10)	2 - 27
Redirecting number	paragraph 4.5.17 on page 179	both	O (see Note 6)	3 - 18
Transit network selection	paragraph 4.5.19 on page 182	u->n	O (see Note 7)	2 - 7
Locking shift	paragraph 4.5.12 on page 171	u->n	O (see Note 8)	1
Operator system access	paragraph 4.5.15 on page 176	u->n	O (see Note 9)	3

Note 1: Used for conveying application information between the SPCS and CPE for calling name, two B-channel transfer, and IP-SCP.

Note 2: The length depends upon the service. The DMS receive maximum is 115 octets and the send maximum is 113 octets.

Note 3: Included in the event of interworking or in connection with the provision of in-band information or patterns.

Note 4: Included when network specific facilities are associated with the call.

Note 5: Included when the calling party number is provided as part of origination or termination.

Note 6: Included when the redirecting number is provided as part of origination or termination. Two redirecting number information elements may be provided.

Note 7: Included by the calling user to select a particular transit network.

Note 8: Included if the operator system access information element is included.

Note 9: Included if the calling user wishes to access an operator system; applies only for speech and 3.1 kHz audio.

Note 10: Called number is optional for some services, i.e. when operator system access is included in the u->n direction .

3.1.11 STATUS

This message is sent by the network or by the user in response to a *STATUS ENQUIRY* message or at any time during a call to report error conditions as described in paragraph 5.9 on page 210.

Table 4-14 *STATUS* **message content**

Message type: *STATUS*

Significance: Local

Direction: Both

Information element	Reference	Direction	Type	Length
Protocol discriminator	paragraph 4.2 on page 130	both	M	1
Call reference	paragraph 4.3 on page 130	both	M	2 - 3
Message type	paragraph 4.4 on page 133	both	M	1
Cause	paragraph 4.5.8 on page 150	both	M	4 - 10 (see Note 1)
Call state	paragraph 4.5.5 on page 144	both	M	3

Note 1: The network does not generate more than two octets of diagnostics.

3.1.12 STATUS ENQUIRY

This message is sent by the network or the user at any time during a call to solicit a *STATUS* message from the peer Layer 3 entity. Sending a *STATUS* message in response to a *STATUS ENQUIRY* message is mandatory.

Table 4-15 *STATUS ENQUIRY* **message content**

Message type: *STATUS ENQUIRY*

Significance: Local

Direction: Both

Information element	Reference	Direction	Type	Length
Protocol discriminator	paragraph 4.2 on page 130	both	M	1
Call reference	paragraph 4.3 on page 130	both	M	2 - 3
Message type	paragraph 4.4 on page 133	both	M	1

3.2 Global call reference messages

Table 4-16 summarizes the messages which may use the global call reference as defined in paragraph 4.3 on page 130 in Chapter 4-4:

Table 4-16 Messages used with the global call reference

Message	Reference
RESTART	paragraph 3.2.1 on page 122
RESTART ACKNOWLEDGE	paragraph 3.2.2 on page 123
SERVICE	paragraph 3.2.3 on page 124
SERVICE ACKNOWLEDGE	paragraph 3.2.4 on page 125
STATUS	paragraph 3.2.5 on page 126

3.2.1 RESTART

This message is sent by the network or the user to request the recipient to restart (that is, return to an idle condition) the indicated channel or interfaces.

Table 4-17 *RESTART* **message content**

Message type: *RESTART* **Significance:** Local **Direction:** Both				
Information element	**Reference**	**Direction**	**Type**	**Length**
Protocol discriminator	paragraph 4.2 on page 130	both	M (see Note 1)	1
Call reference	paragraph 4.3 on page 130	both	M (see Note 2)	2 - 3
Message type	RESTART paragraph 4.4 on page 133	both	M	1
Channel identification	paragraph 4.5.10 on page 156	both	O (see Note 3)	3 - 8
Restart indicator	paragraph 4.5.18 on page 181	both	M	3

Note 1: This message is sent with the protocol discriminator for Q.931 user-to-network call control messages (see paragraph 4.2 on page 130).

Note 2: This message is sent with the global call reference as defined in paragraph 4.3 on page 130.

Note 3: Included when necessary to indicate the particular channel to be restarted.

3.2.2 RESTART ACKNOWLEDGE

This message is sent by the network or by the user to acknowledge the receipt of the *RESTART* message and to indicate that the requested restart is complete.

Table 4-18 *RESTART ACKNOWLEDGE* **message content**

Message type: *RESTART ACKNOWLEDGE*

Significance: Local

Direction: Both

Information element	Reference	Direction	Type	Length
Protocol discriminator	paragraph 4.2 on page 130	both	M (see Note 1)	1
Call reference	paragraph 4.3 on page 130	both	M (see Note 2)	2 - 3
Message type	RESTART ACKNOWLEDGE paragraph 4.4 on page 133	both	M	1
Channel identification	paragraph 4.5.10 on page 156	both	O (see Note 3)	3 - 8
Restart indicator	paragraph 4.5.18 on page 181	both	M	3

Note 1: This message is sent with the protocol discriminator for Q.931 user-to-network call control messages (see paragraph 4.2 on page 130).

Note 2: This message is sent with the global call reference as defined in paragraph 4.3 on page 130.

Note 3: Included when necessary to indicate the particular channel which has been restarted.

3.2.3 SERVICE

This message is sent by the network or the user to change the current status of a channel to one of the following states: In Service or Out of Service.

Table 4-19 *SERVICE* **message content**

Message type: *SERVICE*

Significance: Local

Direction: Both

Information element	Reference	Direction	Type	Length
Protocol discriminator	paragraph 4.2 on page 130	both	M (see Note 1)	1
Call reference	paragraph 4.3 on page 130	both	M (see Note 2)	2 - 3
Message type	SERVICE paragraph 4.4 on page 133	both	M	1
Change status	paragraph 4.5.9 on page 155	both	M	3
Channel identification	paragraph 4.5.10 on page 156	both	M	3 - 8

Note 1: This message is sent with the protocol discriminator for maintenance messages as defined in paragraph 4.2 on page 130.

Note 2: This message is sent with the global call reference as defined in paragraph 4.3 on page 130.

3.2.4 SERVICE ACKNOWLEDGE

This message is sent by the network or the user to acknowledge the change of state indicated in the *SERVICE* message.

Table 4-20 *SERVICE ACKNOWLEDGE* **message content**

Message type: *SERVICE ACKNOWLEDGE*

Significance: Local

Direction: Both

Information element	Reference	Direction	Type	Length
Protocol discriminator	paragraph 4.2 on page 130	both	M (see Note 1)	1
Call reference	paragraph 4.3 on page 130	both	M (see Note 2)	2 - 3
Message type	SERVICE ACKNOWLEDGE paragraph 4.4 on page 133	both	M	1
Change status	paragraph 4.5.9 on page 155	both	M	3
Channel identification	paragraph 4.5.10 on page 156	both	M	3 - 8

Note 1: This message is sent with the protocol discriminator for maintenance messages as defined in paragraph 4.2 on page 130.

Note 2: This message is sent with the global call reference as defined in paragraph 4.3 on page 130.

3.2.5 STATUS

This message may be sent by the network or the user at any time when an unexpected or unrecognized message with a global call reference is received.

Table 4-21 *STATUS* **message content**

Message type: *STATUS* **Significance:** Local **Direction:** Both				
Information element	**Reference**	**Direction**	**Type**	**Length**
Protocol discriminator	paragraph 4.2 on page 130	both	M	1
Call reference	paragraph 4.3 on page 130	both	M (see Note 1)	2 - 3
Message type	STATUS paragraph 4.4 on page 133	both	M	1
Cause	paragraph 4.5.8 on page 150	both	M	4 - 10 (see Note 2)
Call state	paragraph 4.5.5 on page 144	both	M	3

Note 1: This message is sent with the global call reference as defined in paragraph 4.3 on page 130.

Note 2: The network does not generate more than one octet of diagnostics.

3.3 Null call reference messages

The null call reference can be used by the NOTIFY message.

3.3.1 NOTIFY

This message is sent by the network to notify the CPE of an event that is independent of any call that is currently on the PRI interface.

Table 4-22 *NOTIFY* **message content**

Message type: *NOTIFY* **Significance:** Local **Direction:** Network to User				
Information element	**Reference**	**Direction**	**Type**	**Length**
Protocol discriminator	paragraph 4.2 on page 130	n -> u	M	1
Call reference	Null paragraph 4.3 on page 130	n -> u	M (see Note 1)	1
Message type	NOTIFY paragraph 4.4 on page 133	n -> u	M	1
Notification Indicator	paragraph 4.5.14 on page 174	n -> u	M	Note 2

Note 1: This message is sent with the null call reference

Note 2: The length is specified in the supplementary service.

Chapter 4-4: Layer 3 Message Formats

4.1 Overview

Within this protocol, every message consists of the following parts:

- protocol discriminator
- call reference
- message type
- other information elements, as required

The first three parts are common to all messages and are always present, while the last part is specific to each message type. This organization is illustrated in Figure 4-2.

Figure 4-2 General message organization

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
Protocol discriminator								1
0	0	0	0	Length of call reference value				2
Call reference value								3
0	Message type							etc.
Other information elements as required								

A particular message may contain more information than particular (user or network) equipment needs or can understand. All equipment should be able to ignore any extra information present in a message which is not required for the proper operation of that equipment. For example, a user may ignore the calling party number if that number is of no interest to the user when a *SETUP* message is received.

Unless specified otherwise, a particular information element is present only once in a given message.

The term "default" implies that the value defined should be used in the absence of any assignment, or the negotiation of alternative values.

The messages are sent as an ordered set of octets. In the following figures, the message contents are shown with a consistent bit and octet numbering pattern. Within each octet, bit "1" is transmitted first, followed by bits "2" through "8". Similarly, the octet shown at the top of each figure is sent first.

When a field extends over more than one octet, the order of bit values progressively decreases as the octet number increases. The least significant bit of the field is represented by the lowest numbered bit of the highest numbered octet of that field.

4.2 Protocol discriminator

The *Protocol discriminator* information element is used to distinguish the user-to-network call control messages from other messages. In this specification, only two values are allowed; one for maintenance messages and one for call control messages, as shown in Figure 4-3.

The *Protocol discriminator* information element is the first part of every message.

Figure 4-3 Q.931 protocol discriminator coding

8	7	6	5	4	3	2	1	
0	1	0	0	0	0	1	1	Maintenance messages
0	0	0	0	1	0	0	0	Q.931 (I.451) user-to-network call control message

All other values are reserved.

4.3 Call reference

The *Call reference* information element is used to identify the call request at the local user-network interface to which the particular message applies. The *Call reference* information element does not have end-to-end significance.

The *Call reference* information element is the second part of every message, and is shown in Figure 4-4. The length of the *Call reference* information element is indicated in octet 1, bits 1 through 4. The default maximum length of the *Call reference* information element value field is two octets. The *Call* *reference* information element includes the length of the call reference value, the call reference value and the call reference flag.

Figure 4-4 Call reference information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
0	0	0	0	Length of call reference value				1
Flag	Call reference value							2 ... 3

The actions taken by the receiver are based on the Call reference value and are independent of the length of the *Call reference* information element.

The Call reference value may be one or two octets long. A call reference with a numerical value up to 127 may be encoded using one or two octets. The network always uses two octets for the Call reference value.

Call reference values are assigned by the originating side of the interface for a call. These values are unique to the originating side only within a particular D-channel Layer 2 logical link connection. The call reference value is assigned at the beginning of a call and remains fixed for the duration of the call.

When a call ends, the associated call reference value may be reassigned to a later call. Two identical call reference values on the same D-channel Layer 2 logical link connection may be used when each value is associated with a call originated at opposite ends of the link.

The call reference flag is used to identify which end of the Layer 2 logical link originated a call reference. The call reference flag (bit 8 of octet 2) is set to one of the following:

- “0”, indicating that the message is sent from the side that originated the call reference.
- “1”, indicating that the message is sent to the side that originated the call reference.

The call reference flag is used to resolve simultaneous attempts to allocate the same call reference value. The call reference flag also applies to functions which use the global call reference (for example, restart procedures).

The numerical value of the global call reference is zero (see Figure 4-5 and Figure 4-6). The equipment receiving a message containing the global call reference should interpret the message as pertaining to all call references on the associated Layer 2 data link connection identifier. The messages which can use the global call reference value are defined in paragraph 3.2 on page 121.

Figure 4-5 Global call reference (1 octet value)

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
				Length of call reference value				
0	0	0	0	0	0	0	1	1
Flag (0/1)	0	0	0	0	0	0	0	2

Figure 4-6 Global call reference (2 octet value)

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
				Length of call reference value				
0	0	0	0	0	0	1	0	1
Flag (0/1)	0	0	0	0	0	0	0	2
0	0	0	0	0	0	0	0	3

4.4 Message type

The purpose of the *Message type* information element is to identify the function of the message being sent. The *Message type* information element is the third part of every message. The coding of the information element is shown in Figure 4-7.

Figure 4-7 Message type information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
0	Message type							1

8	7	6	5	4	3	2	1	
0	0	0	-	-	-	-	-	**Call establishment messages**
			0	0	0	0	1	Alerting
			0	0	0	1	0	Call Proceeding
			0	0	1	1	1	Connect
			0	1	1	1	1	Connect Acknowledge
			0	0	0	1	1	Progress
			0	0	1	0	1	Setup
0	1	0	-	-	-	-	-	**Call clearing messages**
			0	0	1	0	1	Disconnect
			0	1	1	0	1	Release
			1	1	0	1	0	Release Complete
			0	0	1	1	0	Restart
			0	1	1	1	0	Restart Acknowledge
0	1	1	-	-	-	-	-	**Miscellaneous messages**
			1	1	1	0	1	Status
			1	0	1	0	1	Status Enquiry
			0	0	0	1	0	Facility
			0	1	1	1	0	Notify
0	0	0	-	-	-	-	-	**Maintenance messages (protocol discriminator is 0100 0011)**
			0	1	1	1	1	Service
			0	0	1	1	1	Service acknowledge

4.5 Other information elements

4.5.1 Coding rules

The coding of other information elements follows the coding rules described below. These rules are formulated to allow each piece of equipment which processes a message to find information elements important to it, and to ignore information elements not important to that equipment.

Two categories of information elements are defined:

- single octet information elements (see Figure 4-8)
- variable length information elements (see Figure 4-9)

Figure 4-8 Single octet nformation element format

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
1	Information element identifier			Contents of information element				1

Figure 4-9 Variable length information element format

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
0	Information element identifier							1
Length of contents of information element, octets 3 through n								2
Contents of information element								3 ... n

The descriptions of the following information elements are organized in alphabetical order. However, there is a particular order of appearance for each information element in a message within each codeset (see paragraph 4.5.2 on page 136).

The code values of the information element identifier for the variable length formats are assigned in ascending numerical order, according to the actual order of appearance of each information element in a message. This allows the receiving equipment to detect the presence or absence of a particular information element without scanning through an entire message. Single octet information elements may appear at any point in the message.

Where the description of information elements in this specification contains spare bits, these bits are indicated as being set to “0”. In order to allow compatibility with future implementations, messages are not rejected because a spare bit is set to “1”.

The second octet of a variable length information element indicates the total length of the contents of that information element regardless of the coding of the first octet (that is, the length starting with octet 3). The second octet is a binary coding of the number of octets of the contents, with bit 1 as the least significant bit.

A variable length information element may be present, but empty. For example, a *SETUP* message may contain a *Called party number* information element, which has a content of zero length. This should be interpreted by the receiver as equivalent to that information element being absent. Similarly, an absent information element should be interpreted by the receiver as equivalent to that information element being empty.

The following rules apply for the coding of variable length information elements from octet 3 and above:

- The first digit in the octet number identifies one octet or a group of octets.
- Each octet group is a self-contained entity. The internal structure of an octet group may be defined in alternative ways.
- An octet group is formed by using an extension mechanism. The preferred extension mechanism is to extend an octet (N) through the next octet(s) (Na, Nb, ...) by using bit 8 in each octet as an extension bit. The bit value “0” indicates that the octet group continues through the next octet. The bit value “1” indicates that this octet is the last octet. If an octet (Nb) is present, then the preceding octets (N and Na) must be present.

  In the format descriptions (appearing in the later sections of this chapter), bit 8 is marked “0/1 Ext” if another octet may follow. Bit 8 is marked “1 Ext” if this is the last octet in the extension domain.
- In addition to the extension mechanism defined above, an octet (N) may be extended through the next octet(s) (N.1, N.2 ...) by indications in bits 7 through 1 (of octet N).
- The two extension mechanisms described above may be combined.
- Optional octets are marked with asterisks (*).

Figure 4-10 Codeset 0 information element identifiers

8	7	6	5	4	3	2	1		
1	:	:	:	:	:	:	:	**Single octet information element**	**Paragraph**
	0	0	1	0	1	0	1	Locking Shift (codeset 5)	**4.5.3**
0	:	:	:	:	:	:	:	**Variable length information element**	**Paragraph**
	0	0	0	0	0	0	1	Change status	4.5.9
	0	0	0	0	1	0	0	Bearer capability	4.5.4
	0	0	0	1	0	0	0	Cause (note 1)	4.5.8
	0	0	1	0	1	0	0	Call state	4.5.5
	0	0	1	1	0	0	0	Channel identification	4.5.10
	0	0	1	1	1	0	0	Facility	4.5.11
	0	0	1	1	1	1	0	Progress indicator	4.5.16
	0	1	0	0	0	0	0	Network-Specific Facilities	4.5.13
	0	1	0	0	1	1	1	Notification indicator	4.5.14
	1	1	0	1	1	0	0	Calling party number	4.5.7
	1	1	1	0	0	0	0	Called party number	4.5.6
	1	1	1	0	1	0	0	Redirecting number (note 1)	4.5.17
	1	1	1	1	0	0	0	Transit network selection	4.5.19
	1	1	1	1	0	0	1	Restart indicator	4.5.18
All other values are reserved.									(Note 2)

Note 1: This information element may be repeated once.

Note 2: The reserved values with bits 5 to 8 coded "0000" are for future information elements for which comprehension by the receiver is required (see paragraph 5.9.7.1 on page 215).

Figure 4-11 Codeset 5 information element identifiers

8	7	6	5	4	3	2	1		Paragraph
0	0	0	1	1	1	0	1	Operator system access	4.5.15

4.5.2 Extension of codesets

There are a number of possible information element identifier values using the formatting rules described in the previous section. There are a possible 128 values for the variable length information element format and at least 8 values for the single octet information element format.

It is possible to expand this structure to eight codesets with at least 133 information element identifier values each. One common value in the single octet format is employed in each codeset to allow shifting from one codeset to another. The content of this *Shift* information element identifies the codeset to be used for the next information element or elements. The codeset in use at any given time is referred to as the “active codeset”. By convention, codeset 0 is the initially active codeset. This interface specification only supports information elements with a codeset of 0 or a codeset of 5.

Two codeset shifting procedures are defined: locking and non-locking shift. Only the locking shift procedure is supported (see 4.5.3).The coding rules specified in paragraph 4.5.1 on page 134 apply to information elements belonging to any active codeset.

Transitions from one active codeset to another (that is, by means of the locking shift procedure) may only be made to a codeset with a higher numerical value than the codeset being left.

User or network equipment should have the capability to recognize a *Shift* information element and determine the length of the following information element. The equipment need not be able to interpret and act upon the contents of the information element. This enables the equipment to determine the start of a subsequent information element.

Codeset 5 is reserved for information elements specific to the national network. These information elements do not necessarily have significance across a national or international boundary. Therefore, codeset 5 information elements are treated as if they were unrecognized information elements beyond the national network boundary. (See the procedures in paragraph 5.9.7.1 on page 215.)

4.5.3 Locking shift procedure

The locking shift procedure employs a locking *Shift* information element to indicate the new active codeset. The specified codeset remains active until another locking *Shift* information element is encountered which specifies the use of another codeset.

For example, codeset 0 is active at the start of message content analysis. If a locking *Shift* information element to codeset 5 is encountered, the next information elements are interpreted according to the information element identifiers assigned in codeset 5. Codeset 5 remains active until another *Shift* information element is encountered.

The locking shift is valid only within the message which contains the locking *Shift* information element. At the start of every message content analysis, the active codeset is codeset 0. The locking *Shift* information element uses the single octet information element format, as shown in Figure 4-10.

4.5.4 Bearer capability

The purpose of the *Bearer capability* information element is to indicate a CCITT Recommendation I.231 bearer service to be provided by the network. The use of the *Bearer capability* information element in relation to compatibility checking is described in Annex B.

No default bearer capability is assumed by the absence of this information element.

The maximum length of this information element is 8 octets.

Figure 4-12 Bearer capability information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
0	Bearer capability information element identifier 0	0	0	0	1	0	0	1
Length of information element								2
Ext. 1	Coding standard		Information transfer capability					3
Ext. 1	Transfer mode		Information transfer rate					4
Ext. 1	Transfer rate multiplier							4.1 (Note 1)
Ext. 0 / 1	Layer 1 identifier 0	1	User information layer 1 protocol					5 (Note 2)
Ext 1	0	0	Rate					5.a (Note 3)

Note 1: Octet 4.1 is required if octet 4 indicates multirate 11000

Note 2: Octet 5 may be present for speech, 3.1-kHz audio, and circuit mode 64-kbps unrestricted digital information adapted from 56-kbps. Otherwise octet 5 is not present. For example, NCAS omits octet 5.

Note 3: This octet is present if octet 5 indicates CCITT standardized rate adaption V.110 / X.30.

Coding standard (octet 3)

7 6	
0 0	CCITT standard as in Recommendation Q.931
0 1	Other International Standard (for NCAS only)

Information transfer capability (octet 3)

5 4 3 2 1	
0 0 0 0 0	Speech
0 1 0 0 0	Unrestricted digital information
0 1 0 0 1	Restricted Digital Information (see Note1)
1 0 0 0 0	3.1 kHz audio (see Note 2)

All other values are reserved.

Note 1: Restricted digital information is not supported by National ISDN.

Note 2: 3.1 kHz audio receives identical treatment to speech.

Note 3: NCAS uses 01000 Unrestricted digital information

Transfer mode (octet 4)

7 6	
0 0	Circuit mode

All other values are reserved.

Information transfer rate (octet 4)

5 4 3 2 1	
0 0 0 0 0	Call independent signaling connection (NCAS)
1 0 0 0 0	64 kbit/s
1 0 0 1 1	H0, 384 kbps
1 0 1 0 1	H11, 1536 kbps
1 1 0 0 0	multirate (n x 64 kbps) where n is defined in octet 4.1

All other values are reserved.

Transfer rate multiplier (octet 4.1)

7 6 5 4 3 2 1	
0 0 0 0 0 1 0	2 x 64 kbps
0 0 0 0 0 1 1	3 x 64 kbps
0 0 0 0 1 0 0	4 x 64 kbps
0 0 0 0 1 0 1	5 x 64 kbps
0 0 0 0 1 1 0	6 x 64 kbps

7	6	5	4	3	2	1	
0	0	0	0	1	1	1	7 x 64 kbps
0	0	0	1	0	0	0	8 x 64 kbps
0	0	0	1	0	0	1	9 x 64 kbps
0	0	0	1	0	1	0	10 x 64 kbps
0	0	0	1	0	1	1	11 x 64 kbps
0	0	0	1	1	0	0	12 x 64 kbps
0	0	0	1	1	0	1	13 x 64 kbps
0	0	0	1	1	1	0	14 x 64 kbps
0	0	0	1	1	1	1	15 x 64 kbps
0	0	1	0	0	0	0	16 x 64 kbps
0	0	1	0	0	0	1	17 x 64 kbps
0	0	1	0	0	1	0	18 x 64 kbps
0	0	1	0	0	1	1	19 x 64 kbps
0	0	1	0	1	0	0	20 x 64 kbps
0	0	1	0	1	0	1	21 x 64 kbps
0	0	1	0	1	1	0	22 x 64 kbps
0	0	1	0	1	1	1	23 x 64 kbps
0	0	1	1	0	0	0	24 x 64 kbps

All other values are reserved.

User Information Layer 1 Protocol (octet 5)

5	4	3	2	1	
0	0	0	0	1	CCITT standardized rate adaption V.110/X.30 and implies the presence of octet 5a.
0	0	0	1	0	Recommendation G.711 Mu-law Speech

All other values are reserved.

User Rate (octet 5a)

5	4	3	2	1	**Synchronous Rate**
0	1	1	1	1	56 kbit/s

All other values are reserved.

4.5.4.1 Examples of bearer capability encoding

The encoding of this information element for the bearer services supported by DMS-100 are:

Attribute	Encoding	Octet
(1) Speech		
Transfer capability = speech	1 00 00000	3
Transfer mode and rate = circuit-mode, 64 kbit/s	1 00 10000	4
Layer 1 protocol identifier = Mu law	1 01 00010	5
Octet 5.a is not present		
(2) 64 kbit/s unrestricted digital, rate adapted from 56 kbps, circuit-mode		
Transfer capability = unrestricted digital	1 00 01000	3
Transfer mode and rate = circuit-mode, 64 kbit/s	1 00 10000	4
Layer 1 protocol identifier = Rate adaption	00100001	5
Data rate = 56 kbps	10001111	5a
(3) 64 kbit/s clear, unrestricted digital, circuit-mode		
Transfer capability = unrestricted digital	1 00 01000	3
Transfer mode and rate = circuit-mode, 64 kbit/s	1 00 10000	4
Octets 5 and 5.a are not present		
(4) 64 kbit/s restricted digital, circuit-mode (Supported by the NTNI interface but not supported by National ISDN)		
Transfer capability = restricted digital	1 00 01001	3
Transfer mode and rate = circuit-mode, 64 kbit/s	1 00 10000	4
Octets 5 and 5.a are not present		

Attribute	Encoding	Octet
(5) 3.1 kHz audio		
Transfer capability = 3.1 kHz audio	1 00 10000	3
Transfer mode and rate = circuit-mode, 64 kbit/s	1 00 10000	4
Layer 1 protocol ID = Mu-law	1 01 00010	5
Octet 5.a is not present		
(6) Dialable Wideband Service (128 kbps example)		
Transfer capability = unrestricted digital	1 00 01000	3
Transfer mode and rate = circuit mode, multirate	1 00 11000	4
Transfer rate multiplier = 2 x 64 kbps	1 00 00010	4.1
Octet 5 and 5.a are not present		
(7) Non-Call Associated Signaling (NCAS)		
Coding Standard and Transfer capability	10101000	3
Transfer mode and rate = circuit mode, NCAS	10000000	4
Octets 4.1, 5, and 5.a are not present		

4.5.5 Call state

The purpose of the *Call state* information element is to describe the current status of a call or a global interface state (see paragraph 2.2 on page 104).

The maximum length of this information element is 3 octets.

Figure 4-13 Call state information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
	Call state information element identifier							1
0	0	0	1	0	1	0	0	
Length of information element								2
0	0	0	0	0	0	0	1	
Coding standard		Call state or global call state value (state value is coded in binary)						3

Coding standard (octet 3)

8 7	
0 0	CCITT standard as in Recommendation Q.931

All other values are reserved.

Call state value (octet 3)

6 5	4 3 2 1	State no.	User state	Network state
0 0	0 0 0 0	0	Null	Null
0 0	0 0 0 1	1	Call initiated	Call initiated
0 0	0 0 1 1	3	Outgoing call proceeding	Outgoing call proceeding
0 0	0 1 0 0	4	Call delivered	Call delivered
0 0	0 1 1 0	6	Call present	Call present
0 0	0 1 1 1	7	Call received	Call received
0 0	1 0 0 0	8	Connect request	Connect request
0 0	1 0 0 1	9	Incoming call proceeding	Incoming call proceeding
0 0	1 0 1 0	10	Active	Active
0 0	1 0 1 1	11	Disconnect request	Disconnect request
0 0	1 1 0 0	12	Disconnect indication	Disconnect indication

6 5	4 3 2 1	State no.	User state	Network state
0 1	0 0 1 1	19	Release request	Release request

Global interface state value (octet 3)

6 5	4 3 2 1	State no.	User state	Network states
0 0	0 0 0 0	0	REST 0 - Null	REST 0 - Null
1 1	1 1 0 1	1	REST 1 - Restart request	REST 1 - Restart request
1 1	1 1 1 0	2	REST 2 - Restart	REST 2 - Restart

All other values are reserved.

4.5.6 Called party number

The purpose of the *Called party number* information element is to identify the called party of a call.

The maximum length of this information element is 27 octets.

Figure 4-14 Called party number information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
0	Called party number information element identifier							1
	1	1	1	0	0	0	0	
Length of information element								2
1 Ext.	Type of number			Numbering plan identification				3
0 Spare	Number digits (IA5 characters, see Note)							4 ...n

Note: The number digits appear starting at octet 4 in the same order in which they would be entered, that is, the number digit which would be entered first is located in octet 4. In addition, the number digits shall not include any national or international prefix dialed by the calling party.

Type of number (octet 3)

7 6 5	Type of number
0 0 0	Unknown
0 0 1	International number
0 1 0	National number
1 0 0	Local number

All other values are reserved.

Numbering Plan Identification (octet 3)

4 3 2 1	Numbering plan
0 0 0 0	Unknown
0 0 0 1	ISDN/Telephony numbering plan (E.164/E.163)
1 0 0 1	Private Numbering Plan (see the note below)

Note: DMS will receive 1001 only with Type Of Number coded to Local for Call-By-Call service TIE calls.

All other values are reserved.

Number digit coding (octet 4...n)

Numbers are coded as International Alphabet Number 5 (IA5) characters. No digits are included for NCAS in the called party number information element.

Figure 4-15 International Alphabet Number 5 (IA5) digits 0-9

7 6 5	4 3 2 1	Address digit value
0 1 1	0 0 0 0	0
0 1 1	0 0 0 1	1
0 1 1	0 0 1 0	2
0 1 1	0 0 1 1	3
0 1 1	0 1 0 0	4
0 1 1	0 1 0 1	5
0 1 1	0 1 1 0	6
0 1 1	0 1 1 1	7
0 1 1	1 0 0 0	8
0 1 1	1 0 0 1	9

All other values are reserved.

4.5.6.1 Valid combinations of TON and NPI for call routing

The following combination of type of number (TON) and numbering plan identification (NPI) are supported for call routing:

- International number in ISDN/Telephony numbering plan (E.164/E.163)
- National number in ISDN/Telephony numbering plan (E.164/E.163)
- Local number in ISDN/Telephony numbering plan (E.164/E.163)
- Unknown/Unknown

4.5.7 Calling party number

The purpose of the *Calling party number* information element is to identify the origin of a call.

The maximum length of the information element is 16 octets.

Figure 4-16 Calling party number information element

<table>
<tr><th>Bit 8</th><th>Bit 7</th><th>Bit 6</th><th>Bit 5</th><th>Bit 4</th><th>Bit 3</th><th>Bit 2</th><th>Bit 1</th><th>Octet</th></tr>
<tr><td rowspan="2">0</td><td colspan="7">Calling party number information element identifier</td><td rowspan="2">1</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>1</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td colspan="8">Length of information element</td><td>2</td></tr>
<tr><td>Ext.
0/1</td><td colspan="3">Type of number</td><td colspan="4">Numbering plan identification</td><td>3</td></tr>
<tr><td rowspan="2">Ext.
1</td><td colspan="2" rowspan="2">Presentation indicator</td><td colspan="3">Spare</td><td colspan="2" rowspan="2">Screening indicator</td><td rowspan="2">3a*</td></tr>
<tr><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Spare
0</td><td colspan="7">Number digits (IA5 characters)</td><td>4 … n</td></tr>
</table>

Note: The contents of this information element, other than octet 3a, are coded as shown for the *Called party number* information element in paragraph 4.5.6 on page 146.

Presentation indicator (octet 3a)

7 6	
0 0	Presentation allowed
0 1	Presentation restricted
1 0	Number not available
1 1	Reserved

Note: If octet 3a is omitted:

— "Presentation allowed" is the default in the network -> user direction.

— Subscription default is assumed in the user -> network direction.

Screening indicator (octet 3a)

2	1	
0	0	User provided, not screened
0	1	User provided, verified and passed (see Note 1)
1	0	User provided, verified and failed (see Note 1)
1	1	Network provided

Note 1: This encoding is treated by the network as “user provided, not screened”.

Note 2: If octet 3a is omitted, “user provided, not screened” is the default.

Note 3: Calling number screening is available as a subscription option.

4.5.8 Cause

The purpose of the *Cause* information element is to describe the reason for generating certain messages, to provide diagnostic information in the event of procedural errors and to indicate the location of the cause originator.

The maximum length of this information element is 10 octets. The network generates no more than 6 octets.

The *Cause* information element may be repeated once in a message but only the first cause value is transferred to the remote user through the network. Diagnostic information is not available for every cause.

Figure 4-17 Cause information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
0	Cause information element identifier 0	0	0	1	0	0	0	1
Length of information element								2
Ext. 1	Coding standard		Spare 0	Location				3
Ext. 1	Cause value Class			Value				4
Diagnostics (if any)								5*

Coding standard (octet 3)

7 6	
0 0	CCITT standardized coding

All other values are reserved.

Location (octet 3)

4 3 2 1	
0 0 0 0	User
0 0 0 1	Private network serving the local user
0 0 1 0	Public network serving the local user
0 0 1 1	Transit network
0 1 0 0	Public network serving the remote user
0 1 0 1	Private network serving the remote user
0 1 1 1	International network
1 0 1 0	Network beyond the interworking point

All other values are reserved.

Note: The General Location passed by the DMS-100 to the CPE (network to user direction) reflects the location of the source of the information element. In the opposite direction (user to network), the CPE should use a General Location value of User, Private Network Serving the Local User, or Private Network Serving the Remote User. See Annex D for a discussion of DMS-100 General Location treatment.

Cause value (octet 4)

The cause value is divided into two fields, a class (bits 5 through 7) and a value within the class (bits 1 through 4). The class indicates the general nature of the event.

Class (000)	Normal event
Class (001)	Normal event
Class (010)	Resource unavailable
Class (011)	Service or option not available
Class (100)	Service or option not implemented
Class (101)	Invalid message (for example, parameter out of range)
Class (110)	Protocol error (for example, unknown message)
Class (111)	Interworking

Diagnostics (octet 5)

Diagnostic information is not available for every cause. The inclusion of diagnostics is optional. When the network provides diagnostics, they are a maximum of two octets long with one octet providing a locking *Shift* information element identifier (if appropriate) to indicate a codeset other than codeset 0.

The cause values are listed below and further defined in Annex D in paragraph 9.4 on page 285. Not all values in the table below are NI compliant.

Table 4-23 Cause value definitions

Cause value Class 7 6 5	Cause value Value 4 3 2 1	Cause no.	Cause (and definition)	Diagnostics
		Normal event class		
0 0 0	0 0 0 1	1	Unallocated (unassigned) number	
0 0 0	0 0 1 0	2	No route to specified transit network	
0 0 0	0 0 1 1	3	No route to destination	
0 0 0	0 1 1 0	6	Channel unacceptable	
0 0 1	0 0 0 0	16	Normal call clearing	
0 0 1	0 0 0 1	17	User busy	
0 0 1	0 0 1 0	18	No user responding	
0 0 1	0 0 1 1	19	No answer from user (user alerted)	
0 0 1	0 1 0 1	21	Call rejected	
0 0 1	0 1 1 0	22	Number changed	
0 0 1	1 0 1 1	27	Destination out of order	
0 0 1	1 1 0 0	28	Invalid number format (address incomplete)	
0 0 1	1 1 0 1	29	Facility rejected	
0 0 1	1 1 1 0	30	Response to STATUS ENQUIRY	
0 0 1	1 1 1 1	31	Normal, unspecified	
		Resource unavailable class		
0 1 0	0 0 1 0	34	No circuit/channel available	
0 1 0	1 0 0 1	41	Temporary failure	
0 1 0	1 0 1 0	42	Switch equipment congestion	
0 1 0	1 0 1 1	43	Access information discarded	
0 1 0	1 1 0 0	44	Requested circuit/channel not available	
0 1 0	1 1 1 1	47	Resources unavailable, unspecified	
		Service or option not available class		
0 1 1	0 0 1 0	50	Requested facility not subscribed	

Table 4-23 Cause value definitions (Continued)

Cause value Class 7 6 5	Value 4 3 2 1	Cause no.	Cause (and definition)	Diagnostics
0 1 1	0 1 1 0	54	Incoming calls barred	
0 1 1	1 0 0 1	57	Bearer capability not authorized	
0 1 1	1 0 1 0	58	Bearer capability not presently available	
0 1 1	1 1 1 1	63	Service or option not available, unspecified	
			Service or option not implemented class	
1 0 0	0 0 0 1	65	Bearer capability not implemented	
1 0 0	0 0 1 0	66	Channel type not implemented	
1 0 0	0 1 1 0	70	Only restricted digital information bearer capability is available	
1 0 0	1 1 1 1	79	Service or option not implemented, unspecified	
			Invalid message class	
1 0 1	0 0 0 1	81	Invalid call reference value	
1 0 1	0 0 1 0	82	Identified channel does not exist	
1 0 1	1 0 0 0	88	Incompatible destination	
1 0 1	1 0 1 0	90	Destination address missing, and direct call not subscribed	
1 0 1	1 1 1 1	95	Invalid message, unspecified	
			Protocol error class	
1 1 0	0 0 0 0	96	Mandatory information element is missing	Information element identifier
1 1 0	0 0 0 1	97	Message type non-existent or not implemented	Message type
1 1 0	0 0 1 1	99	Information element non-existent or not implemented	Information element identifier
1 1 0	0 1 0 0	100	Invalid information element contents	Information element identifier
1 1 0	0 1 0 1	101	Message not compatible with call state	Message type
1 1 0	0 1 1 0	102	Recovery on timer expiry	
1 1 0	1 1 1 1	111	Protocol error, unspecified	
			Interworking class	
1 1 1	1 1 1 1	127	Interworking, unspecified	

Table 4-23 Cause value definitions (Continued)

Cause value		Cause no.	Cause (and definition)	Diagnostics
Class	Value			
7 6 5	4 3 2 1			

All other values are reserved.

4.5.9 Change status

The purpose of the *Change status* information element is to change the current status of either an interface or channel to one of the following states: “in service” or “out of service”.

The *Change status* information element is used with the maintenance protocol discriminator.

The maximum length of this information element is 3 octets.

Figure 4-18 Change status information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
0	Change status information element identifier 0	0	0	0	0	0	1	1
Length of information element								2
Ext. 1	Prefer-ence	Spare 0	0	0	New status			3

Preference (octet 3)

7	
0	Reserved
1	Channel

New Status (octet 3)

3 2 1	
0 0 0	In service
0 1 0	Out of service (see Note 1)

All other values are reserved.

Note 1: D-channel service messages only support a status of “In service”. Both the “In service” and the “Out of service” status are used for B-channel service messages.

4.5.10 Channel identification

The purpose of the *Channel identification* information element is to identify a channel within the interface controlled by these signaling procedures.

The maximum length for this information element is 8 octets.

Figure 4-19 Channel identification information element

<table>
<tr><th>Bit 8</th><th>Bit 7</th><th>Bit 6</th><th>Bit 5</th><th>Bit 4</th><th>Bit 3</th><th>Bit 2</th><th>Bit 1</th><th>Octet</th></tr>
<tr><td rowspan="2">0</td><td colspan="7">Channel identification information element identifier</td><td rowspan="2">1</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td colspan="8">Length of information element</td><td>2</td></tr>
<tr><td>Ext.
1</td><td>Interface identifier present</td><td>Interface type</td><td>Spare
0</td><td>Preferred / Exclusive</td><td>D-channel indicator</td><td colspan="2">Channel Selection Information</td><td>3</td></tr>
<tr><td>Ext.
1</td><td colspan="7">Interface identifier</td><td>3.1 (Note 1,2)</td></tr>
<tr><td>Ext.</td><td colspan="2">Coding standard</td><td>Chan # / Slot Map</td><td colspan="4">Channel type</td><td rowspan="2">3.2 (Note 2,3)</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>0 / 1</td><td>0</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td colspan="7">Channel number / Slot map</td><td>3.3 (Note 2,3)</td></tr>
</table>

Note 1: When the “interface identifier present” field in octet 3 indicates “interface implicitly identified”, octet 3.1 is omitted. Octet 3.1 is not used if the PRI interface consists of only one DS1 facility.

Note 2: When the “interface identifier present” field in octet 3 indicates “interface explicitly indentified” and a whole DS1 facility is to be identified rather than a channel on a DS1 facility, octets 3.2 and 3.3 are omitted and octet 3.1 is used to explicitly identify the DS1 facility. This encoding can be used in various messages and to indicate a 1536 kbps call.

Note 3: Octets 3.2 and 3.3 are coded when a channel number or slot map must be specified. If octet 3.2 indicates a channel number, a single octet 3.3 is coded but if octet 3.2 indicates a slot map, the following three octets are coded as the slot map.

Note 4: NCAS codes octet 3 as 10101100 and 3.1, 3.2, and 3.3 are omitted.

Interface identifier present (octet 3, bit 7)

7	
0	Interface implicitly identified (see Note 1)
1	Interface explicitly identified in octet 3.1 (interface identifier).

Note 1: The interface which includes the D-channel carrying this information element is indicated.

Note 2: When the interface is implicitly identified, octet 3.1 is omitted.

Interface type (octet 3, bit 6)

6	
0	Reserved
1	Primary rate interface

Preferred / Exclusive (octet 3, bit 4)

4	
0	Indicated channel is preferred
1	Exclusive; only the indicated channel is acceptable

Note: Preferred/exclusive has significance only for B-channel selection. They are both treated as exclusive by this specification.

D-channel indicator (octet 3, bit 3)

3	
0	Channel identified is not the D-channel
1	Channel identified is the D-channel

Note: D-channel indication has significance in D-channel use. No other information affects D-channel use.

Information channel selection (octet 3, bits 1 and 2)

2	1	**Primary interface**
0	0	No channel
0	1	As indicated in the following octets

All other values are reserved.

Interface identifier (octet 3.1)

Binary code in the range 0 to 31 assigned to the interface at subscription time.

> ***Note:*** When the interface is implicitly identified, octet 3.1 is omitted.

Coding standard (octet 3.2)

7 6	
0 0	CCITT Standardized coding

All other values are reserved.

Number / Map (octet 3.2)

5	
0	Channel is indicated by the number in the following octet
1	The following 3 octets contain a slot map of the channels

Channel type / Map element type (octet 3.2)

4 3 2 1	
0 0 1 1	B-channel units

All other values are reserved.

Slot map (octet 3.3)

8	7	6	5	4	3	2	1	
24	23	22	21	20	19	18	17	To specify a channel, code the bit associated
16	15	14	13	12	11	10	9	with that channel to 1, otherwise code to 0.
8	7	6	5	4	3	2	1	Three octets are required for the slot map

All other values are reserved.

Channel number (octet 3.3)

The binary number that is assigned to the channel. For B-channels, the channel number equals the time slot number.

NOTE: Bit 5 in octet 3.2 specifies whether slot map or channel number coding is used. Slot map and channel number are mutually exclusive.

4.5.11 Facility

The purpose of the *Facility* information element is to transport information between the CPE and the serving switch. Depending upon the service being provided, the switch may forward the information through the network to another destination (eg: an SCP).

The maximum length of the information element depends on the service provided.

Figure 4-20 Facility information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
Facility information element identifier								
0	0	0	1	1	1	0	0	1
Length of information element								2
Ext. 1	Spare 0	0	Protocol Profile					3
Network Facility Extension								3.1*
Network Protocol Profile								3.2*
Interpretation Component								3.3
User data (Component) Note 1.								4 ... n

*Reserved for future use

Note 1. One or more components may be included as defined by the service.

4.5.11.1 Protocol Profile (octet 3)

The Protocol Profile is coded as shown below.

Protocol Profile (octet 3)

5	4	3	2	1	
1	0	0	0	1	Supplementary services (ROSE)
1	1	1	1	1	Networking Extensions

All other values are reserved.

4.5.11.2 Interpretation Component (octet 3.3)

If the Protocol Profile field indicates Networking Extensions, octet 3.3 may or may not (as specified by the supplementary service) contain an Interpretation Component. An Interpretation Component consists of an identification tag octet (1000 1011), a length octet, and an interpretation value octet. For example the value used by Calling Name is "(0000 0000) Discard any Invoke component containing unrecognized Operation Value".

If the Protocol Profile field is coded for Supplementary services, the Interpretation Component is not coded.

4.5.11.3 User data (octet 4, etc.)

Whether the Protocol Profile is coded for Supplementary services or Networking Extensions, the user data field contains ROSE protocol. The ROSE protocol is defined in the ANSI T1.610 standard and summarized below.

Component

A component is a sequence of data elements each of which is made up of a tag, a length and contents. There are 4 types of components, each identified by a unique component tag.

The following components are supported:

- Invoke
- Return result
- Return error
- Reject

The structure of each type of component is shown in Figure 4-21 through Figure 4-24.

Figure 4-21 Invoke component

Invoke Component		Reference	Mandatory Indication	Octet Group
Component type tag		Page 165	Mandatory	4
Component length (see Note 1)		Page 164		5
	Invoke identifier tag	Page 165	Mandatory	6
	Invoke identifier length	Page 164		7
	Invoke identifier	Page 165		8
	Linked value tag	Page 164	Optional	9
	Linked value length	Page 164		10
	Linked value	Page 165		11
	Operation value tag	Page 166	Mandatory	12
	Operation value length	Page 164		13
	Operation value	(see Note 3)	(see Note 2)	14 (see Note 3)
	Argument (see Note 2)	Page 164	Optional	15
		(see Note 3)		etc.

Note 1: The component length is coded to indicate the number of octets contained in the component, excluding the component type tag and the component length octets.

Note 2: This is a parameter of the Invoke component type.

Note 3: The coding is service dependent. The length of the operation value can be >1 octet.

Figure 4-22 Return Result component

Return Result Component		Reference	Mandatory Indication	Octet Group
Component type tag		Page 164	Mandatory	4
Component length (see Note 3)		Page 164		5
	Invoke identifier tag	Page 165		6
	Invoke identifier length	Page 164	Mandatory	7
	Invoke identifier	Page 165		8
	Sequence tag	Page 168	Optional	9
	Sequence length (see Note 4)		(see Note 1)	10
	Operation value tag	Page 166	Optional	11
	Operation value length	Page 164		12
	Operation value	(see Note 6)	(see Note 2)	13 (see Note 6)
	Result (see Note 5)	Page 164	Optional	14
		(see Note 6)		etc.

Note 1: If the Return result component does not include any result, then the sequence and operational value are omitted. "Sequence and set tags" on page 169 shows the coding for the sequence tag.

Note 2: If a result is included, the operation value is mandatory and is the first element in the sequence.

Note 3: The component length is coded to indicate the number of octets contained in the component, excluding the component type tag and the component length octets.

Note 4: The sequence length is coded to indicate the number of octets contained in the sequence, excluding the sequence type tag and the sequence length octets.

Note 5: This is a parameter of the Return result component type.

Note 6: The coding is service dependent. The length of the value can be >1 octet.

Figure 4-23 Return error component

Return Error Component		Reference	Mandatory Indication	Octet Group
Component type tag		Page 164	Mandatory	4
Component length (see Note 1)		Page 164		5
	Invoke identifier tag	Page 165		6
	Invoke identifier length	Page 164	Mandatory	7
	Invoke identifier	Page 165		8
	Error value tag	Page 166		9
	Error value length	Page 164	Mandatory	10
	Error value	(see Note 3)		11(see Note 3)
	Parameter	Page 168	Optional	12
	(see Note 2)	(see Note 3)		etc.

Note 1: The component length is coded to indicate the number of octets contained in the component, excluding the component type tag and the component length octets.

Note 2: This is a parameter of the Return result component type.

Note 3: The coding is service dependent. The length of the error value can be >1 octet.

Figure 4-24 Reject component

Reject Component		Reference	Mandatory Indication	Octet Group
Component type tag		Page 164	Mandatory	4
Component length (see Note 1)		Page 164		5
	Invoke identifier tag	Page 165	Mandatory	6
	Invoke identifier length	Page 164		7
	Invoke identifier	Page 165		8
	Problem tag	Page 167	Mandatory	9
	Problem length	Page 164		10
	Problem (see Note 2)	Page 167		11

Note 1: The component length is coded to indicate the number of octets contained in the component, excluding the component type tag and the component length octets.

Note 2: The value of the Problem octet is context sensitive.

Length of each component or data element

Lengths up to 127 octets are coded using the short form of the length field. The length format is set to “0” and the remaining 7 bits are the length of the contents in octets. Bit 7 is the most significant bit (MSB) and bit 1 is the least significant bit (LSB).

Figure 4-25 Format of the length field (short form)

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1
Length format 0	Length of contents MSB						LSB

Lengths greater than 127 octets are not supported.

Note: The network may use the long form of the length field for lengths less than 128 octets for some constructor data elements.

Component types

Every component is specified with a component type tag. The following table contains the tags for the component types.

Component type tags

8 7 6 5	4 3 2 1	
1 0 1 0	0 0 0 1	Invoke
1 0 1 0	0 0 1 0	Return result
1 0 1 0	0 0 1 1	Return error
1 0 1 0	0 1 0 0	Reject

Invoke and Link identifiers

An invoke integer identifier is used to identify an operation invocation and is reflected in the Return result or Return error that responds to it. An Invoke may refer to another Invoke through the linked identifier. When a protocol error occurs, the invoke identifier is reflected in the Reject component, but if it is not available, a null is returned. Nortel supports invoke and linked identifiers that are one octet long. No check is make for duplicate invoke identifiers. The null has zero length.

The invoke identifier and linked identifier are unique within a call reference. That is, the same identifiers can be used simultaneously in separate call references without ambiguity.

Invoke, Link, and Null identifier tags

8 7 6 5	4 3 2 1	
0 0 0 0	0 0 1 0	Invoke identifier
1 0 0 0	0 0 0 0	Linked identifier
0 0 0 0	0 1 0 1	Null

An example of the Invoke identifier coding is:

0000 0010 = coding of Invoke identifier tag

0000 0001 = coding of Invoke identifier length

0000 1000 = coding of Invoke identifier value 8

Operations

The operation value specifies the service or operation being requested. If the operation value tag is #2, then the operation value is an integer value. If the operation value tag is #6, then the operation value is a sequence of octets. In either case, the operation value’s meaning is specific to each service. Operation values are unique within each service discriminator.

Operation value tags

8	7	6	5	4	3	2	1	
0	0	0	0	0	0	1	0	Operation value — Integer
0	0	0	0	0	1	1	0	Operation value — Sequence

Operation values

Operation values are either integer or sequence and examples of each are shown below.

Integer operation values include: 0000 0000 = Calling Name

Sequence operation values include:

{1 2 840 10005 0 8} = EnhancedExplicitECTExecute

{1 2 840 10005 0 9} = dCIdentifierRequest

{1 2 840 10005 0 10} = SetCallTag

{1 2 840 10005 2 1} = TransferredCallClearing

{1 2 840 10005 0 1} = MessageWaitingIndicatorControl

The following is a coding example of EnhancedExplicitECTExecute:

0010 1010 = coding of “1” and “2” using 40 x 1 + 2 from GR-2823-CORE

1000 0110 = coding of 840 (bit 8 = 1 indicating more octets)

0100 1000 = coding of 840 (bit 8 = 0 indicating last octet)

1100 1110 = coding of 10005 (bit 8 = 1 indicating more octets)

0001 0101 = coding of 10005 (bit 8 = 0 indicating last octet)

0000 0000 = coding of 0

0000 1000 = coding of 8

Errors

Operations report errors as specified for each operation.

Error value tags

8	7	6	5	4	3	2	1	
0	0	0	0	0	0	1	0	Error value — Integer
0	0	0	0	0	1	1	0	Error value — Sequence

Problems

Protocol problems are indicated in groups. The first of the following tables specifies the tags for these groups. The remaining tables specify the problem values associated with each problem group.

Problem tags

8	7	6	5	4	3	2	1	
1	0	0	0	0	0	0	0	General problem
1	0	0	0	0	0	0	1	Invoke problem
1	0	0	0	0	0	1	0	Return result problem
1	0	0	0	0	0	1	1	Return error problem

General problems

8	7	6	5	4	3	2	1	
0	0	0	0	0	0	0	0	Unrecognized component
0	0	0	0	0	0	0	1	Mistyped component
0	0	0	0	0	0	1	0	Badly structured component

Invoke problems

8	7	6	5	4	3	2	1	
0	0	0	0	0	0	0	0	Duplicate invocation
0	0	0	0	0	0	0	1	Unrecognized operation
0	0	0	0	0	0	1	0	Mistyped argument
0	0	0	0	0	0	1	1	Resource limitation
0	0	0	0	0	1	0	0	Initiator releasing
0	0	0	0	0	1	0	1	Unrecognized linked identifier
0	0	0	0	0	1	1	0	Linked response unexpected
0	0	0	0	0	1	1	1	Unexpected child operation

Return result problems

8 7 6 5	4 3 2 1	
0 0 0 0	0 0 0 0	Unrecognized invocation
0 0 0 0	0 0 0 1	Result response unexpected
0 0 0 0	0 0 1 0	Mistyped result

Return error problem

8 7 6 5	4 3 2 1	
0 0 0 0	0 0 0 0	Unrecognized invocation
0 0 0 0	0 0 0 1	Error response unexpected
0 0 0 0	0 0 1 0	Unrecognized error
0 0 0 0	0 0 1 1	Unexpected error
0 0 0 0	0 1 0 0	Mistyped parameter

Arguments, Results, and Parameters

The argument of Invoke, result of Return result or parameter of Return error are indicated in the operation specification. They may include optional and default parameters. Parameters are one of the following:

- a sequence of parameters
- a set of parameters
- a specific parameter with its own tag
- null (absent)

An example of the argument of Invoke for calling name with the presentation indicator of restricted, is shown below:

1000 0111 = coding of name restricted

An example of the argument of Invoke for calling name with the presentation indicator of name not available, is shown below:

1000 0100 = coding of name not available

An example of the argument of Invoke for calling name with the presentation indicator allowed, is shown below:

1000 0000 = coding of name allowed

xxxx xxxx = coding of the name (may contain up to 15 octets)

An example of the result in the Return result of a D-Channel ID request is:

0000 0100 = coding of the D-Channel tag

0000 0100 = coding of the length of 4

0000 0101 = coding of the first octet of the value

0000 0001 = coding of the second octet of the value

0000 0100 = coding of the third octet of the value

0000 0101 = coding of the fourth octet of the value

If more than one parameter is required, they follow a sequence or set tag, as specified for the operation. Each parameter in a set or sequence is allowed to be a set or sequence.

Sequence and set tags

8	7	6	5	4	3	2	1	
0	0	1	1	0	0	0	0	Sequence tag
0	0	1	1	0	0	0	1	Set tag

For example, sequence is specified as part of the invoke component in a Two B-Channel Transfer across two different D channels {1 2 840 10005 0 8}. See the example coding below:

1010 0001 = coding of the Invoke tag

0001 1000 = coding of the length of 24

0000 0010 = coding of the Invoke ID tag

0000 0001 = coding of the Invoke ID length

0000 0100 = coding of the Invoke ID of 4

0000 0110 = coding of the Operation Value tag

0000 0111 = coding of the Operation Value length

0010 1010 = coding of “1” and “2” using 40 x 1 + 2 from GR-2823-CORE

1000 0110 = coding of 840 (bit 8 = 1 indicating more octets)

0100 1000 = coding of 840 (bit 8 = 0 indicating last octet)

1100 1110 = coding of 10005 (bit 8 = 1 indicating more octets)

0001 0101 = coding of 10005 (bit 8 = 0 indicating last octet)

0000 0000 = coding of 0

0000 1000 = coding of 8

0011 0000 = coding of Sequence tag

0000 1010 = coding of the length of 10

0000 0010 = coding of Link ID tag

0000 0010 = coding of length of 2

0000 0100 = coding of link id octet 1

0000 0101 = coding of link id octet 2

0000 0100 = coding of d channel ID tag

0000 0100 = coding of octet 1 of the d channel id value

0000 0101 = coding of octet 2 of the d channel id value

0000 0110 = coding of octet 3 of the d channel id value

0000 1110 = coding of octet 4 of the d channel id value

4.5.12 Locking Shift

The purpose of the *Locking Shift* information element is employed in the CCITT Recommendation Q.931-defined codeset to shift to the national-specific codeset (codeset 5).

The maximum length of the information element is 1 octet.

Figure 4-26 Information request information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
	Locking Shift Identifier				Codeset			
1	0	0	1	0				1

Codeset (octet 1)

3 2 1	
1 0 1	National Specific Codeset

All other values are reserved.

4.5.13 Network-Specific Facilities

The *Network-Specific Facilities* information element is used to request a particular service from the network or to provide an indication of the service being provided.

Figure 4-27 Network-Specific Facilities information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
	Network-specific facilities information element identifier							1
0	0	1	0	0	0	0	0	
Length of Network-specific facilities information element								2
Length of network identification								3
Ext.	Type of network identification			Network identification plan				3.1
1								
Spare	Network identification							3.2
0								
Ext.	Exp	Serv/Feat	Facility Coding Value					4
0/1	1	1						
Spare	Service Parameters							5 ... n
0								

Length of network identification (octet 3)

This field is the binary encoding of the length, in octets, of the network identification contained in Octet 3.1 and the repetition of Octet 3.2. A length of “0000 0000” indicates the local service provider. Octets 3.1 and 3.2 are not included when the length is coded to zero.

To terminate INWATS, FX, and TIE calls using call by call service selection, the DMS-100 will code the length to zero. To originate IntraLATA OUTWATS, FX, TIE, Hotel/Motel, and SCOCS calls, the user equipment should code octet 3 to zero indicating the local service provider. To originate InterLATA or banded OUTWATS, or interLATA Hotel/Motel or SCOCS calls, the user equipment should code octet 3 to the length of the network identification and octets 3.1 and 3.2 as described below.

Type of network identification (octet 3.1)

7 6 5	
0 1 0	Nationally standardized identification

All other values are reserved.

Network identification plan (octet 3.1)

4 3 2 1	
0 0 0 1	Carrier identification code

All other values are reserved.

Network identification (octet 3.2)

Network identification is coded as International Alphabet Number 5 (IA5) characters (see Figure 4-15) and is organized according to the rules of the network identification plan specified in octet 3.1. Identification of an interexchange carrier is the 3 or 4 digit code assigned to carriers by Bellcore.

Ext (octet 4)

This field is coded to 1 if service parameters are not present or to 0 if service parameters are present. Service parameters, when present, begin at octet 5.

Exp (octet 4)

This field is coded to 1 to indicate that the coding value of the facility is in the following 6 bits. Coding of this field to 0 is reserved.

Serv/Feat (octet 4)

This field is coded to 1 to indicate “Service”. Coding of this field to 0 is reserved.

Facility Coding Value (octet 4)

Only the values shown below are supported.

5 4 3 2 1	
1 0 0 0 1	INWATS Selection
1 0 0 1 0	OUTWATS Selection
1 0 0 1 1	Foreign Exchange Selection
1 0 1 0 0	Tie Trunk Selection
1 0 1 0 1	Hotel/Motel Selection
1 0 1 1 0	Selective Class of Call Screening Selection

All other values are reserved.

Service Parameter (octet 5)

Service parameters are coded as International Alphabet Number 5 (IA5) characters (see Figure 4-15). The upper limit of the service parameter is 1,023.

4.5.14 Notification indicator

The *Notification indicator information element* carries notification information that may or may not relate to an active call on a PRI. The Notification indicator is for Notification to Controller (part of the Two B-Channel Transfer service).

Figure 4-28 Notification indicator information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
	Notification indication Information element identifier							1
0	0	1	0	0	1	1	1	
Length of information element								2
Ext.	Notification description							3
1								
ASN.1 Encoded Data Structure								4..n

Notification description (octet 3)

7 6 5	4 3 2 1	
1 0 0	0 0 0 0	Notification description ASN.1 for ISO

All other values are reserved.

ASN.1 Encoded Data Structure (octet 4..n)

The encoded data structure consists of three parts; Sequence, Notification value, and Arguments. For Notification to Controller (part of the Two B-Channel Transfer service) the three parts map to Sequence, Operation value, and Call Tag, respectively. Further description of Sequence, Operation value and Arguments can be found in paragraph 4.5.11.3 on page 160.

The following is a coding example of the Notification to Controller:

0011 0000 = sequence tag

0000 1110 = sequence length

0000 0110 = operation value tag - sequence

0000 0111 = operation value length

operation value {1 2 840 10005 2 1} TransferredCallClearing coded as

0010 1010 = coding of “1” and “2” using 40 x 1 + 2 from GR-2823-CORE

1000 0110 = coding of 840 (bit 8 = 1 indicating more octets)

0100 1000 = coding of 840 (bit 8 = 0 indicating last octet)

1100 1110 = coding of 10005 (bit 8 = 1 indicating more octets)

0001 0101 = coding of 10005 (bit 8 = 0 indicating last octet)

0000 0010 = coding of 2

0000 0001 = coding of 1

1000 0001 = coding of CallTag tag implicit integer

0000 0011 = coding of CallTag length

0000 1000 = coding of call tag value first octet

0000 0110 = coding of call tag value second octet

0000 1000 = coding of call tag value third octet

4.5.15 Operator System Access

The *Operator System Access information element* allows the user to request access to an operator services system. It is a national-specific information element.

The maximum length of the information element is 3 octets.

Figure 4-29 Operator System Access information element

Bit 8	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Octet**
	Operator System Access Information Element Identifier							1
0	0	0	1	1	1	0	1	
Length of information element								2
0	0	0	0	0	0	0	1	
Ext.	Type of service					Type of access		3
1	0	0	0	0	0			

Type of service (octet 3)

7 6 5 4 3	
0 0 0 0 0	Unspecified

All other values are reserved.

Type of access (octet 3)

2 1	
0 0	Public/principal: default operator system
0 1	Public/alternate: operator system determined by user subscription

All other values are reserved.

4.5.16 Progress indicator

The *Progress indicator* information element is used to describe an event which has occurred during the life of a call.

The maximum length of the information element is 4 octets.

Figure 4-30 Progress information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
0	Progress indicator information element identifier 0	0	1	1	1	1	0	1
Length of information element								2
Ext. 1	Coding standard		Spare 0	Location				3
Ext. 1	Progress description							4

Coding standard (octet 3)

7 6	
0 0	CCITT standard

All other values are reserved.

Location (octet 3)

4 3 2 1	
0 0 0 0	User
0 0 0 1	Private network serving the local user
0 0 1 0	Public network serving the local user
0 0 1 1	Transit network
0 1 0 0	Public network serving the remote user
0 1 0 1	Private network serving the remote user
1 0 1 0	Network beyond the interworking point

All other values are reserved.

Note: The General Location passed by the DMS-100 to the CPE (network to user direction) reflects the location of the source of the information element. In the opposite direction (user to network), the CPE should use a General Location value of User, Private Network Serving the Local User, or Private Network Serving the Remote User. See Annex D for a discussion of DMS-100 General Location treatment.

Progress description (octet 4)

7 6 5	4 3 2 1	Number	
0 0 0	0 0 0 1	1	Call is not end-to-end ISDN; further call progress information may be available in-band (see Note 1)
0 0 0	0 0 1 0	2	Called equipment is non-ISDN (see Note 2)
0 0 0	0 0 1 1	3	Calling equipment is non-ISDN (see Note 3)
0 0 0	1 0 0 0	8	In-band information or pattern is now available (see Note 4)
0 0 0	1 0 1 0	10	Delay in response at called interface (see Note 5)

All other values are reserved.

Note 1: Progress descriptor #1 can be received or sent in either a SETUP message or a PROGRESS message.

Note 2: Progress descriptor #2 can only be received in a CONNECT message.

Note 3: Progress descriptor #3 can be received or sent in a SETUP message.

Note 4: Progress descriptor #8 can be received or sent in either an ALERTING message or a PROGRESS message.

Note 5: Progress descriptor #10 can be received or sent in a PROGRESS message.

4.5.17 Redirecting Number

The *Redirecting Number* information element identifies an address associated with the party who redirected a call. A SETUP message may contain either one or two *Redirecting Number* information elements depending upon whether the call has been redirected more than once. The first information element pertains to the original forwarding user and the second pertains to the most recent forwarding user.

The DMS-100 will accept the following combinations of Type of Number (octet 3), Numbering Plan Identification (octet 3), and Digits (octet 4) from the redirecting interface:

- Unknown number / Unknown numbering plan / 0 - 15 digits
- Local number / ISDN numbering plan / 7 digits
- National number / ISDN numbering plan / 10 digits
- International number / ISDN numbering plan / 1-15 digits

Figure 4-31 Redirecting Number information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
	Redirecting Number information element identifier							1
0	1	1	1	0	1	0	0	
Length of redirecting number information element								2
Ext.	Type of number			Number plan idendifier				3
1								
Ext.	Origin of number and presentation status							3a
0/1								(Note 1)
Ext.	Spare			Reason for redirection				3b
1	0	0	0					(Note 1)
Spare	Digits							4 ... n
0	(IA5 Characters)							(Note 1)

Note 1: These octets may be omitted in some cases.

Type of number (octet 3)

7 6 5	
0 0 0	Unknown

7 6 5	
0 0 1	International number
0 1 0	National number
1 0 0	Local number

All other values are reserved.

Numbering plan identification (octet 3)

4 3 2 1	
0 0 0 0	Unknown
0 0 0 1	ISDN/Telephony numbering plan (E.164/E.163)

All other values are reserved.

Origin of number and presentation status (octet 3a)

7 6 5	4 3 2 1	
0 0 0	0 0 0 0	Presentation allowed of user-provided number, number not screened
0 0 0	0 0 0 1	Presentation allowed of user-provided number, number passed network screening
0 0 0	0 0 1 0	Presentation allowed of user-provided number, number failed network screening
0 0 0	0 0 1 1	Presentation allowed of network-provided number
0 1 0	0 0 0 0	Presentation prohibited of user-provided number, number not screened
0 1 0	0 0 0 1	Presentation prohibited of user-provided number, number passed network screening
0 1 0	0 0 1 0	Presentation prohibited of user-provided number, number failed network screening
0 1 0	0 0 1 1	Presentation prohibited of network-provided number
1 0 0	0 0 1 1	Number not available

All other values are reserved.

Reason for redirection (octet 3b)

4 3 2 1	
0 0 0 0	Unknown
0 0 0 1	Call forwarding busy
0 0 1 0	Call forwarding no reply
1 1 1 1	Call forwarding unconditional

All other values are reserved.

Digits (octet 4 ... n)

The digits are coded as IA5 characters (see Figure 4-15).

4.5.18 Restart indicator

The purpose of the *Restart indicator* information element is to identify the class of the facility (that is, indicated channel, single DS1, or all channels associated with the D-channel) to be restarted.

Figure 4-32 Restart indicator information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
0	Restart indicator information element identifier 1	1	1	1	0	0	1	1
Length of information element 0	0	0	0	0	0	0	1	2
Ext. 1	Spare 0	0	0	0	Class			3

Class (octet 3)

3 2 1	
0 0 0	Indicated channel (see Note 1)
1 1 0	Single DS1 Facility (see Note 1)
1 1 1	All channels associated with the D-channel

All other values are reserved.

Note 1: The *Channel identification* information element must be included and indicates which channel is to be restarted.

4.5.19 Transit network selection

The purpose of the *Transit network selection* information element is to identify the requested transit network. This information element should not be included in a *SETUP* message when a *Network-specific facilities* information element is present or the presubscribed carrier is to be used.

The maximum length of the information element is 7 octets.

Figure 4-33 Transit network selection information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
0	Transit network selection information element identifier							1
	1	1	1	1	0	0	0	
Length of information element								2
Ext. 1	Type of network identification			Network identification plan				3
Spare 0	Network identification (IA5 characters)							4 ... n

Type of Network identification (octet 3)

7 6 5	
0 1 0	National network identification

All other values are reserved.

Network identification Plan (octet 3)

4 3 2 1	
0 0 0 1	Carrier identification code

All other values are reserved.

Network Identification Characters (octet 4)

These IA5 characters are organized according to the network identification plan specified in octet 3.

Chapter 4-5: Layer 3 Call Control Procedures

This chapter describes the procedures that define the flow of messages across a primary rate interface between an ISDN user and the network. The call states referred to in this chapter refer to

- states seen by the network
- states seen by the user
- states which are common to both user and network

Unless noted, all states described in the following text should be understood as common. (See paragraph 2.1.1 on page 102 for user and network call states.)

Detailed Specification and Description Language (SDL) diagrams for the procedures specified in this section are contained in Annex A in paragraph 9.1 on page 241. If there is an ambiguity in the narrative text, the SDL diagrams should be used to resolve the conflict. If the text and SDL are in disagreement, the text should be considered correct.

> ***Note:*** This chapter describes the sequence of messages associated with the control of circuit-switched connections.

Before these procedures are invoked, Layer 3 must be established on an active D-channel (see Chapter 4-6: Single D-Channel Maintenance). All Layer 3 messages are sent to the data link layer using a *DL-Data-Request* primitive. The data link services described in the Layer 2 procedures (Section 3 of this specification) are assumed.

The *Call reference* information element contained in all messages exchanged across the user-network interface contains the call reference value specified in the *SETUP* message. In selecting a call reference, the dummy (null) call reference is not used.

5.1 Call establishment at the originating interface

5.1.1 Call request procedure

A user initiates call establishment by transferring a *SETUP* message across the user-network interface.

Following the transmission of the *SETUP* message, the call is considered by the user to be in the *Call initiated* state. The message always contains a *Call reference* information element, selected according to the procedures given in paragraph 4.3 on page 130. In selecting a call reference, the dummy call reference value is not used. The *Bearer capability and Channel identification* information elements are mandatory in the *SETUP* message.

If the user knows all appropriate channels controlled by the D-channel are in use, it does not send a *SETUP* message across the user-network interface. If the user does not monitor the status of the channels in use or if a non-call associated signaling (NCAS) connection is being established, it may send a *SETUP* message when all channels are busy.

The *SETUP* message contains all of the call information necessary for call establishment.

5.1.2 Channel selection — originating

In the *SETUP* message, the user indicates one of the following using the *Channel identification* information element

- channel is indicated, no acceptable alternative
- channel is indicated, any alternative is acceptable

If no *Channel identification* information element is included, the procedures in paragraph 5.9.6.1 on page 214 for a missing mandatory information element are followed. In both cases, if the indicated channel is available, the network selects it for the call.

The selected B-channel (or D-channel for NCAS) is indicated in the first message returned by the network in response to the *SETUP* message (that is, a *CALL PROCEEDING* message). For B-channel calls, after transmitting this message, the network activates the selected B-channel connection.

The user need not attach until it receives a *CALL PROCEEDING*, *PROGRESS*, or *ALERTING* message with a *Progress indicator* information element with one of the following *Progress description* values:

- #1 “Call is not end-to-end ISDN; further call progress information may be available in-band”
- #8 “Inband information or appropriate pattern is now available”

Prior to this time, the network does not assume that the user has attached to the B-channel. After this time, the user is connected to the B-channel, provided the equipment does not generate local tones. Upon receipt of the *CONNECT* message, the user attaches to the B-channel (if it has not already done so).

If the specified B-channel is not available, the network

- sends a *RELEASE COMPLETE* message with *Cause* value #44 “Requested circuit/channel not available”
- enters the *Null* state

Reasons for B-channel non-availability include another call is allocated to the same B-channel or the B-channel is out of service (see Chapter 4-7: B-Channel Maintenance).

5.1.3 Invalid call information

If, following the receipt of the *SETUP* message, the network determines that the call information received from the user is invalid (for example, an invalid number is sent), the network initiates call clearing in accordance with paragraph 5.3 on page 191. The *Cause* value returned is one of the following:

- #1 “Unallocated (unassigned) number”
- #3 “No route to destination”
- #28 “Invalid number format (address incomplete)”

5.1.4 Call proceeding

If the network determines that the *SETUP* message contains all the information required from the user to establish the call and that access to the requested service is authorized and available, the network:

- sends a *CALL PROCEEDING* message to the user to acknowledge the *SETUP* message and to indicate that the call is being processed
- enters the *Outgoing call proceeding* state

When the user receives the *CALL PROCEEDING* message, the user also enters the *Outgoing call proceeding* state.

If the network determines that a requested service is not authorized or is not available, the network initiates call clearing in accordance with paragraph 5.3 on page 191. The network returns one of the following *Cause* values:

- #34 “No circuit/channel available”
- #57 “Bearer capability not authorized”
- #65 “Bearer capability not implemented”

5.1.5 Notification of interworking at the originating interface

During call establishment, the call may leave the ISDN environment (for example, because of interworking with non-ISDN facilities). When this situation occurs, a *Progress indicator* information element is returned to the calling user in the *PROGRESS* message:

The *Progress indicator* information element in the message sent to the user has *Progress description* value #1 “Call is not end-to-end ISDN; further call progress information may be available in-band”.

On receipt of the *Progress indicator* information element in the *PROGRESS* message, the calling user does not change state, but any supervisory timers are stopped. The user connects to (if not connected already) and then monitors the B-channel for further in-band information.

If the interface at which the *Progress indicator* originates is where the call enters the ISDN environment from a non-ISDN environment, any *SETUP* message sent to the network includes a *Progress indicator* information element with *Progress description* value #1 “Call is not end-to-end ISDN ; further call progress information may be available in-band”.

5.1.6 Call confirmation indication

Upon receiving an indication that user alerting has been initiated at the called address, the network

- sends an *ALERTING* message across the user-network interface to the calling user
- enters the *Call delivered* state

The *ALERTING* message contains a *Progress indicator* information element with *Progress description* value #8 “In-band information or appropriate pattern is now available” if the bearer capability is “speech” or “3.1 kHz Audio”. When the user receives the *ALERTING* message, it enters the *Call delivered* state.

5.1.7 Call connected

Upon receiving an indication that the call has been accepted, the network

- sends a *CONNECT* message across the user-network interface to the calling user
- enters the *Active* state

The *CONNECT* message indicates to the calling user that a connection has been established through the network.

On receipt of the *CONNECT* message, the calling user

- (optionally) sends a *CONNECT ACKNOWLEDGE* message

- enters the *Active* state

The network takes no action on receipt of a *CONNECT ACKNOWLEDGE* message if the call is in the *Active* state.

5.1.8 Call rejection

Upon receiving an indication that the network or the called user is unable to accept the call, the network initiates clearing at the originating user-network interface as described in paragraph 5.3 on page 191 using the cause value provided by the terminating network or the called user.

5.2 Call establishment at the destination interface

5.2.1 Network response to an incoming call

The network indicates the arrival of a call toward the user-network interface by transferring a *SETUP* message across the interface. This message is sent if the network can select an idle B-channel.

In addition to the mandatory information elements, the *SETUP* message may include any of the optional information elements described in paragraph 3.1.10 on page 117.

After sending the *SETUP* message, the network

- starts timer T303
- enters the *Call present* state

The *SETUP* message contains all the information required by the called user to process the call. Upon receipt of a *SETUP* message, the user enters the *Call present* state.

If no response to the *SETUP* message is received by the network before the first expiry of timer T303

- the network retransmits the *SETUP* message
- timer T303 is restarted

5.2.2 B-channel selection — destination

In the *SETUP* message, the network indicates the B-channel to be used, with no acceptable alternative, for the call. If the indicated channel is acceptable, the user equipment selects it for the call.

If the B-channel indicated in the first response message is not the channel offered by the network, the network clears the call by sending a *RELEASE* message with *Cause* value #6 “Channel unacceptable” (see paragraph 5.3.2 on page 191).

When a B-channel has been accepted by the user, the user may connect to that channel.

If the indicated B-channel is not available, the user

- sends a *RELEASE COMPLETE* message with *Cause* value #44 “Requested circuit/channel not available”
- enters the *Null* state

Reasons for B-channel non-availability include another call is allocated to the same B-channel or the B-channel is out of service (see Chapter 4-7: B-Channel Maintenance).

5.2.3 Call confirmation

5.2.3.1 Receipt of *RELEASE COMPLETE*

If an incompatible bearer capability has been requested, the user-side responds to the *SETUP* message by sending a *RELEASE COMPLETE* message with *Cause* value #88 “Incompatible destination” and enters the *Null* state.

If the user is busy, the user-side responds to the *SETUP* message by sending a *RELEASE COMPLETE* message with *Cause* value #17 “User busy” and enters the *Null* state.

If the user refuses the call, the user-side responds to the *SETUP* message by sending a *RELEASE COMPLETE* message with *Cause* value #21 “Call rejected” and enters the *Null* state.

For each of the above cases, the network processes the *RELEASE COMPLETE* message by stopping timer T303 and enters the *Null* state. The network also clears the call toward the original caller.

When the user determines that sufficient call setup information has been received, compatibility requirements have been satisfied, the user is not busy and the call is not refused then the call continues as described in the following paragraphs.

5.2.3.2 Receipt of *Call proceeding* and *Alerting*

Upon receipt of the *CALL PROCEEDING* message from a user, the network

- stops timer T303
- starts timer T310
- enters the *Incoming call proceeding* state

Upon receipt of the *ALERTING* message from a user, the network

- stop timers T303 or T310 (if running)

- starts timer T301
- enters the *Call received* state
- sends a corresponding *ALERTING* message to the calling user

If the received *ALERTING* message is the first response to the *SETUP* message it contains the *Channel identification* information element.

5.2.3.3 Called user clearing during incoming call establishment

If a *RELEASE COMPLETE* or *DISCONNECT* message is received before a *CONNECT* message, the network

- stops timer T301, T303 or T310 (if running)
- continues to clear the user as described in paragraph 5.3.3 on page 192
- clears toward the original caller

5.2.3.4 Call failure

If the network does not receive any response to the retransmitted *SETUP* message prior to the expiration of timer T303, the network

- initiates clearing procedures towards the calling user with *Cause* value #18 “No user responding”
- initiates clearing procedures towards the called user in accordance with the procedures defined in paragraph 5.3.4 on page 194 using *Cause* value #102 “Recovery on timer expiry”.

If the network has received a *CALL PROCEEDING* message, but does not receive an *ALERTING*, *CONNECT*, or *DISCONNECT* message prior to the expiration of timer T310, the network

- initiates clearing procedures toward the calling user with *Cause* value #18 “No user responding”
- initiates clearing procedures towards the called user in accordance with the procedures defined in paragraph 5.3.4 on page 194 using *Cause* value #102 “Recovery on timer expiry”

If the network receives an *ALERTING* message, but does not receive a *CONNECT* or *DISCONNECT* message prior to the expiration of timer T301, the network

- initiates clearing procedures toward the calling user with *Cause* value #19 “No answer from user (user alerted)”
- initiates clearing procedures towards the called user in accordance with the procedures defined in paragraph 5.3.4 on page 194 using *Cause* value #102 “Recovery on timer expiry”

5.2.4 Notification of interworking at the terminating interface

During call establishment, a call may enter a non-ISDN environment because, for example

- the ISDN network is interworking with another network
- the call may be from or to a non-ISDN user

When this occurs, the point at which the call enters the non-ISDN environment causes a *Progress indicator* information element to be included in the *SETUP* message that is sent to the called user. The information element could have *Progress description* value #1 “Call is not end-to-end ISDN; further call progress information may be available inband”. If the originating interface was PRI and contained a *Progress indicator* with descriptor #3, then the *Progress description* value could also be #3 “Called user is non-ISDN”.

On receipt of *Progress indicator* information element with *Progress description* value #1, the called user connects to the B-channel in accordance with the procedures defined in paragraph 5.2.6 on page 190.

In addition, the called user notifies the calling party if the call has left the ISDN environment within the called user’s premises and the possible availability of in-band call progress information. When such situations occur, a *Progress indication* information element is sent by the user to the network in the *PROGRESS* message. The *Progress indicator* information element contains the *Cause* value #1 “Call is not end-to-end ISDN; further call progress information may be available in-band”.

On receipt of the *Progress indicator* information element in a *PROGRESS* message, the network does not change state but any supervisory timers are stopped.

5.2.5 Call accept

A user indicates acceptance of an incoming call by sending a *CONNECT* message to the network. If an *ALERTING* message has previously been sent to the network, the *CONNECT* message may contain only the *Call reference* information element.

If a call can be accepted using the B-channel indicated in the *SETUP* message, and no user alerting is required, a *CONNECT* message may be sent without a previous *ALERTING* message. If the *CONNECT* message is the first response to the *SETUP* message, it contains the *Channel identification* information element.

5.2.6 Active indication

On receipt of the first *CONNECT* message, the network

- stops timers T301, T303 and T310 (if running)

- completes the circuit-switched path to the selected B-channel
- sends a *CONNECT ACKNOWLEDGE* message to the user
- initiates procedures to send a *CONNECT* message towards the calling user
- enters the *Active* state

The *CONNECT ACKNOWLEDGE* message indicates completion of the circuit-switched connection. There is no guarantee of an end-to-end connection until a *CONNECT* message is received at the calling user interface.

Upon receipt of the *CONNECT ACKNOWLEDGE* message, the called user:

- stops timer T313
- enters the *Active* state

If timer T313 expires prior to receipt of a *CONNECT ACKNOWLEDGE* message, the called user initiates clearing toward the network in accordance with the procedures defined in paragraph 5.3.3 on page 192 with cause #102 “Recovery on timer expiry”.

A user that has received the *SETUP* message may connect to the B-channel as soon as channel selection has been completed.

5.3 Call clearing

5.3.1 Terminology

The following terms are used in the description of the clearing procedures:

- A channel is *connected* when the channel is part of a circuit-switched ISDN connection established according to this specification.
- A channel is *disconnected* when the channel is no longer part of a circuit-switched ISDN connection, but is not yet available for use in a new connection.
- A channel is *released* when the channel is not part of a circuit-switched ISDN connection and is available for use in a new connection. Similarly, a call reference that is *released* is available for reuse.

5.3.2 Exception conditions

Under normal conditions, call clearing is initiated when the user or the network sends a *DISCONNECT* message and the procedures in paragraph 5.3.3 on page 192 or paragraph 5.3.4 on page 194, respectively, are followed. The only exceptions to this rule are:

- In response to a *SETUP* message, the user or network can reject a call (for example, because of the unavailability of a suitable B-channel) by
  - responding with a *RELEASE COMPLETE* message, provided no other response has previously been sent

   - releasing the call reference and entering the *Null* state

- Unsuccessful termination of the B-channel selection procedure by the side offering the call (when the first response to the *SETUP* message contains an unacceptable B-channel). The call is cleared by

   - sending a *RELEASE* message with *Cause* value #6 “Channel unacceptable”
   - entering the *Release requested* state

- Receipt of a *RELEASE* message by the network (note that this is the normal termination of an NCAS connection) causes the network to respond by

   - sending a *RELEASE COMPLETE* message
   - stopping timers (if running) and releasing a B-channel (if a B-channel was associated)
   - releasing the call reference and entering the *Null* state

5.3.3 Clearing initiated by the user

Apart from the exception conditions identified in paragraph 5.3.2 on page 191 and paragraph 5.9 on page 210, the user initiates clearing by

- sending a *DISCONNECT* message
- disconnecting the B-channel
- entering the *Disconect request* state

When the network receives a *DISCONNECT* message from the user, it

- enters the *Disconnect request* state
- disconnects the B-channel and initiates clearing the other party(s)
- sends a *RELEASE* message to the user
- starts timer T308
- enters the *Release request* state

> ***Note:*** The *RELEASE* message has only local significance and does not imply an acknowledgement of clearing from the remote user.

On receipt of the *RELEASE* message, the user

- cancels timer T305
- releases the B-channel
- sends a *RELEASE COMPLETE* message
- releases the call reference
- enters the *Null* state

Following the receipt of a *RELEASE COMPLETE* message from the user, the network

- stops timer T308
- releases both the B-channel and the call reference
- enters the *Null* state

If a *RELEASE COMPLETE* message is not received by the network before the first expiry of timer T308, the *RELEASE* message is retransmitted and timer T308 is restarted. If no *RELEASE COMPLETE* message is received from the user before T308 expires a second time, the network

- places the B-channel in a maintenance state
- releases the call reference
- enters the *Null* state

If timer T305 expires, the user

- sends a *RELEASE* message to the network with the cause number originally contained in the *DISCONNECT* message
- starts timer T308
- enters the *Release request* state

The user may include in the *RELEASE* message a second *Cause* information element with *Cause* value #102 “Recovery on timer expiry”.

If user timer T308 expires for the first time, the user

- retransmits the *RELEASE* message
- restarts timer T308

The user may include in the *RELEASE* message a second *Cause* information element with the *Cause* value #102 “Recovery on timer expiry”.

If no *RELEASE COMPLETE* message is received from the network before timer T308 expires a second time, the user

- may place the B-channel in a maintenance state
- releases the call reference
- enters the *Null* state

Note: The restart procedures contained in paragraph 5.7 on page 200 may be used on B-channels in the maintenance state.

5.3.3.1 Cause Screening

When an initial call clearing message is received by the terminating interface with a cause other than the ones which result in a reroute attempt or inband treatment, the terminating interface normally sends a clearing message to the originating interface with the cause received. However cause values that only have significance locally are mapped to a more generalized one for the DMS-100 platform. Table 4-24 on page 194 shows the causes that are affected. When one of these causes is received at the terminating interface, cause #41, "temporary failure", may be substituted.

Table 4-24 Cause screening table

Received cause
6. Channel unacceptable
30. Response to status enquiry
45. Preempt[a]
81. Invalid call reference value
82. Identified channel does not exist
90. Destination address missing
95. Invalid message unspecified
96. Mandatory information element is missing
97. Message type nonexistent or not implemented
99. Information element nonexistent or not implemented
100. Invalid information element contents
101. Message not compatible with state
102. Recovery on timer expiry
111. Protocol error, unspecified

a. This cause is screened for PRI trunks that are **not** AUTOVON agents.

5.3.4 Clearing initiated by the network

Apart from the exceptions identified in paragraph 5.3.2 on page 191 and paragraph 5.9 on page 210, the network initiates clearing by

- sending a *DISCONNECT* message
- entering the *Disconnect indication* state

Note that the network does not initiate clearing of NCAS connections.

5.3.4.1   Clearing when tones or announcements provided

When tones or announcements are provided in conjunction with call clearing, the network sends a *PROGRESS message* (see paragraph 5.4 on page 198).

If a call originating on a PRI trunk cannot be completed, a clearing message containing an appropriate cause is generally sent back to the calling interface.

In some cases, however, an inband treatment (a tone or an announcement) may be preferable to immediately clearing the call. Inband treatment procedures apply only for originating PRI calls with a bearer capability (BC) of speech or 3.1-kHz audio. Inband treatment is available when normally, a DISCONNECT or RELEASE COMPLETE message containing either cause #1, “unallocated (unassigned) number”,or cause #27, “destination out of order”, would be sent to the calling interface. Inband treatment can also be applied if the terminating interface receives a call clearing message containing cause #1, “unallocated (unassigned) number”.

Subscribing to this option enables inband treatment procedures for originating PRI calls with a bearer capability (BC) of speech or 3.1-kHz audio for the following scenarios:

- The call attempt results in a DMS treatment of VACT (vacant code), UNDN (unassigned number), or BLDN (blank directory number). (Normally, a DISCONNECT or RELEASE COMPLETE message containing cause #1, “unallocated (unassigned) number”, would be sent to the calling interface.)
- The terminating interface receives a call clearing message containing cause #1, “unallocated (unassigned) number”.
- The call attempt results in a DMS treatment of TRBL (trouble intercept). (Normally, a DISCONNECT or RELEASE COMPLETE message containing cause #27, “destination out of order”, would be sent to the calling interface.)

For these cases, when inband treatment is subscribed to, the originating interface will send the calling interface a PROGRESS message containing progress indicator #8, and either cause #1 or cause #27 (as appropriate), and a tone or an announcement will be supplied over the allocated B-channel.

5.3.4.2   Clearing when tones or announcements not provided

When tones or announcements are not provided, the network initiates clearing by

- sending a *DISCONNECT* message
- starting timer T305

- disconnecting the B-channel
- entering the *Disconnect indication* state

On receipt of the *DISCONNECT* message the user

- disconnects the B-channel
- sends a *RELEASE* message
- starts timer T308
- enters the *Release request* state

On receipt of the *RELEASE* message, the network

- stops timer T305
- releases the B-channel
- sends a *RELEASE COMPLETE* message
- releases the call reference
- enters the *Null* state

If timer T305 expires, the network

- sends a *RELEASE* message to the user with the *Cause* value originally contained in the *DISCONNECT* message
- starts timer T308
- enters the *Release request* state

5.3.4.3 Completion of clearing

Following the receipt of a *RELEASE COMPLETE* message from the user, the network

- stops timer T308
- releases both the B-channel and the call reference
- enters the *Null* state

If a *RELEASE COMPLETE* message is *not* received by the network before the first expiry of timer T308, the network

- retransmits the *RELEASE* message
- restarts timer T308

If no *RELEASE COMPLETE* message is received from the user before timer T308 expires a second time, the network

- places the B-channel in a maintenance state

- releases the call reference
- enters the *Null* state

If a *RELEASE COMPLETE* message is not received by the user before the first expiry of timer T308, the user

- retransmits the *RELEASE* message
- restarts timer T308

The user may include in the *RELEASE* message a second *Cause* information element with the *Cause* value #102 “Recovery on timer expiry”.

If a *RELEASE COMPLETE* message is not received from the network before T308 expires a second time, the user

- may place the B-channel in a maintenance state
- releases the call reference
- enters the *Null* state

  Note: The restart procedures contained in paragraph 5.7 on page 200 may be used on B-channels in the maintenance state.

5.3.5 Clear collision

Clear collision occurs when both the user and the network simultaneously transfer *DISCONNECT* messages specifying the same call reference value. When the network receives a *DISCONNECT* message while in the *Disconnect indication* state, the network

- stops timer T305
- sends a *RELEASE* message
- starts timer T308
- enters the *Release request* state.

Similarly, when the user receives a *DISCONNECT* message while in the *Disconnect request* state, the user

- stops timer T305
- disconnects the B-channel (if not disconnected)
- sends a *RELEASE* message
- starts timer T308
- enters the *Release request* state

Clear collision can also occur when both sides simultaneously transfer *RELEASE* messages related to the same call reference value. The entity receiving such a *RELEASE* message while within the *Release request* state

- stops timer T308
- releases the call reference and B-channel, if appropriate
- enters the *Null* state (without sending or receiving a *RELEASE COMPLETE* message)

5.4 In-band tones and announcements

Inband treatment procedures apply only for PRI calls with a bearer capability (BC) of speech or 3.1-kHz audio. When in-band tones or announcements not associated with a call state change are to be provided before reaching the *Active* state, a *PROGRESS message* is returned with the application of the in-band tone or announcement. The *PROGRESS* message contains the *Progress indicator* information element with *Progress description* value #8 “In-band information or appropriate pattern now available”.

> ***Note:*** When the *PROGRESS message* is used, the user may initiate call clearing as a result of the applied in-band tone or announcement, according to procedures in paragraph 5.3.3 on page 192.

5.5 Interworking with existing networks

Although the method of functional out-of-band signaling is unique to ISDN facilities, it is essential to preserve the same human interface for calls that are routed over these facilities, and to allow for interworking with non-ISDN interfaces. Methods for providing audible ringback, user busy tones, and announcements are essential to preserving the traditional human interface for telephony calls.

These procedures identify the agent responsible for generating in-band busy and audible ringback tones. The agent generates the tones for calls that are within an ISDN network as well as calls between ISDN and non-ISDN networks.

Three call scenarios are considered:

- The call has been delivered successfully to the terminating user, who is being alerted.
- The call is unsuccessful because the terminating user is busy.
- The call requires that network-provided tones or announcements be sent to the calling user.

In addition, three types of network connections need to be considered

- Type 1, within ISDN

- Type 2, from non-ISDN to ISDN
- Type 3, from ISDN to non-ISDN

Note that the decision making concerning the responsibility for the generation of tones is at the terminating side of the call only (the originating side simply receives the tones). Also, this specification is concerned with PRI ISDN. Therefore, the remainder of this section "Interworking with existing networks" will discuss the terminating side of the call in which the terminating circuit is a PRI which is Type 1 and Type 2.

5.5.1 Generation of audible ringback tones

Theoretically, generation of audible ringback tones could be provided by the DMS (network side) or the PRI CPE (user side) for calls that are offered to the PRI CPE. However, the DMS performs cut-through and expects the PRI CPE to provide audible ringback tone. This is true whether the call originated in the ISDN network or in a non-ISDN network.

5.5.2 Generation of busy tones

In-band busy tones are generated as close as possible to the calling user, allowing network resources to be released.

ISDN to ISDN (Type 1 network connection)

To indicate that the called user is busy, the PRI CPE sends a *DISCONNECT* message with *Cause* value #17 "User busy" to the DMS. The DMS disconnects the B-channel. If the call originated locally, the DMS generates the in-band busy tone locally. However, if the call originated from another ISDN office, the disconnect is propagated toward that office.

Non-ISDN to ISDN (Type 2 network connection)

As above, the DMS receives a *DISCONNECT* message with cause #17, "User busy" and disconnects the B-channel. If the call originated locally or from a non-ISDN circuit, the DMS generates the in-band busy tone locally and sends it toward the user.

5.5.3 Announcements

Calls within an ISDN may still have treatment applied, involving in-band information, for example, tones or voice announcements.

The cut-through procedures ensure that in-band tones will be heard by users, if provided. Therefore, the network or user may insert in-band tones or announcements before reaching the *Active* state, after sending a *PROGRESS* message.

5.6 Channel cut-through procedures

When the user-side requests a call and specifies a B-channel, if the B-channel is acceptable and the request can be processed, the DMS responds by sending a *Call Proceeding* message and cuts-through (connects) to the agreed upon B-channel.

When the network-side requests a call and specifies a B-channel, if the B-channel is acceptable and the request can be processed, the CPE responds with a *Call Proceeding, Alerting, or Connect* message with the specified B-channel. After receiving the first of these response messages, the DMS cuts-through (connects) to the agreed upon B-channel.

5.7 B-channel restart procedures

The B-channel restart procedures are used to return a single B-channel or all B-channels in a DS1, or all B-channels associated with the PRI interface to an idle condition. Restart procedures clear all calls on the identified B-channels. Further calls are prohibited on these B-channels until a REST ACK message is received in response to the REST message. The restart procedures are invoked:

- after a data link reset following a data link failure (that is, after expiry of timer T309).
- following expiry of timer T308 for a second time, caused by the absence of a response to the RELEASE message.
- on data link establish at time of system initialization.
- when adding or returning B-channels to service from a Maintenance or Out of Service state.

5.7.1 Sending Restart

A REST message is sent by the network or user to return a single B-channel or all B-channels in a DS1 or all B-channels associated with the PRI interface to the idle state.

When an entire PRI interface is to be restarted, the network tries to minimize the messaging by restarting the entire PRI interface if possible (see paragraph 5.7.1.1 on page 201). If the entire PRI interface cannot be restarted, the network tries to restart entire DS1s if possible (see paragraph 5.7.1.2 on page 201). If an entire DS1 cannot be restarted, the network tries to restart individual B-channels (see paragraph 5.7.1.3 on page 202). Before the network initiates a restart request it checks to see if there are any active calls. If there are no active calls the network immediately sends a REST message. If there are active calls the network will tear down the calls. Once the calls have been cleared the network will send a REST message.

During restart procedures, sending SERV (IS) message is redundant as the network side has already confirmed the idle status of B-channel with a REST ACK message. The network will not send a SERV (IS) message for a B-channel during the restart procedures.

5.7.1.1 Sending a PRI Restart message

A PRI restart will be initiated by the network only if all B-channels can be idled. For example, if the network wants to restart a PRI but there are B-channels in the PRI that are in the INB, MB, CPD or RMB states, the REST message will not be sent for the whole PRI and the network will attempt to send a series of DS1 restart messages as described in paragraph 5.7.1.2 on page 201.

If all of the channels can be idled, all of the active calls are torn down and a REST message will be sent that specifies the whole PRI.

After transmitting a REST message for the PRI, the sender,

- starts timer T316.

When a REST ACK message for the PRI is received by the sender of the REST message, the sender

- stops timer T316
- frees the channel and call reference values for reuse.
- places all B-channels in the idle state.

If the network does not receive a REST ACK message for the PRI on the initial attempt to restart all B-channels before timer T316 expires, the network will re-send a REST message and re-start timer T316. Until a valid response is received, no calls are allowed on the channels associated with the restart.

If the network does not receive a REST ACK message acknowledging the PRI restart before the second expiry of timer T316, the network will attempt to start the DS1's individually as described in paragraph 5.7.1.2 on page 201.

If the network receives a PRI REST ACK message while timer T316 is not running the network will discard the REST ACK message.

5.7.1.2 Sending a single DS1 Restart message

A DS1 restart will be initiated by the network only if all of the B-channels can be idled. For example, if the network wants to restart a DS1 but there are B-channels in the DS1 that are in the INB, MB, CPD or RMB states, the REST message will not be sent for the whole DS1 and the network will attempt to send a series of individual B-channel restart messages as described in paragraph 5.7.1.3 on page 202. When several DS1's are to be restarted, the network will complete work on a specific DS1 (even if this means performing individual B-channel restarts associated with the specific DS1) before attempting to restart the next DS1.

If all of the channels can be idled, all of the active calls are torn down and a REST message will be sent that specifies the whole DS1.

After transmitting a REST message for the DS1, the sender,

- starts timer T316.

When a REST ACK message for the DS1 is received by the sender of the REST message, the sender

- stops timer T316
- frees the channel and call reference values for reuse.
- places all B-channels in the idle state.

If the network does not receive a REST ACK message for the DS1 on the initial attempt to restart all B-channels before timer T316 expires, the network will re-send a REST message and re-start timer T316. Until a valid response is received, no calls are allowed on the channels associated with the restart.

If the network does not receive a REST ACK message acknowledging the DS1 restart before the second expiry of timer T316, the network will attempt to start the B-channels individually as described in paragraph 5.7.1.3 on page 202.

If the network receives a DS1 REST ACK message while timer T316 is not running the network will discard the REST ACK message.

5.7.1.3 Sending a single B-channel Restart message

A single B-channel REST message can be sent by the network to initialize a single B-channel. When a single B-channel REST ACK message is received, the network will put the B-channel in the idle state.

A B-channel in the MB state can only be returned to service by craftsperson from the MAP by posting the B-channel, and then performing the RTS command on the B-channel. This will initiate the single B-channel restart procedure on the B-channel.

After transmitting a single B-channel REST message, the sender,

- starts timer T316.

When a single B-channel REST ACK message is received by the sender of the REST message, the sender,

- stops timer T316

- frees the channel and call reference value for reuse.
- places the B-channel in the idle state.

On the first expiry of timer T316, a single B-channel REST message will be re-sent by the network and timer T316 will be re-started. On the second expiry of timer T316 the network will not re-send a single B-channel REST message for the B-channel and will take the concerned B-channel out of service and send a SERVice (OOS) message to the user. The PRI audit procedure for B-channels will then periodically try to restart the B-channel.

If the network receives a single B-channel REST ACK message for a B-channel while the B-channel is in the RMB state and timer T316 is not running, the network will send a SERV (IS) message for the B-channel to the CPE.

5.7.2 Receipt of REST message

The response to the received REST message depends upon whether the message specifies a PRI, DS1, or single B-channel. The response also depends on whether the function for B-channel service messaging is enabled or disabled.

> ***Note:*** For more information on B-channel service messaging see paragraph 7.2 on page 227.

5.7.2.1 Receipt of a PRI or DS1 REST message

If the function for B-channel service messaging is enabled, after receiving a PRI or DS1 REST message, the network will:

- If none of the B-channels indicated in the REST message can be idled (i.e., all B-channels are in the INB, MB or CPD states) a REST ACK will not be sent to the CPE.
- If some of the B-channels indicated in the REST message cannot be idled (i.e. these B-channels are in the INB, MB or CPD states), then,
  - — B-channels which can be made available will be cleared of any active calls then idled.
  - — a REST ACK message will be returned to the CPE
  - — SERV (OOS) messages will be sent for B-channels that could not be idled. They will be placed in the OOS state.
- If all the B-channels indicated in the REST message can be idled (i.e., no B-channels are in the INB, MB or CPD states), then,
  - — B-channels which can be made available will be cleared of any active calls then idled.
  - — a REST ACK message will be returned to the CPE

If the function for B-channel service messaging is disabled by the network, the network will:

- — not respond to the received REST message if there are B-channels in the MB, INB or CPD state. However, any active calls are cleared and the channels that were not MB, INB, or CPD are placed in the RMB state.
- — respond to the received REST message if all of the B-channels can be idled. Any active calls are cleared before the response is given.

Note: The DMS craft may try to return to service B-channel which is part of the group being restarted as described in the above section 5.7.2.1. In such cases, the B-channel will be put in a state which can be idled after the REST ACK is sent.

5.7.2.2 Receipt of a single B-channel REST message

If the function for B-channel service messaging is enabled, after receiving a single B-channel REST message,

- If the indicated B-channel is not in the MB, INB or CPD state, the recipient,
  - — initiates the appropriate internal actions to return the specified B-channel to the idle condition.
  - — sends a single B-channel REST ACK message to the originator after completion of internal clearing, specifying the same B-channel as received in the single B-channel REST message
  - — places the B-channel in the idle state
- If the indicated B-channel is in the MB, INB or CPD state, the recipient responds with a SERV (OOS) message. No REST ACK message will be sent. The B-channel state remains in the same state.

If the function for B-channel service messaging is disabled by the network, the network will not respond to the received single B-channel REST message if the B-channel is in the MB, INB or CPD state.

5.7.3 Coordination of B-channel restart procedures and B-channel service messaging procedures

For the coordination of B-channel restart procedures and B-channel service messaging procedures, see paragraph 7.4.4 on page 230

5.7.4 Coordination of B-channel restart procedures and backup D-channel procedures

For the coordination of B-channel restart procedures and D-channel procedures, see paragraph 9.3.6 on page 280.

5.7.5 Message collisions

Please refer to the tables that follow. The titles of the tables describe a point in time from the network's point of view. The table's contents show, for each next message, the network action taken.

Table 4-25 After Sending a B-Channel RESTart Message

Next Message	Action Taken
Send B-Channel RESTart	Not Possible
Send DS1 RESTart	Stop T316, Proceed with the DS1 Restart
Send PRI RESTart	Stop T316, Proceed with the PRI Restart
Received B-Channel RESTart	Send RESTart ACK
Received DS1 RESTart	Stop T316, Proceed with the DS1 Restart
Received PRI RESTart	Stop T316, Proceed with the PRI Restart
Send SERVice (IS)	Not Possible
Send SERVice (OOS)	Abort Restart, Wait for SERVice ACK (OOS)
Receive SERVice (IS)	Send SERVice ACK (IS), Wait for RESTart ACK
Receive SERVice (OOS)	Send SERVice ACK (OOS), Stop timer T316

Table 4-26 After Sending a DS1 RESTart Message

Next Message	Action Taken
Send B-Channel RESTart	Not Possible
Send DS1 RESTart	Not Possible
Send PRI RESTart	Stop T316 for DS1 restart, Proceed with PRI Restart
Received B-Channel RESTart	Proceed with the DS1 Restart
Received DS1 RESTart	Send RESTart ACK
Received PRI RESTart	Proceed with the PRI Restart
Send SERVice (IS)	Not Possible
Send SERVice (OOS)	Not Possible
Receive SERVice (IS)	Send SERVice ACK (IS), continue the DS1 Restart
Receive SERVice (OOS)	Continue the DS1 Restart, Send SERVice ACK (OOS)

Table 4-27 After Sending a PRI RESTart Message

Next Message	Action Taken
Send B-Channel RESTart	Not Possible
Send DS1 RESTart	Not Possible
Send PRI RESTart	Not Possible
Received B-Channel RESTart	Proceed with the PRI Restart
Received DS1 RESTart	Proceed with the PRI Restart
Received PRI RESTart	Send RESTart ACK
Send SERVice (IS)	Not Possible
Send SERVice (OOS)	Wait for RESTart ACK, wait for SERVice ACK (OOS)
Receive SERVice (IS)	Send SERVice ACK (IS), continue the PRI Restart
Receive SERVice (OOS)	Send SERVice ACK (OOS), continue the PRI Restart

Table 4-28 After Receiving a B-Channel RESTart Message

Next Message	Action Taken
Send B-Channel RESTart	Not Possible
Send DS1 RESTart	Proceed with DS1 Restart
Send PRI RESTart	Proceed with PRI Restart
Received B-Channel RESTart	Proceed with B-Channel Restart
Received DS1 RESTart	Proceed with DS1 Restart
Received PRI RESTart	Proceed with PRI Restart
Send SERVice (IS)	Not Possible
Send SERVice (OOS)	Proceed with B-Channel Restart, Wait for SERVice ACK (OOS)
Receive SERVice (IS)	Send RESTart ACK, send SERVice ACK (IS)
Receive SERVice (OOS)	No RESTart ACK, Send SERVice ACK (OOS)

Table 4-29 After Receiving a DS1 RESTart Message

Next Message	Action Taken
Send B-Channel RESTart	Not Possible
Send DS1 RESTart	Not Possible
Send PRI RESTart	Proceed with PRI Restart
Receive B-Channel RESTart	Proceed with DS1 Restart
Receive DS1 RESTart	Proceed with DS1 Restart
Receive PRI RESTart	Proceed with PRI Restart
Send SERVice (IS)	Not Possible
Send SERVice (OOS)	Proceed with DS1 Restart, Send SERVice (OOS) after DS1 Restart
Receive SERVice (IS)	Send RESTart ACK, send SERVice ACK (IS)
Receive SERVice (OOS)	Proceed with DS1 Restart, Send SERVice ACK (OOS)

Table 4-30 After Receiving a PRI RESTart Message

Next Message	Action Taken
Send B-Channel RESTart	Not Possible
Send DS1 RESTart	Not Possible
Send PRI RESTart	Not Possible
Receive B-Channel RESTart	Proceed with PRI Restart
Receive DS1 RESTart	Proceed with PRI Restart
Receive PRI RESTart	Proceed with PRI Restart
Send SERVice (IS)	Not Possible
Send SERVice (OOS)	Proceed with PRI Restart, wait for SERVice ACK (OOS)
Receive SERVice (IS)	Send RESTart ACK, send SERVice ACK (IS)
Receive SERVice (OOS)	Send SERVice ACK (OOS), continue restart procedure

Table 4-31 After Sending SERVice (IS) Message

Next Message	Action Taken
Send B-Channel RESTart	Not Possible
Send DS1 RESTart	Stop T323, Proceed with DS1 Restart
Send PRI RESTart	Proceed with PRI Restart
Receive B-Channel RESTart	Proceed with B-Channel Restart
Receive DS1 RESTart	Stop T323, Proceed with DS1 Restart
Receive PRI RESTart	Proceed with PRI Restart
Send SERVice (IS)	Not Possible
Send SERVice (OOS)	Wait for SERVice ACK (OOS)
Receive SERVice (IS)	Proceed as a SERVice ACK (IS) is received
Receive SERVice (OOS)	Send SERVice ACK (OOS)
Receive SETUP	Process the call request

Table 4-32 After Sending a SERVice (OOS) Message

Next Message	Action Taken
Send B-Channel RESTart	Stop T323, Proceed B-Channel Restart
Send DS1 RESTart	Not Possible
Send PRI RESTart	Not Possible
Receive B-Channel RESTart	No RESTart ACK, wait for SERVice ACK (OOS)
Receive DS1 RESTart	Stop T323, Proceed with DS1 Restart, which re-sends SERVice (OOS)
Receive PRI RESTart	Process PRI Restart, which re-sends SERVice (OOS)
Send SERVice (IS)	Wait for SERVice ACK (IS), ignore SERVice ACK (OOS)
Send SERVice (OOS)	Not Possible
Receive SERVice (IS)	Send SERVice ACK (OOS)
Receive SERVice (OOS)	Proceed as SERVice ACK (OOS) is received
Receive SETUP	Reject call request (send RELease COMplete)

Table 4-33 After Receiving a SERVice (IS) Message

Next Message	Action Taken
Send B-Channel RESTart	Not Possible
Send DS1 RESTart	Proceed with DS1 Restart
Send PRI RESTart	Proceed with PRI Restart
Receive B-Channel RESTart	Proceed with B-Channel Restart
Receive DS1 RESTart	Proceed with DS1 Restart
Receive PRI RESTart	Proceed with PRI Restart
Send SERVice (IS)	Not Possible
Send SERVice (OOS)	No SERVice ACK (IS), wait for SERVice ACK (OOS)
Receive SERVice (IS)	Send SERVice ACK (IS), if NE/INSV
Receive SERVice (OOS)	Send SERVice ACK (OOS)
Reveive SETUP	Process the call request, if NE/INSV

Table 4-34 After Receiving a SERVice (OOS) Message

Next Message	Action Taken
Send B-Channel RESTart	Not Possible
Send DS1 RESTart	Not Possible
Send PRI RESTart	Not Possible
Receive B-Channel RESTart	No SERVice ACK (OOS), process B-Channel Restart
Receive DS1 RESTart	No SERVice ACK (OOS), process DS1 Restart
Receive PRI RESTart	No SERVice ACK (OOS), process PRI Restart
Send SERVice (IS)	Not Possible
Send SERVice (OOS)	Not Possible
Receive SERVice (IS)	Send SERVice ACK (IS), if NE/INSV
Receive SERVice (OOS)	Send SERVice ACK (OOS)
Receive SETUP	Process the call request, if NE/INSV

5.7.6 Error handling

If the channel id in the REST ACK message received by the network is not the same as the one specified in the original REST message sent by the network, the network will then ignore the REST ACK message and allow timer T316 to continue to run.

If the network receives a REST message with restart indicator IE set to 0 (meaning the channel to be restarted is indicated in the channel identification IE) and the channel identification IE does not have the channel number to restart, then the message is ignored and no action is taken.

An unsolicited REST ACK message received by the network will be ignored except when it is a single B-channel restart acknowledgment message and the B-channel is in OOS/FE state. In the exception case, a SERV (IS) message will be sent to CPE by the network.

5.8 Call collisions

The term “Call collisions” is a slight misnomer. Simultaneous incoming and outgoing call requests are not a problem since both calls are processed easily unless they both attempt to select the same channel. The term “Channel selection collision” would probably be more accurate.

Channel selection collision may occur if an incoming call and outgoing call select the same channel. This is resolved by the network through the channel selection procedures described in paragraph 5.1.2 on page 184 and paragraph 5.2.2 on page 187.

In such conflicts, the network gives priority to the incoming call over the outgoing call request received from the user.

The network clears the outgoing call if the B-channel cannot be

- allocated by the network
- accepted by the user originating the call

5.9 Handling of error conditions

All messages using the Q.931 protocol discriminator must pass the checks described in paragraph 5.9.1 on page 211 through paragraph 5.9.7 on page 215.

Errors found in messages using the maintenance protocol discriminator, described in paragraph 4.2 on page 130, cause the message to be ignored, that is, as if the message had never been received.

Errors found in messages using the call control protocol discriminator, result in NCAS connections being released if the error count exceeds a threshold. Normal calls are not released and trunks are not removed from service due to the number of protocol errors.

The procedures in paragraph 5.9.1 on page 211 through paragraph 5.9.7 on page 215 are listed in order of precedence.

5.9.1 Protocol discrimination error

When a message is received with a protocol discriminator coded other than "Q.931 user-network call control message" or "Maintenance messages", that message is ignored.

5.9.2 Message too short error

When a message is received that is too short to contain a complete *Message type* information element, that message is ignored.

5.9.3 Call reference error

5.9.3.1 Invalid call reference format

In the *Call reference* information element, if octet 1, bits 5 through 8 are not set to "0000", the message is ignored.

In the *Call reference* information element, if octet 1, bits 1 through 4 indicate a length greater than the maximum length supported by the receiving equipment, the message is ignored. (See paragraph 4.3 on page 130 for further details.)

5.9.3.2 Call reference procedural errors

- Whenever any message except *SETUP*, *RELEASE COMPLETE*, *STATUS*, or *STATUS ENQUIRY* is received specifying a call reference which is not recognized as relating to an active call or to a call in progress, the receiver initiates clearing. Clearing is initiated by sending a *RELEASE COMPLETE* message with *Cause* value #81 "Invalid call reference value". This message specifies the call reference value of the received message. The receiver remains in the *Null* state.
- When a *RELEASE COMPLETE* message is received specifying a call reference value which is not recognized as relating to an active call or to a call in progress, no action is taken.
- When a *SETUP* message is received specifying a call reference value which is not recognized as relating to an active call or to a call in progress, and with a call reference flag incorrectly set to "1", the message is ignored.
- When a *SETUP* message is received specifying a call reference value which is recognized as relating to an active call or to a call in progress, this message is ignored.

- When any message except *RESTART*, *RESTART ACKNOWLEDGE*, *SERVICE*, *SERVICE ACKNOWLEDGE*, or *STATUS* is received using the global call reference, no action is taken. A *STATUS* message using the global call reference with a call state indicating the current state associated with the global call reference and a *Cause* value #81 “Invalid call reference value” is returned.
- When a *STATUS* message is received specifying a call reference value which is not recognized as relating to an active call or to a call in progress, the procedures in paragraph 5.9.11 on page 219 are followed.
- When a *STATUS ENQUIRY* message is received specifying a call reference value which is not recognized as relating to an active call or to a call in progress, a *STATUS* message is returned indicating the *Null* call state with *Cause* value #30 “Response to Status enquiry”.

5.9.4 Message type or message sequence errors

Whenever an unexpected message, except *RELEASE*, *RELEASE COMPLETE*, *CONNECT_ACK* or an unrecognized message is received in any state other than the *Null* state, a *STATUS* message is returned with one of the following *Cause* values

- #97 “Message type non-existent or not implemented”
- #101 “Message not compatible with call state”

However, there are exceptions to the above procedure:

- When the network or the user receives an unexpected *RELEASE* message (for example, if the *DISCONNECT* message is corrupted by undetected transmission errors). In this case, no *STATUS* message is sent.
  - — When the network receives an unexpected *RELEASE* message, the network
    - – disconnects and releases the B-channel
    - – clears the network connection and the call to the remote user with the *Cause* value in the *RELEASE* message sent by the user or, if not included, *Cause* value #31 “Normal, unspecified”
    - – returns a *RELEASE COMPLETE* message to the user
    - – releases the call reference
    - – stops all timers
    - – enters the *Null* state
  - — When the user receives an unexpected *RELEASE* message, the user
    - – disconnects and releases the B-channel
    - – returns a *RELEASE COMPLETE* message to the network

  - releases the call reference
  - stops all timers
  - enters the *Null* state

- When the network or the user receives an unexpected *RELEASE COMPLETE* message
  - When the network receives an unexpected *RELEASE COMPLETE* message, the network
    - disconnects and releases the B-channel
    - clears the network connection and the call to the remote user with the *Cause* value indicated by the user or, if not included, *Cause* value #111 “Protocol error, unspecified”
    - releases the call reference
    - stops all timers
    - enters the *Null* state
  - Whenever the user receives an unexpected *RELEASE COMPLETE* message, the user
    - disconnects and releases the B-channel
    - releases the call reference
    - stops all timers
    - enters the *Null* state

- When a *NOTIFY* message is received which is in error
  - the recipient ignores the message, since, in general, the reception of a *NOTIFY* message does not cause the generation of a *STATUS* message.

- When the network or the user receives an unexpected connect_ack message in the call state N12 (Disconnect indication), no action is taken; message is ignored. In any other states, a STATUS message is sent with cause #101.

5.9.5 General information element errors

The general information element error procedures may also apply to information elements in codesets other than 0. The diagnostics in the *Cause* information element may indicate information elements other than those in codeset 0 by applying the locking shift procedures as described in paragraph 4.5.3 on page 137.

5.9.5.1 Information element out-of-sequence error

A variable length information element which has a code value lower than the code value of the variable length information element preceding it is considered as an out-of-sequence information element.

If a message with an out-of-sequence information element (mandatory or non-mandatory IE) is received, the network will ignore the information element.

5.9.5.2 Duplicated information elements error

If an information element is repeated in a message in which repetition of the information element is not permitted, only the contents of the information element appearing first are handled. All subsequent repetitions of the information element are ignored.

When repetition of information elements is permitted, only the contents of permitted information elements are handled. If the limit on repetition of information elements is exceeded, the contents of information elements appearing first up to the limit of repetitions are handled. All subsequent repetitions of the information element are ignored.

> ***Note:*** There are some legitimate exceptions in which all entries of the duplicate IE will be handled up to the maximum limit allowed.

5.9.6 Mandatory information element errors

5.9.6.1 Mandatory information element missing

When a message other than *SETUP*, *DISCONNECT, RELEASE* or *RELEASE COMPLETE* is received that has one or more mandatory information elements missing, no action is taken on this message and no state change occurs. A *STATUS* message is returned with *Cause* value #96 “Mandatory information element is missing”.

When a *SETUP* or *RELEASE* message is received that has one or more mandatory information elements missing, a *RELEASE COMPLETE* message with *Cause* value #96 “Mandatory information element is missing” is returned.

When a *DISCONNECT* message is received with the *Cause* information element missing, the actions taken are same as if a *DISCONNECT* message with *Cause* value #31 “Normal, unspecified” was received (see paragraph 5.3 on page 191). The exception is that the *RELEASE* message sent to the user has *Cause* value #96 “Mandatory information element is missing”.

When a *RELEASE COMPLETE* message is received with a *Cause* information element missing, it is assumed that a *RELEASE COMPLETE* message has been received with *Cause* value #31 “Normal, unspecified”.

5.9.6.2 Mandatory information element content error

When a message other than *SETUP*, *DISCONNECT*, *RELEASE* or *RELEASE COMPLETE* is received that has one or more mandatory information elements with invalid content, no action is taken on this message and no state change occurs. A *STATUS* message is returned with *Cause* value #100 “Invalid information element contents”.

When a *SETUP* or *RELEASE* message is received that has one or more mandatory information elements with invalid content, a *RELEASE COMPLETE* message is returned with *Cause* value #100 “Invalid information element contents”.

When a *DISCONNECT* message is received with invalid content of the *Cause* information element, the action taken is the same as if a *DISCONNECT* message with *Cause* value #31 “Normal, unspecified” was received (see paragraph 5.3 on page 191). The exception is that the *RELEASE* message sent on the local interface has *Cause* value #100 “Invalid information element contents”.

When a *RELEASE COMPLETE* message is received with invalid content of the *Cause* information element, it is assumed that a *RELEASE COMPLETE* message was received with *Cause* value #31 “Normal, unspecified”.

Information elements with a length exceeding the maximum length are treated as information elements with content error.

Receipt of an information element which has been truncated (for example, the length of IE is more than it receives) would lead to ignoring the message by the network, and no state change should occur.

5.9.7 Non-mandatory information element errors

The following sections identify actions on information elements not recognized as mandatory.

5.9.7.1 Unrecognized information elements

Unrecognized information elements are non-mandatory information elements whose information element identifiers are not implemented by the receiver of the information element.

When a message is received which has one or more unrecognized information elements, the receiving entity checks whether any are encoded to indicate “comprehension required”. If any unrecognized information element is encoded to indicate “comprehension required”, the procedures in paragraph 5.9.6.1 on page 214 are followed. That is, as if a missing mandatory information element error condition had occurred.

If all unrecognized information elements are not encoded to indicate "comprehension required", the receiving entity proceeds as follows:

- Action is taken on the message and those information elements which are recognized and have valid content.
- When the received message is other than *DISCONNECT*, *RELEASE* or *RELEASE COMPLETE*, a *STATUS* message is returned by the network and may be returned by the user. It has one *Cause* information element. The *STATUS* message indicates the call state in which the receiver detected the error. The *Cause* information element has *Cause* value #99 "Information element non-existent or not implemented", and the diagnostic field contains the information element identifier of each unrecognized information element. The network sends only the first unrecognized information element identifier in the diagnostic field.
- Subsequent actions are determined by the sender of the unrecognized information elements. If a clearing message contains an unrecognized information element, the error is reported to the local user as follows:
  - — When a *DISCONNECT* message is received that has an unrecognized information element, a *RELEASE* message is returned with *Cause* value #99 "Information element non-existent or not implemented". The *Cause* information element diagnostic field, if present, contains the information element identifier for each information element which was unrecognized. The network sends only the first unrecognized information element identifier in the diagnostic field.
  - — When a *RELEASE* message is received that has an unrecognized information element, a *RELEASE COMPLETE* message is returned with *Cause* value #99 "Information element non-existent or not implemented". The *Cause* information element diagnostic field contains the first information element identifier that is unrecognized. The network sends only the first unrecognized information element identifier in the diagnostic field.
  - — When a *RELEASE COMPLETE* message is received that has an unrecognized information element, no action is taken on the unrecognized information.

  Note: The diagnostic of *Cause* value #99 facilitates the decision in selecting an appropriate recovery procedure at the reception of a *STATUS* message. Therefore, it is recommended that the user provide *Cause* value #99 with diagnostics if it expects the network to take appropriate action at the receipt of a *STATUS* message, although inclusion of the diagnostics is optional.

5.9.7.2 Non-mandatory information element content error

When a message is received that has one or more non-mandatory information elements with invalid content, action is taken on the message and those information elements that are recognized and have valid content.

A *STATUS* message is returned by the network and may be returned by the user containing one *Cause* information element. If the message containing one or more non-mandatory information elements with invalid content is a *RELEASE COMPLETE* message, no *STATUS* message is returned.

The *STATUS* message indicates the call state in which the receiver detected the error. The *Cause* information element has *Cause* value #100 “Invalid information element contents”. The diagnostic field, if present, contains the information element identifier of the information elements that have invalid contents. The network sends only the first information element which had invalid contents in the diagnostic field.

Information elements with a length exceeding the maximum length are treated as information elements with content error.

Receipt of an information element which has been truncated (for example, the length of IE is more than it receives) would lead to ignoring the message by the network, and no state change should occur.

5.9.8 Data link reset

Whenever Layer 3 is informed of a spontaneous data link layer reset by means of the *DL-Establish-Indication* primitive, the following procedures are carried out:

- For calls in the disestablishment phase (states N11, N12, N19, U11, U12 or U19), no action is taken.
- Calls in the establishment phase (states N1, N3, N4, N6, N7, N8, N9, U1, U3, U4, U6, U7, U8 or U9) are cleared according to the procedures in paragraph 5.3 on page 191.
- For calls in the active state (state N10 or U10), a *STATUS ENQUIRY* is not sent from the network to the user but may be sent from the user to the network. (See paragraph 5.9.10 on page 218 and paragraph 5.9.11 on page 219 for further information.)

5.9.9 Data link failure

Whenever Layer 3 is notified by its data link entity by means of the *DL-Release-Indication* primitive that there is a data link layer malfunction, the following procedures are performed:

- Any calls not in an active state are cleared internally.
- Any call in the active state will remain active, and timer T309 will be started (see Note).

> ***Note:*** If timer T309 is already running, it is not restarted. The timer T309 is an optional timer of the user side, but mandatory on the network side (see below).

Layer 3 requests a Layer 2 re-establishment by sending a *DL-Establish-Request* primitive. When informed of Layer 2 re-establishment by means of the *DL-Establish-Confirm* primitive, Layer 3 stops timer T309, and

- either sends out a *STATUS* message with *Cause* value #31 “Normal, unspecified” to report the current state to the peer entity
- OR, sends out a *STATUS ENQUIRY* message to verify the call state of the peer entity (NOTE: DMS-100 does not send *STATUS ENQUIRY*)

If timer T309 expires prior to data link re-establishment, the network

- clears the network connection and call to the remote user with *Cause* value #27 “Destination out of order”
- disconnects and releases the B-channel
- releases the call reference
- enters the *Null* state

The implementation of timer T309 on the user side is optional, but is mandatory on the network side. If timer T309 expires prior to data link establishment, the user:

- clears the attached connection (if any) with *Cause* #27 “Destination out of order”
- disconnects and releases the B-channel
- releases the call reference
- enters the *Null* state

When a back-up D-channel is available, the back-up D-channel procedures, as specified in Annex C paragraph 9.3 on page 272, are used.

5.9.10 Status enquiry procedure

Whenever an entity wishes to check the call state at a peer entity, a *STATUS ENQUIRY* message is sent requesting the call state. Note that DMS-100 does not send *STATUS ENQUIRY* messages.

After sending the *STATUS ENQUIRY* message, the user side may start timer T322 in anticipation of receiving a *STATUS* message. While timer T322 is running only one outstanding request for call state information can exist. Therefore, if timer T322 is already running, it is not restarted. If a clearing message is received before timer T322 expires, timer T322 is stopped, and call clearing continues.

When a *STATUS ENQUIRY* message is received, the receiver responds with a *STATUS* message, reporting the current call state and *Cause* value #30 “Response to status enquiry”. Receipt of the *STATUS ENQUIRY* message does not result in a state change.

The sending or receipt of the *STATUS* message in such a situation does not directly affect the call state of either the sender or receiver. The side having received the *STATUS* message inspects the *Cause* information element. If a *STATUS* message is received that contains *Cause* #30 “Response to status enquiry”, timer T322 is stopped and the appropriate actions taken, based on the information in the *STATUS* message, relative to the current state of the receiver. On the network side, the call is cleared if the state of the incoming *STATUS* message is not compatible with the network state.

Further “appropriate actions” taken by a user are implementation dependent. However, the actions described in the following sections apply.

If timer T322 expires (that is, no *STATUS* message was received) the *STATUS ENQUIRY* message may be retransmitted one or more times until a response is received. The number of times a *STATUS ENQUIRY* message is retransmitted by the user is an implementation dependent value. The network does not retransmit the *STATUS ENQUIRY* message. The call is cleared to the local interface with *Cause* value #41 “Temporary failure”, if the *STATUS ENQUIRY* is retransmitted the maximum number of times. If appropriate, the network also clears the network connection, using *Cause* value #41 “Temporary failure”.

5.9.11 Receiving a *STATUS* message

When a *STATUS* message reporting an incompatible state is received, if the receiving entity determines that the state mismatch is a valid error condition (see Note below) it carries out one of the following procedures:

- Clears the call by sending the appropriate clearing message with *Cause* value #101 “Message not compatible with call state”.
- Takes other actions that attempt to recover from the mismatch. These actions are implementation dependent.

  Note: The sending and receiving state machines are dynamic, and valid state mismatches can occur due to message flow during the status enquiry and response stage. Further, one or both entities may not implement all call states.

The determination of which states are incompatible is an implementation option for the user.

The network considers the following states to be incompatible:

- If a *STATUS* message indicating any call state except the *Null* state is received in the *Null* state, the receiving entity sends a *RELEASE COMPLETE* message with *Cause* value #101 “Message not compatible with call state”. The receiving entity remains in the *Null* state.
- If a *STATUS* message indicating any call state except the *Null* state is received in the *Release request* state, no action is taken.
- If a *STATUS* message indicating the *Null* state is received in any state except the *Null* state, the receiver releases all resources and enters the *Null* state. When in the *Null* state, the receiver of a *STATUS* message that indicates the *Null* state takes no action other than to discard the message.
- If a *STATUS* message indicating any call state except the *Active* state is received in the *Active* state, a *STATUS ENQUIRY* message is sent.

A *STATUS* message may be received indicating a compatible call state but which has one of the following *Cause* values:

- #96 “Mandatory information element is missing”
- #97 “Message type non-existent or not implemented”
- #99 “Information element non-existent or not implemented”
- #100 “Invalid information element contents”.

The actions taken by the user are an implementation option. If other procedures are not defined, the receiver clears the call with the appropriate procedure defined in paragraph 5.3 on page 191. It uses the *Cause* value specified in the received *STATUS* message. The network clears the call only when receiving a *Cause* value #96 “Mandatory information element is missing”.

On receipt of a *STATUS* message specifying a global call reference and reporting an incompatible state in the *Restart request* or *Restart* state, the receiving Layer 3 entity informs layer management and takes no further action on this message.

When in the *Null* state, if a *STATUS* message is received with the global call reference, no action is taken.

Chapter 4-6: Single D-Channel Maintenance

This section describes the single D-channel maintenance procedures that are supported between the user and the network. Procedures for backup D-channels are described in “9.3 Annex C - Backup D-channel service” on page 272.

The single D-channel procedures are initiated by one of the following actions:

- initialization of an ISDN PRI interface
- manually busy the D-channel
- manually return the D-channel to service
- automatic detection of D-channel failure, that is, receipt of a DL-Release-Indication primitive from layer 2

6.1 Single D-channel states

The DMS switch supports the following single D-channel MAP states:

INS	In Service. The D-channel is in Multiple Frame Established state at layer 2 and is able to carry signaling via layer 3 for call control and/or services.
WAI	Wait. In this state the maintenance entity has initiated moving the D-channel to the IS state and is waiting for confirmation from the other end of the interface.
CFL	Carrier Fail. The D-channel enters this state when the carrier where the D-channel resides has failed and is unavailable for use.
LO	Lock Out. A D-channel is in LO state indicates a failure at layer 2 or lower.

PMB Peripheral Man Busy. This state indicates that the D-channel is out of service due to the XPM being manually busied.

RNR Remote Not Ready. This state is entered when trying to establish layer 2 on the D-channel and Layer 2 establishment fails and times out.

INI Initialize. This state is used during an ONP. The D-channels are put in this state on the inactive side before the CM SWACT.

MB Manual Busy. The D-channel has been placed in the TEI assigned state by external control and is not available. Any requests for layer 2 establishment will be denied in the MB state. Only manual intervention on the near end can move the D-channel to a more available state.

INB Installation Busy. This is the D-channel state when it is first provisioned, or when service changes are being made to the interface. In other respects, this state is identical to MB.

The LO and CFL states are all considered to be out of service (OOS) states in the following sections. The PRI audit periodically attempts to establish layer 2 on the D-channel.

The D-channel will remain in the OOS state until one of the following occurs:

- If a DM is received for a SABME the network will place the link in a OOS state while layer 3 periodically request layer 2 to establish the link
- A non-signaling/external control request is made to disconnect the link, which would place the D-channel in the MB state.

While in the MB state a link request will result in a layer 2 link establishment denial. This means that if a SABME is received in the MB state the DMS switch will respond with a UA immediately followed by a DISC message.

6.2 Timers

The following timers are defined for D-channel maintenance.

T3DW This timer determines the maximum time that a maintenance entity waits for a *DL-Establish-Confirm* or *DL-Establish-Indication* primitive after sending a *DL-Establish-Request* primitive. The value of this timer in the network is 5 seconds. The value of this timer on the user side is not critical, but should be greater than N200 x T200 (see Section 3) to ensure that Layer 2 establishment has failed.

T309 This timer is the maximum amount of time allowed for data link re-establish. This timer is started if there are active calls when the data link fails. The default value of this timer for D-channel backup protocol is 90 seconds.

T316 This timer is the maximum amount of time that layer 3 waits for a response to a REST message used in the B-channel restart procedure. This timer is started when a REST message is sent. The default value of this timer in the network is 120 seconds.

T321 This timer is the maximum amount of time that layer 3 waits for a response to a SERV message used in the backup D-channel procedures. This timer is started when a SERV message is sent. The default value of this timer in the network is 40 seconds.

6.3 Single D-channel procedures

Those procedures in section 5.9.8 on page 217 and in section 5.9.9 on page 217 are referenced where there are interactions between the D-channel maintenance procedures and call control.

6.3.1 Service changes

In order for the network to allow the D-channel service changes the D-channel must be in the INB state. Similarly, the user side should also ensure that layer 3 is not established while service changes are being made.

On the network side, the D-channel must be in the MB state before it can be manually moved to the INB state. Similarly, when the D-channel is in the INB state, it can only be moved to the MB state.

6.3.2 Single D-channel Initialization procedure

To begin the transfer of normal Layer 3 messages across the user-network interface requires the establishment of, first Layer 2 and then Layer 3. These procedures are described in this section.

6.3.2.1 Layer 2 establishment

D-channel establishment is initiated by manual intervention on the near-end of the interface to move the D-channel state from MB to IS. When the D-channel moves to the IS state, Layer 3 first

- sends a *DL-Establish-Request* primitive to Layer 2
- starts timer T3DW

If timer T3DW expires, the Layer 3 entity in the network resends the *DL-Establish-Request* primitive periodically, approximately every 120 seconds, although the first interval may be shorter. The user may also periodically request Layer 2 establishment.

When Layer 3 receives a *DL-Establish-Confirm* or *DL-Establish-Indication* primitive from Layer 2, the D-channel first moves to state IS, then Layer 3 establishment can proceed, as described below. If running, timer T3DW is stopped. If a *DL-Establish-Indication* primitive is received when the D-channel state is less available than IS, Layer 3 responds with a *DL-Release-Request* primitive.

If Layer 3 receives a *DL-Establish-Indication* primitive from Layer 2 when the D-channel is in the IS state, a data link reset has occurred. In this case, Layer 3 clears all calls which are not in the *Active* state, following the procedures in section 5.9.8 on page 217. The D-channel remains in the IS state.

6.3.2.2 Layer 3 establishment

For single D-channel configurations, the D-channel can not be brought into service via SERV/SERV ACK messages. The D-channel in single D-channel configurations will be moved to an in service state when layer 2 is established on the D-channel. Once layer 2 is established and the single D-channel has been moved to IS, the B-channels will then be restarted by using restart procedures as follows:

- send a PRI restart (see section 5.7 on page 200) to the CPE if all B-channels on the network side can be brought into service (i.e., no B-channels are in INB, MB, CPD or RMB states), otherwise,
- send a DS1 restart (see section 5.7 on page 200) to the CPE for each DS1 that can be brought into service (i.e., no B-channels are in INB, MB, CPD, or RMB states), otherwise,
- send single B-channel restarts (see section 5.7 on page 200) to the CPE for each B-channel that can be brought into service (i.e., B-channels that are not in INB, MB, CPD or RMB states).

However, if Layer 3 was previously established and the interruption in Layer 3 is corrected before T309 expires, then restart procedures are not used. If the interface is provisioned with SERV/SERV ACK messaging, the network sends SERV (IS) messages for idle B-channels and SERV (OOS) messages for Near-End Out-Of-Service B-Channels.

6.3.3 Layer 3 failure

Layer 3 failure on the D-channel occurs when layer 3 receives a DL-Release-Indication primitive from layer 2, or layer 3 receives a failure indication from layer 1. When the single D-channel is declared failed the D-channel will be placed in LO state. Timer T309 will be started when the D-channel fails if there are active calls.

6.3.4 Layer 3 removal

Layer 3 can be removed from service by manual intervention to move the D-channel to the MB state.

When this occurs, the network

- clears all calls
- sends a DL-Release-Request primitive to layer 2, if the D-channel state is IS.
- moves the D-channel to the MB state.

6.3.5 D-channel audit

The PRI D-channel audit is used to detect D-channel failures and to act on D-channel failures if they have occurred (i.e. act on D-channel in the LO state, etc.). It runs every 60 seconds.

If the PRI D-channel audit finds a D-channel in the LO state, the audit will try to bring layer 2 up by sending a layer 2 establishment request on the D-channel.

6.3.6 Error handling for maintenance messages

Maintenance messages transmitted with protocol discriminator other than “0100 0011” (#43) will be ignored.

Service messages cannot be used to change the status of the D-channel in a simplex D-channel configuration.

Chapter 4-7: B-Channel Maintenance

This chapter describes the B-channel maintenance procedures that are supported between the user and the network. These procedures provide for the transfer of individual B-channel states between in service, out of service, and maintenance conditions.

The procedures have no affect on the call processing state of existing calls in progress, but affect the availability to calls that occur after these procedures have been invoked.

Test calls, T-rest timer, status audit and B-channel negotiation will not be supported in this release.

7.1 B-channel states

In order of decreasing availability, the allowed B-channel states are defined below.

- In service (IS): the B-channel can be allocated to a call by Layer 3 call control
- Out of service (OOS): the B-channel is not available for use by Layer 3 call control

The Out of service state is further categoried to identify which end of the interface initiated to move to that state. The possible categories are

- near-end (NE)
- far-end (FE)

These categories are used to ensure that only the side of the interface which initiated the move to Out of service state can subsequently move the B-channel to the In service state.

The categories/subcategories, in order of increasing priority, are IS, OOS/FE, and OOS/NE. The network may separately track NE and FE status but the NE status procedures take precedence over the far end procedures. Thus, if the NE status of the channel is OOS/NE and the NE receives a request to change to OOS, the status at the NE will stay OOS/NE.

OOS is considered busy for normal call processing. A channel that is in the OOS status will not be assigned for normal outgoing traffic by the ISDN switch.

B-channels with an IS status will be assigned for calls by the ISDN switch and to be used for calls offered from the CPE. Test calls using the channel will not be supported.

If a channel is carrying a call and the OOS state is to be reached once the call ceases, the signalling procedures to notify the CPE of the new OOS/NE status will be initiated. However the channel state will remain IS (CPD in DMS) until the call ceases. When the call ceases the channel state will be changed to a OOS state.

If a channel is to be placed in a OOS state without waiting for the call to cease, the signalling procedure to notify the CPE of the new OOS/NE status will be initiated, the call cleared, and the channel state will be changed to a OOS state. This is achieved in DMS by issuing a FRLS command to the channel.

7.2 B-channel service message provisioning

The function for B-channel service messaging associated with a D-channel is automatically provided in the DMS-100. As the default, this function is enabled. To disable B-channel service messaging, datafill in table LTDATA is required in the DMS-100.

7.3 B-channel audit / SERVice ACK timing

When the network initially sends a SERVice message, timer T323 is started while waiting for SERVice ACK. If T323 expires before SERVice ACK is received, the SERVice message is re-sent and T323 is re-started. If T323 expires for the second time before SERVice ACK is received, T323 is stopped and the B-channel audit function, described below, handles further processing.

The PRI B-channel audit handles B-channels which have transmitted a SERV message but have not received a SERV ACK from the far end. If the B-channel which previously sent the SERV has not received a SERV ACK after 2 audit cycles, the SERV message is retransmitted. Audit cycles are 1 minute in duration. Therefore, depending on when the SERV message was originally sent and the timing of the audit cycle, a SERV message will be retransmitted after 1 to 2 minutes if a SERV ACK is not received.

7.4 B-channel maintenance procedures

B-channel maintenance procedures are initiated by one of the following actions

- addition and initialization of an ISDN PRI
- manual intervention to add or remove B-channels or DS-1 links on an ISDN PRI
- automatic detection of B-channel failure or recovery
- receipt of maintenance messages from the far-end of the interface

As described in the following procedures, performance of the above B-channel maintenance actions may require the use of *SERVICE* and *SERVICE ACKNOWLEDGE* messages. When sending these messages, the protocol discriminator in the *Protocol discriminator* information element is set to “Maintenance messages”, ie., 01000011 and the global call reference is used. At Layer 2, the same SAPI as for normal call control (“0”) is used.

7.4.1 State change procedures

The network shall only initiate B-channel service messaging for the following cases.

7.4.1.1 Busying the B-channel

The network shall initiate B-channel service messaging for B-channel maintenance (i.e. manual busy of a B-channel from the MAP, automatic detection of B-channel failure).

7.4.1.2 During PRI or DS1 restarts

If the network receives a PRI or DS1 restart request when some of the B-channels involved in the restart are in a INB, MB, or CPD state, service messaging is initiated. In this case the network:

— sends a REST ACK message, and

— sends a SERV message with status OOS for each B-channel in the INB, MB, or CPD state.

Note: For more information on restarts see section 5.7.2.1 on page 203.

7.4.1.3 Handling unsolicited SERV ACK messages

Service messaging is initiatied if the network receives an unsolicited SERV ACK message while in one of the following states:

Table 4-35 Unsolicited SERV ACK network response

State of B-channel	Unsolicited RESTACK status	Action taken by the network
MB	SERV ACK (IS)	SERV (OOS) is sent
RMB	SERV ACK (IS)	SERV (IS) is sent
IDL	SERV ACK (OOS)	SERV (IS) is sent

7.4.1.4 Handling unsolicited REST ACK messages

Service messaging is initiated if the network receives an unsolicited REST ACK message while in one of the following states:

Table 4-36 Unsolicited REST ACK network response

State of B-channel	Unsolicited RESTACK status	Action taken by the network
RMB	Single B-channel REST ACK	SERV (IS) is sent

7.4.1.5 B-channel audit

Service messaging is also used for the B-channel audit (see section 7.3 on page 227).

7.4.2 Layer 3 establishment

Sending and receiving Layer 3 B-channel maintenance messages is only possible when Layer 3 is established on a D-channel associated with the ISDN PRI. Other maintenance actions that do not require the exchange of maintenance messages are allowed when no Layer 3 link is established on a D-channel. See Chapter 4-6: “Single D-Channel Maintenance” for Layer 3 establishment procedures.

When Layer 3 of an ISDN PRI is not established, that is, there is no active D-channel, all of its B-channels are in the Out of service state. Movement to this state is considered to have been initiated by the near-end of the interface.

When Layer 3 is subsequently established, the B-channels are brought into service using the restart procedures described in section 5.7.1 on page 200.

7.4.3 Receiving SERV message

If a SERV message is received, a SERV ACK message will be sent in response, specifying the same B-channel indicated in the SERV message.

If the current status of the B-channel is OOS/NE, then the change of status information element sent in the SERV ACK message will indicate OOS, and the B-channel remains OOS/NE.

If the current status of the B-channel is OOS/FE and the change of status information element received in the SERV message indicates IS, then the change of status information element in the SERV ACK message will indicate IS, and the status of the B-channel will be changed to IS.

If the current status of the B-channel is OOS/FE and the change of status information element received in the SERV message indicates OOS, then the change of status information element in the SERV ACK message will indicate OOS and the B-channel will remain OOS/FE.

If the current status of the B-channel is IS and the change of status information element received in the SERV message indicates OOS, then the change of status information element in the SERV ACK message will indicate OOS and the B-channel will change to OOS/FE.

If the current status of the B-channel is IS and the change of status information element received in the SERV message indicates IS, then the change of status information element in the SERV ACK message will indicate IS and the status of the B-channel will remain IS.

7.4.4 Coordination of B-channel service messaging procedures and restart procedures

The B-channel service messaging procedures serve a different purpose than restart procedures. Restart procedures clear all calls on specified B-channels. Further calls are prohibited on these B-channels only until a REST ACK message is received in response. B-channel service messaging procedures however do not clear calls, but prohibit call setup on the specified B-channels until a less restrictive status is agreed between the two ends.

If a manual maintenance action is desired to re-initialize B-channels which have active calls on them, the B-channel service messaging procedures will first be invoked to prohibit new call setup. When all of the calls have been cleared, the restart procedures can be invoked to initialize the channels.

During restart procedures or after restart failure, calls are not assigned to the affected B-channel(s). Calls offered by the CPE will be rejected by the switch.

If the restart procedures fail to initialize a B-channel, the B-channels associated with the restart failure are removed to an OOS condition.

For more information regarding the action taken when various combinations of service and restart messages are sent and received, see section 5.7.5 on page 205.

7.4.5 Status on provisioning

When the B-channels are newly provisioned at either end of the interface the other end may not yet be provisioned. Newly provisioned channels will initially be placed in the OOS category. Initially, the network will be in control of newly provisioned channels to prevent unauthorized use of the network. Therefore the OOS status will be NE for the network and FE for the CPE. The Suspend Both (SB) attribute will be assigned to the newly provisioned channels.

The definition of SB is that an attempt to establish connection to or from the entity is administratively prohibited for non-maintenance reasons. The SB attribute is equivalent to the INB state.

7.4.6 Adding B-channels to service

This procedure is followed when one or more B-channels, including one or more DS-1 links, are added to service on an ISDN PRI. That is, the current state of each B-channel is Maintenance or Out of service.

This procedure is typically used for B-channels which are newly provisioned or were previously removed from service. This procedure may be used by the user, but is not used by the network, if the Layer 1 entity had previously detected a failure condition which prevented continued use of one or more B-channels, and a D-channel remained active. When Layer 1 recovers, B-channel restart procedures are initiated to bring the B-channels back into service. B-channel service messages are not sent by the network in this case.

For each B-channel being added to service, the initiating side of the interface

- initiates and completes a single-channel restart for the individual B-channel, following the procedures in section 5.7 on page 200
- Once the restart procedures have completed, the B-channel is moved to an IS state and is made available for call processing.

The network will not send service messages after a restart procedure. However, it will accept them if they are sent by the far end.

7.4.7 Removing B-channels from service

This procedure is followed when one or more B-channels, including one or more DS-1 links, are removed from service on an ISDN PRI. That is, the current state of each B-channel is In service.

This procedure is typically used for B-channels which are no longer subscribed to by the customer or for testing purposes. This procedure is used by the user, but is not used by the network, if the Layer 1 entity detects a failure condition which prevents continued use of one or more B-channels, and a D-channel remains active. When Layer 1 fails, the network moves the affected B-channels to the Out of service state, without the exchange of maintenance messages.

For each B-channel being removed from service, the initiating side of the interface

- sends a *SERVICE* message to the responding side of the interface containing
  - — a *Channel identification* information element which identifies the individual B-channel
  - — a *Change status* information element with the Preference field set to “Channel” and the New status field set to “Out of service”
- changes the state of the B-channel to Out of service

When the responding side of the interface receives the above *SERVICE* message, it checks the state of the indicated B-channel. If the current B-channel state is In service, the responding side

- sends a *SERVICE ACKNOWLEDGE* message to the initiating side of the interface containing
  - — a *Channel identification* information element which identifies the individual B-channel
  - — a *Change status* information element with the Preference field set to “Channel” and the New status field set to “Out of service”
- changes the state of the B-channel to Out of service, and considers the state change to have been initiated by the far-end

If the B-channel state at the responding side is currently Out of service, the responding side

- sends a *SERVICE ACKNOWLEDGE* message to the initiating side of the interface, as described above, but with the New status field of the *Change status* information element set to “Out of service”
- leaves the B-channel state as Out of service, and does not alter the category of the Out of service state (whether near-end or far-end)

If the initiating side of the interface receives a *SERVICE ACKNOWLEDGE* message for the B-channel before the B-channel audit completes two audit cycles, it

- changes the B-channel state to that specified in the received *Change status* information element, if it is not already in that state

> ***Note:*** The state specified in the received *Change status* information element may not be the one requested in the *SERVICE* message, depending on conditions at the responding side of the interface.

If the new B-channel state is Out of service, the initiating side of the interface considers the state change to have been intiated by itself (near-end).

7.4.8 Maintenance action on an active B-channel

B-channel states and call control states are independent. That is, call control and maintenance action can be performed independently.

Due to this independence, it is possible to have unexpected actions occur if care is not taken to avoid maintenance action on a B-channel associated with an active call reference. For example, placing test tones on a B-channel which has been placed in an Out of service state while there is an existing user call on that B-channel.

Before initiating maintenance action on a B-channel, other than either side of the interface initiating the lowering of the B-channel state from In service (see section 7.4.7 on page 231), the user should restart the B-channel or otherwise clear any active call associated with that B-channel. In the least intrusive case, an existing call can be allowed to clear normally, resulting in no direct user impact, after which no new calls can be established.

7.5 Error procedures

7.5.1 Message structure

If the Protocol discriminator information element is not coded as "Maintenance messages" in a SERV or SERV ACK message (see section 4.2 on page 130), the SERV or SERV ACK message is ignored.

If a SERV message is received with a missing Change Status or channel ID information element, the ISDN switch will ignore the message.

If a SERV message is received with invalid contents for either the Change Status or channel ID information element, the ISDN switch will ignore the message.

If the channel id IE received in a SERV message is recognized as referring to an unprovisioned, unadministered B-channel, the ISDN switch will ignore the message.

If a SERV ACK message is received without a Change Status or channel ID information element, the ISDN switch will ignore the message.

If a SERV ACK message is received with a Change Status IE with invalid contents, the ISDN switch will ignore the message.

For the ISDN switch's response to an unsolicited SERV ACK message, please refer to section 7.5.2 on page 234.

7.5.2 Unexpected *SERVICE ACKNOWLEDGE* message

If the state of the bearer channel was changed by the near end, for example DMS-100, then an unexpected SERVICE ACKNOWLEDGE Message will be handled as follow:

- If the change status field matches the network state, then the SERVICE ACKNOWLEDGE Message will be ignored.
- If the change status field does not match the network state then a SERVICE Message will be sent by the DMS-100 with the change status field set to the appropriate state, as indicated in Table 4-35 on page 229, and the B-channel audit is started.

7.5.3 *SERVICE* message collision

Service Message Collision occurs when a SERV message is received in the time between when the SERV message is sent and its responding SERV ACK is received for the same B-channel. When this occurs, the incoming SERV message is treated normally, that is, the appropriate SERV ACK message will be sent. The following procedure ensures that the final state of the B-channel at both sides of the interface is equal to the state with the lowest availability of those in the SERV messages sent by each side of the interface.

If the new state sent in the *SERVICE* message is "In-Service", the side which detects the collision

- responds to the received *SERVICE* message with a *SERVICE ACKNOWLEDGE* message with the New status field of the *Change status* information element set to the state in the received *SERVICE* message
- changes the B-channel state to that specified in the received *Change status* information element, if it is not already in that state; if the final state is Out of service, it is considered to have been initiated by the far-end of the interface

If the new state sent in the *SERVICE* message is "Out-of-Service", the side which detects the collision

- responds to the received *SERVICE* message with a *SERVICE ACKNOWLEDGE* message with the New status field of the *Change status* information element set to "Out-of-Service"
- leaves the B-channel state as Out of service, and does not alter the state category (whether near-end or far-end)

Table 4-37 on page 235 shows the results of SERV message collision under various condition at the near side:

Table 4-37 Near-End States Resulting from Service Message Collision

	Previous NE Status	Desired NE Status and SERV Message Sent	Colliding SERV Message Received by NE	Resultant NE Status and SERV ACK Message Sent
1	OOS/NE	IS	IS	IS
2	OOS/FE	IS	IS	IS
3	OOS/NE	IS	OOS	OOS/FE
4	OOS/FE	IS	OOS	OOS/FE
5	OOS/NE	OOS	IS	OOS/NE
6	OOS/FE	OOS	IS	OOS/NE
7	OOS/NE	OOS	OOS	OOS/NE
8	OOS/FE	OOS	OOS	OOS/NE
9	IS	IS	IS	IS
10	IS	IS	OOS	OOS/FE
11	IS	OOS	IS	OOS/NE
12	IS	OOS	OOS	OOS/NE

Chapter 4-8: Layer 3 System Parameters

8.1 Timers

This section lists all the timers associated with the Layer 3 primary rate interface. The description of timers in the following tables should be considered a brief summary. The detailed procedures for timer usage are found in Chapter 4-5 through Chapter 4-8, which contain the definitive descriptions.

The timer values shown in Table 4-38 on page 237 are the defaults used by the network side of the interface. The timers are modifiable by the telephone operating company.

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Table 4-38 Timers on the network side of the interface

Timer number	Default time-out value	State	When started	When stopped (normally)	Action taken on expiry	Cross Reference
T301	5 m	N7	On receiving *ALERT* message	On receiving *CONNECT* message	Clear call.	Mandatory
First start of T303	4 s	N6	On sending *SETUP* message	On receiving *ALERT, CONNECT, PROG* or *RELEASE COMPLETE* message	Resend *SETUP* message. Restart T303. If *RELEASE COMPLETE* message is received, clear the call	Mandatory
Second start of T303	4 s	N6	On resending *SETUP* message	On receiving *CALL PROCEEDING, ALERT, CONNECT, RELEASE COMPLETE* message	Clear network connection.	Mandatory
T305	30 s	N12	On sending *DISCONNECT* message	On receiving *RELEASE, REL COMP or DISCONNECT* message	Send *RELEASE* message.	Mandatory
First start of T308	4 s	N19	On sending *RELEASE* message	On receiving *RELEASE* or *RELEASE COMPLETE* message	Resend *RELEASE* message. Restart T308.	Mandatory
Second start of T308	4 s	N19	On resending *RELEASE* message	On receiving *RELEASE* or *RELEASE COMPLETE* message	Initiate restart procedures (section 5.7 on page 200).	Mandatory

Table 4-38 Timers on the network side of the interface (Continued)

Timer number	Default time-out value	State	When started	When stopped (normally)	Action taken on expiry	Cross Reference
T309	90 s	Any stable state	Data link disconnection. Calls in stable state not lost	1)Data link reconnected or 2) receipt of *STATUS, DISCONNECT, RELEASE, RELEASE COM* from CPE	1) Clear network connection. Release B-channel and call reference and awaits for layer 2 reestablishment before intiating restart 2) when T322 also expires, initiate restart	Mandatory
T310	10 s	N9	On receiving *CALL PROCEEDING* message	On receiving *ALERT, CONNECT, PROGRESS* or *DISCONNECT* message	Clear call in accordance with section 5.2.3.3 on page 189.	Mandatory
First start of T316	30s	Restart Request	On sending *RESTART* message	On receiving *RESTART ACKNOWLEDGE* message	Resend *RESTART* .	Mandatory
Second start of T316	30s	Restart Request	On resending *RESTART* message	On receiving *RESTART ACKNOWLEDGE* message	Take channel(s) Out Of Service (OOS). The network then initiates restart procedures periodically (B-channel audit).	
T321	40 s	Any call state	On sending a *SERVICE* message to initiate Layer 3 on a D-channel.	On receiving a *SERVICE* or *SERVICE ACKNOWLEDGE* message.	Send *DL-Establish-Request* on both D-channels.	Mandatory when section 9.3 on page 272 is implemented, otherwise optional

Table 4-38 Timers on the network side of the interface (Continued)

Timer number	Default time-out value	State	When started	When stopped (normally)	Action taken on expiry	Cross Reference
T322	4 s	Any call state	On sending *STATUS ENQUIRY* message	On receiving *STATUS, DISCONNECT, RELEASE,* or *RELEASE COMPLETE* message	1) T309 running: resend STAT ENQ; T309 expired: clears call internally and initiates call clearing remotely 2) initiate call clearing.	Mandatory
First start of T323	120 s	Any state	On sending SERVice message	On receiving SERVice ACK message	Re-send SERVice message	Mandatory
Second start of T323	120 s	Any state	On re-sending SERVice message	On receiving SERVice ACK message	Allow PRI B-channel audit to periodically re-send SERVice message	

Chapter 4-9: Annexes

9.1 Annex A: Layer 3 SDL diagrams

This section includes overview and detailed SDL diagrams which show Layer 3 protocol control for circuit-switched basic calls. In the event of conflict between these diagrams and the text in the previous chapters of this Section, the text should be considered as the definitive source. Similarly, in the event of conflict between overview SDL and detailed SDL diagrams, the detailed SDL diagrams should be the considered as the definitive source.

Figure 4-34 Key to Layer 3 protocol control SDL diagrams (network side)

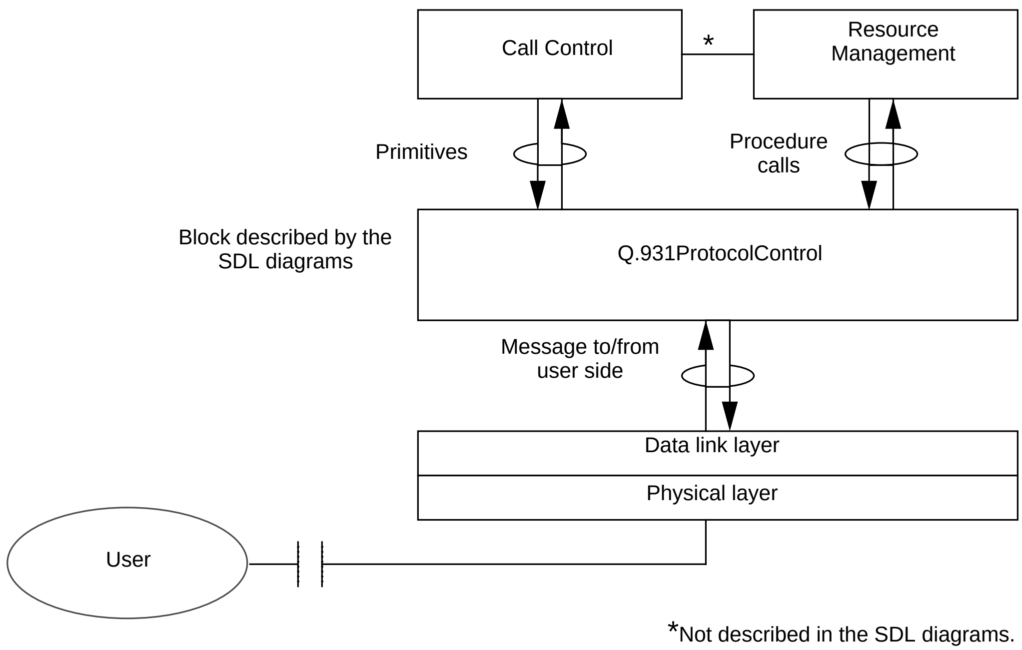
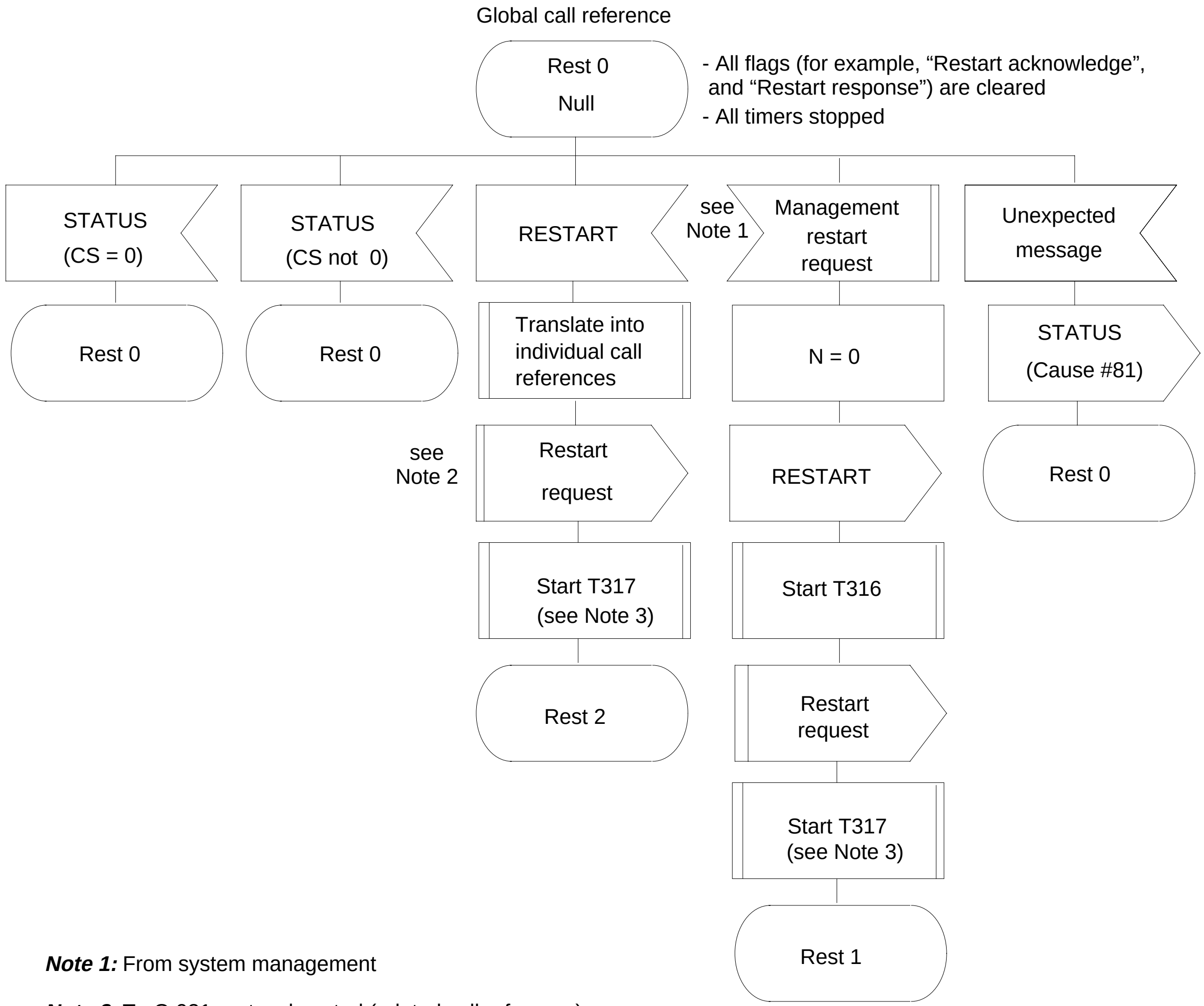


Figure 4-35 Detailed protocol control for the global call reference (1 of 4)



Note 1: From system management

Note 2: To Q.931 protocol control (related call reference)

Note 3: The value of T317 is implementation dependent.

Figure 4-36 Detailed protocol control for the global call reference (2 of 4)

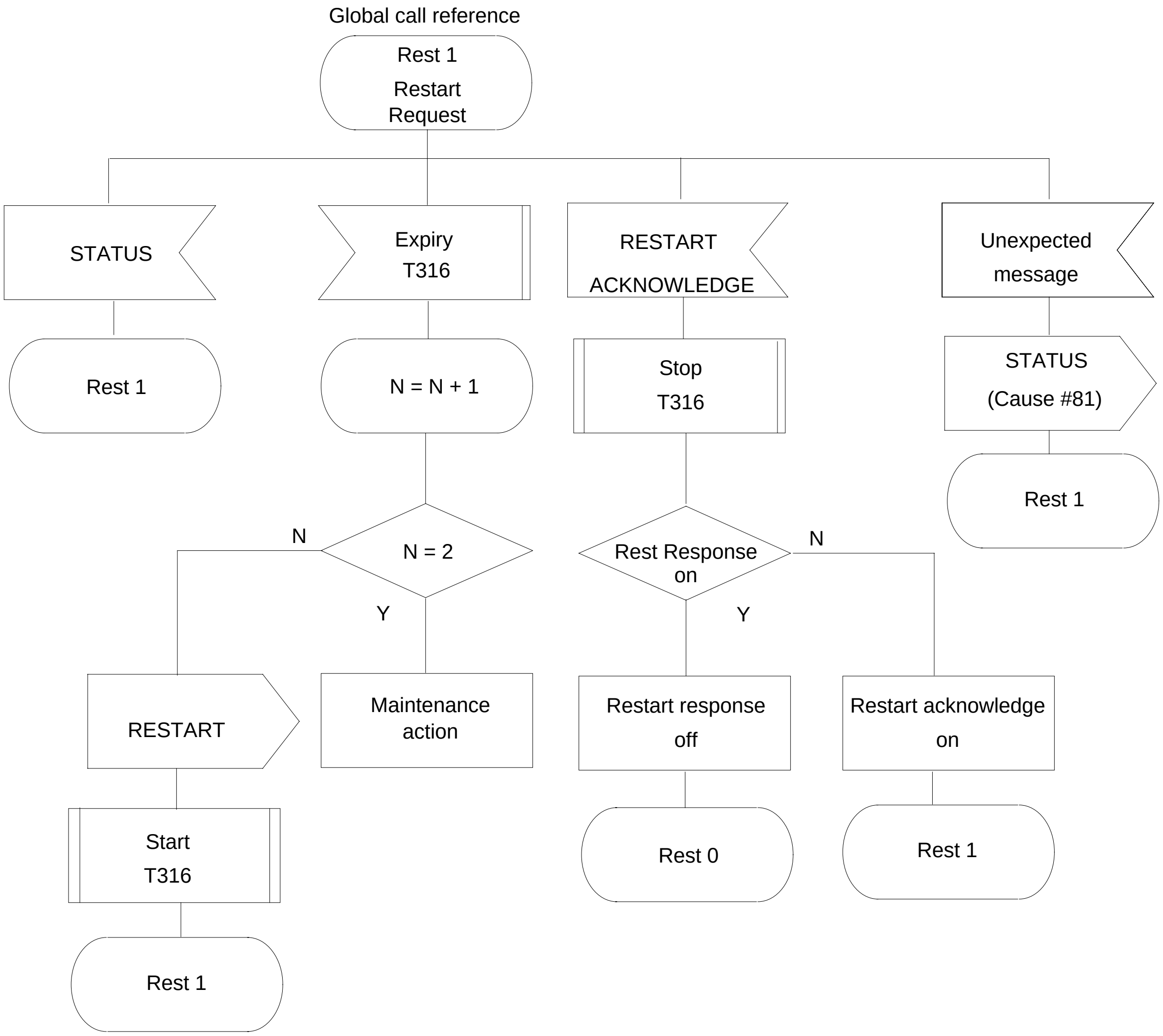


Figure 4-37 Detailed protocol control for the global call reference (3 of 4)

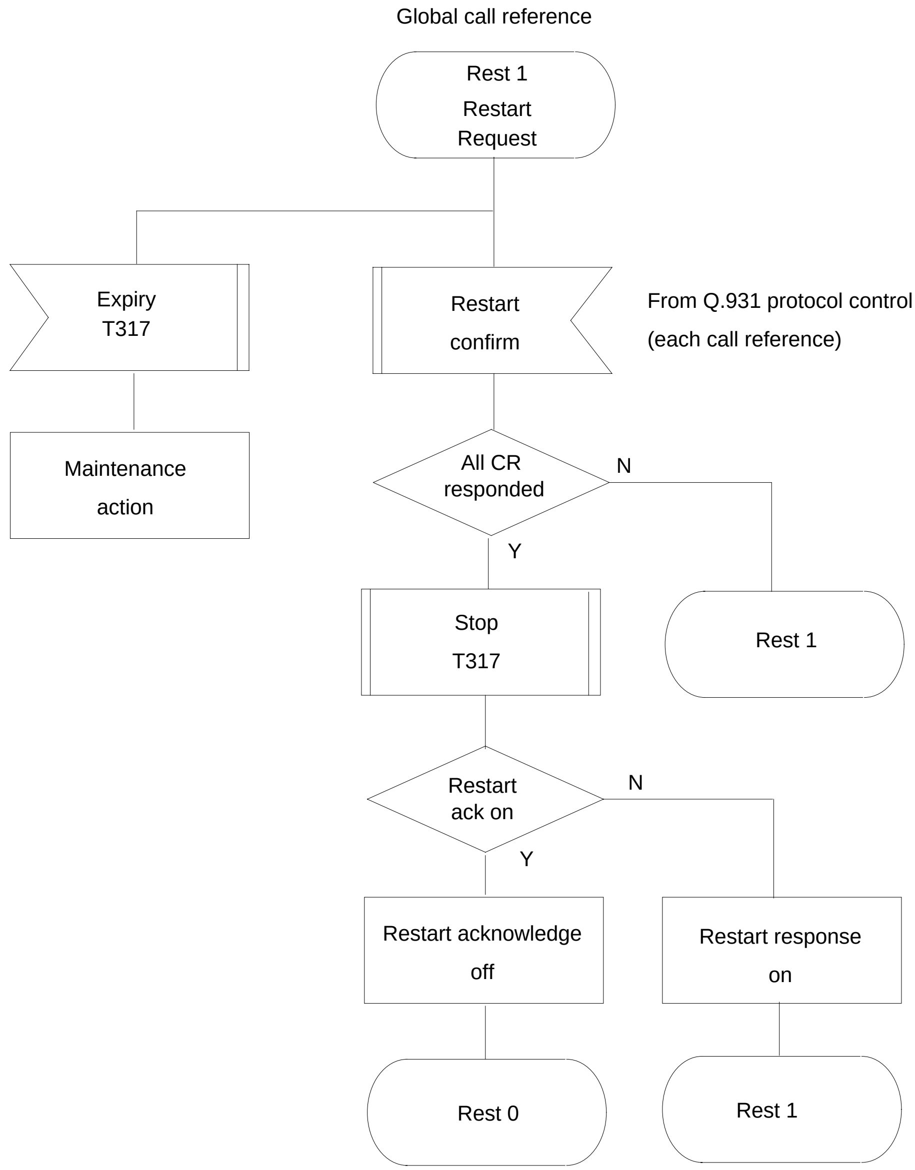


Figure 4-38 Detailed protocol control for the global call reference (4 of 4)

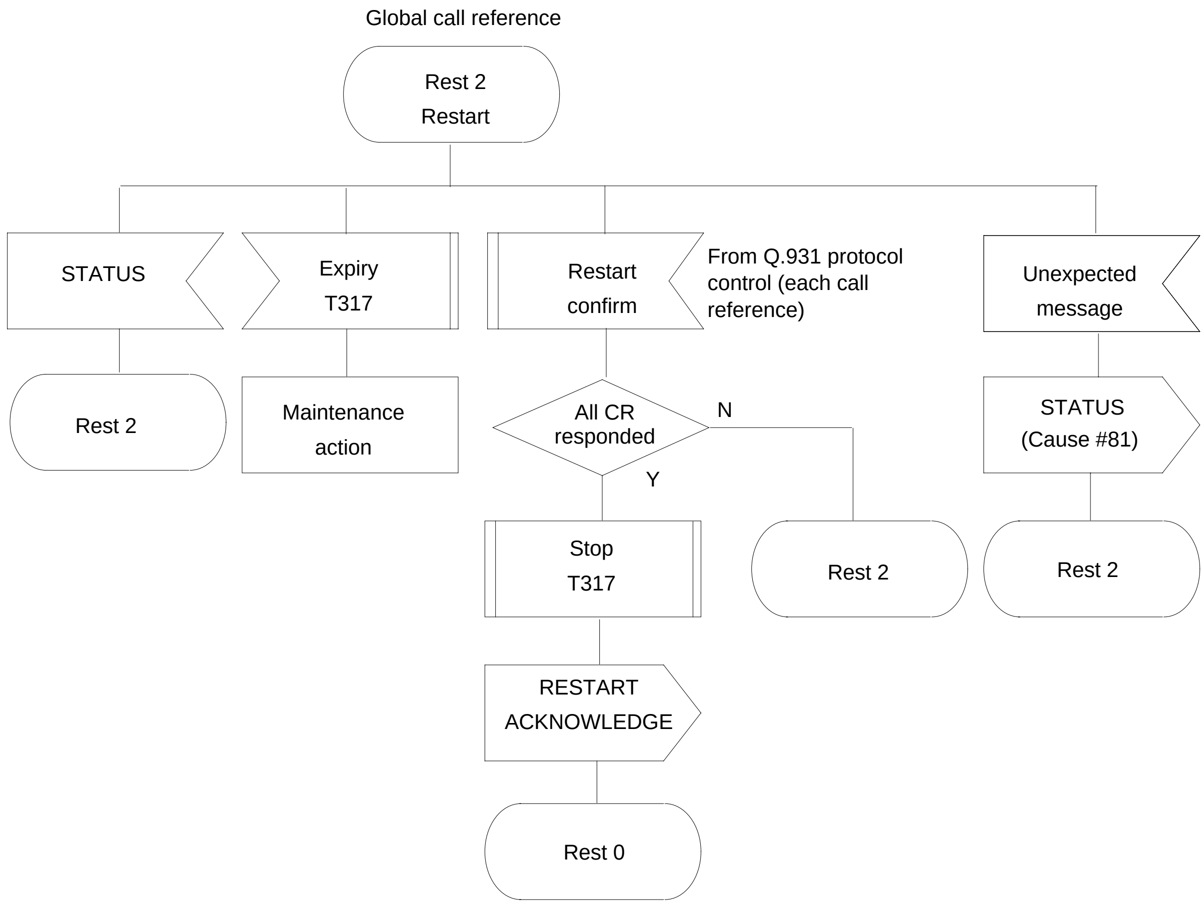


Figure 4-39 Overview protocol control: Network side (1 of 6)
Outgoing setup procedure (1 of 2)

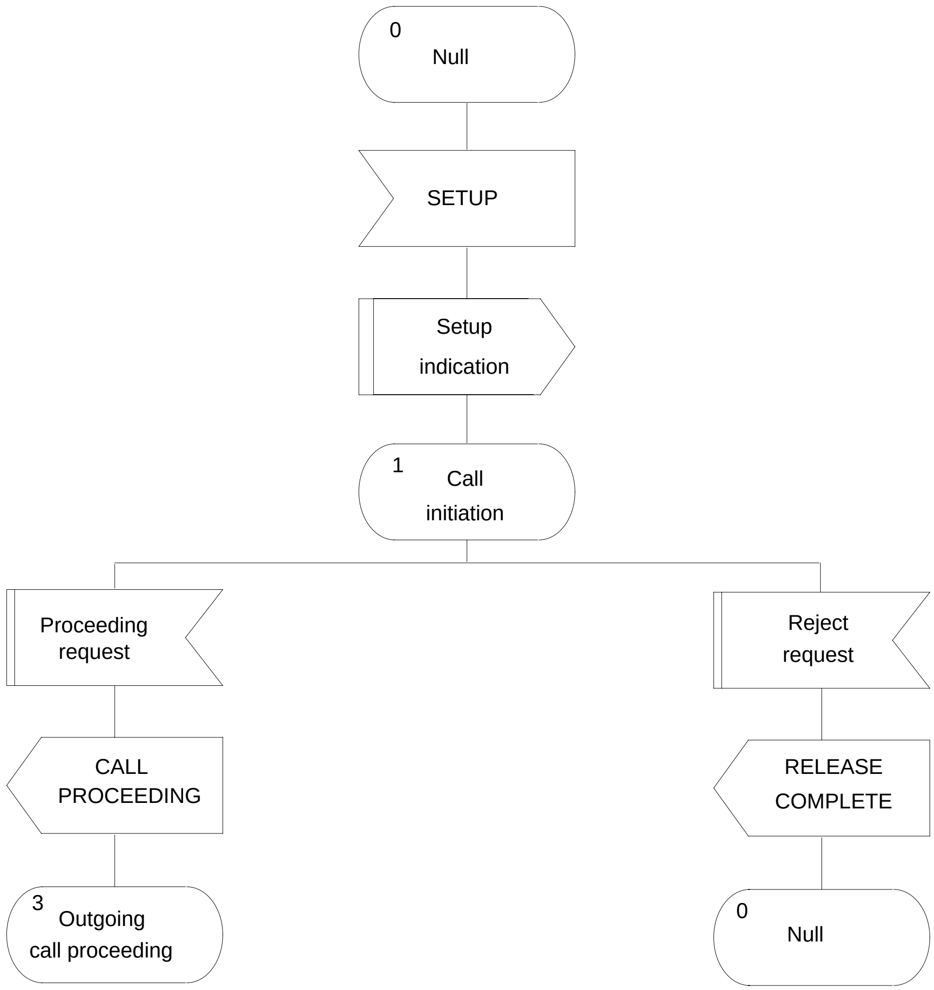


**Figure 4-40 Overview protocol control: Network side (2 of 6)
Outgoing setup procedure (2 of 2)**

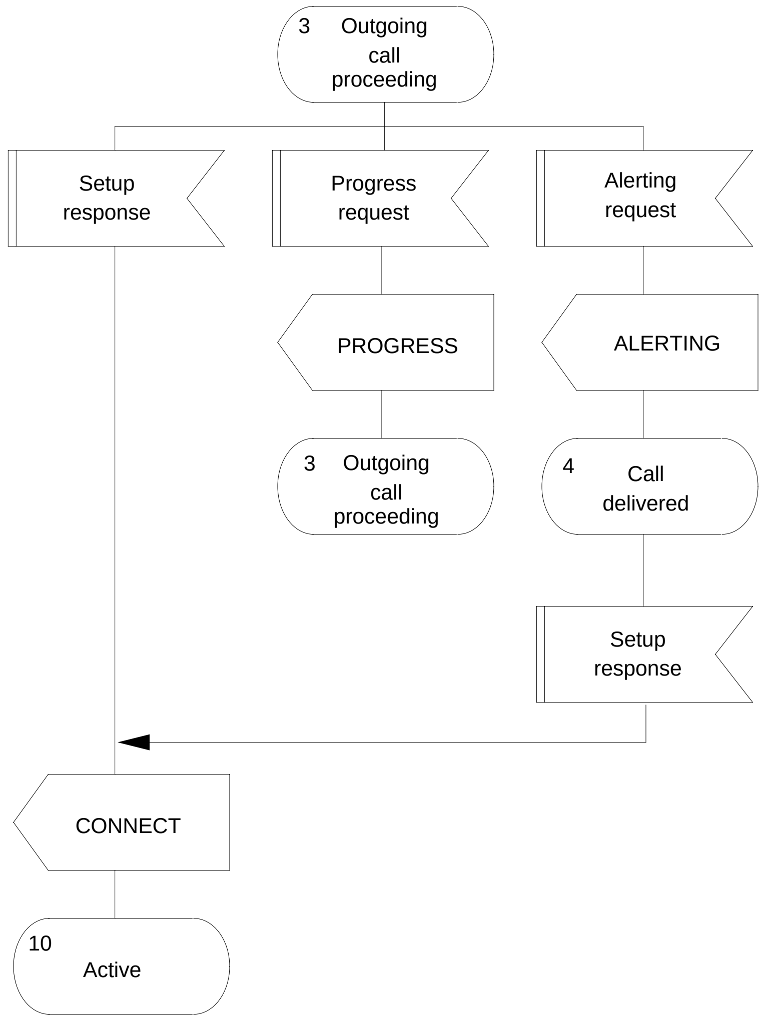


Figure 4-41 Overview protocol control: Network side (3 of 6)
Incoming setup procedure (1 of 2)

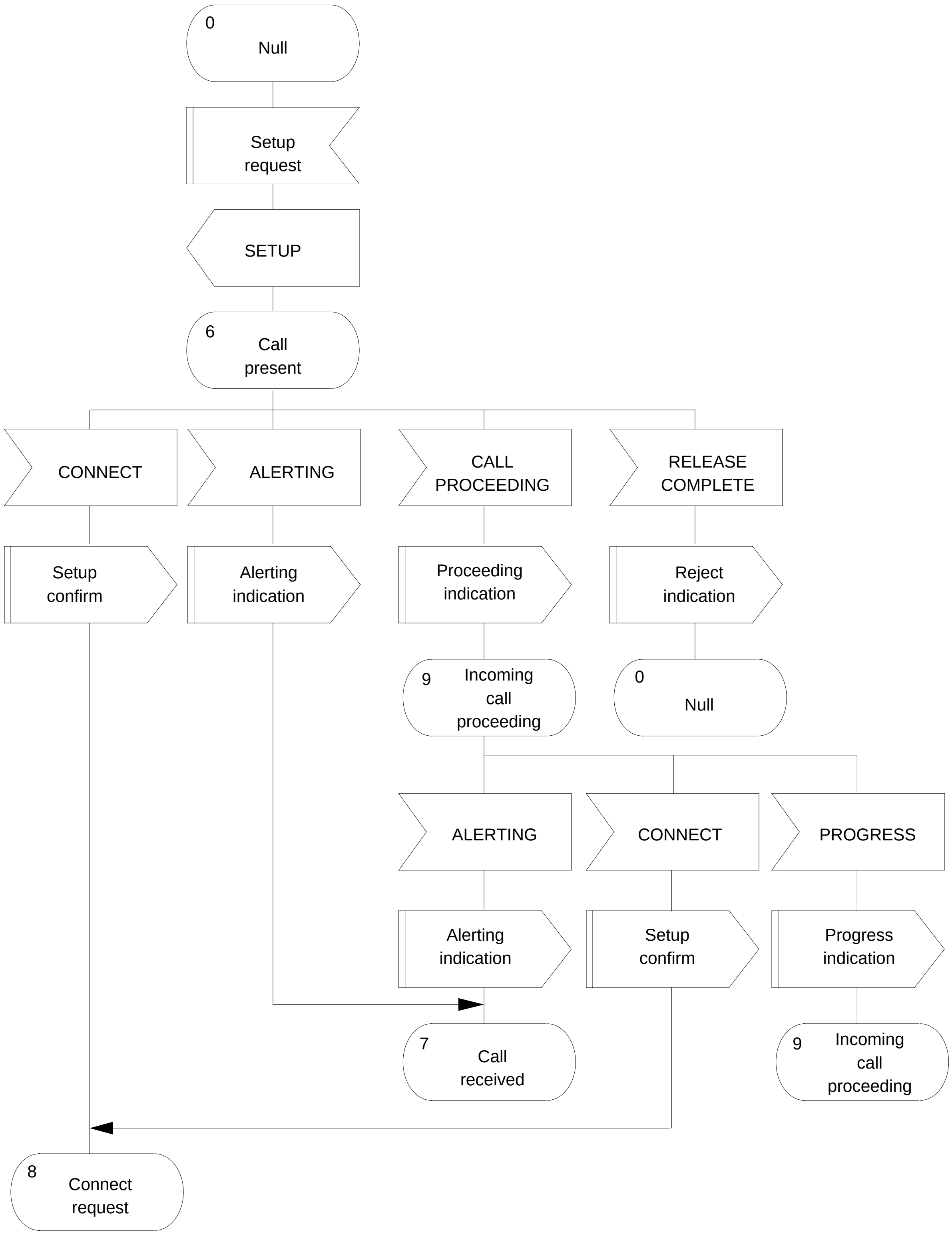


Figure 4-42 Overview protocol control: Network side (4 of 6)
Incoming setup procedure (2 of 2)

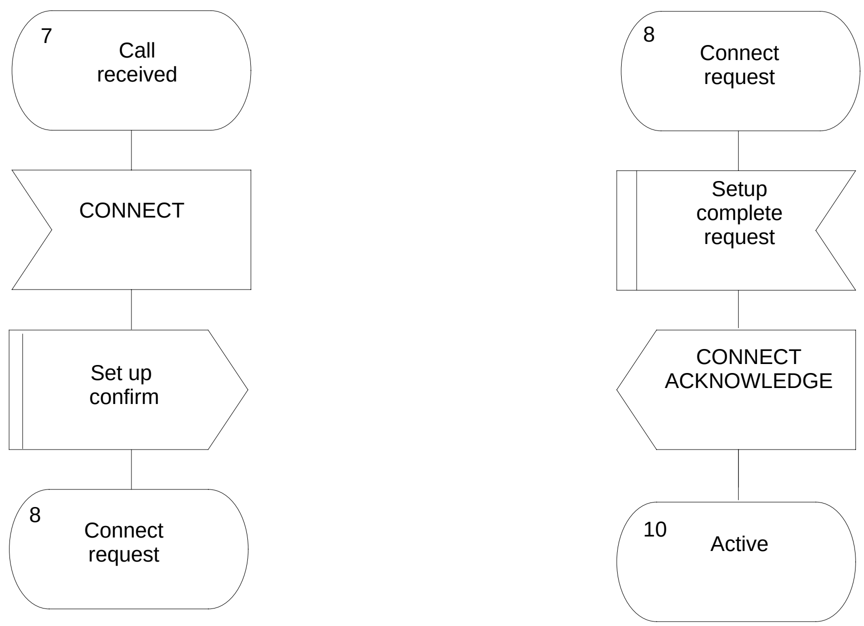


Figure 4-43 Overview protocol control: Network side (5 of 6)
Clearing procedure (1 of 2)

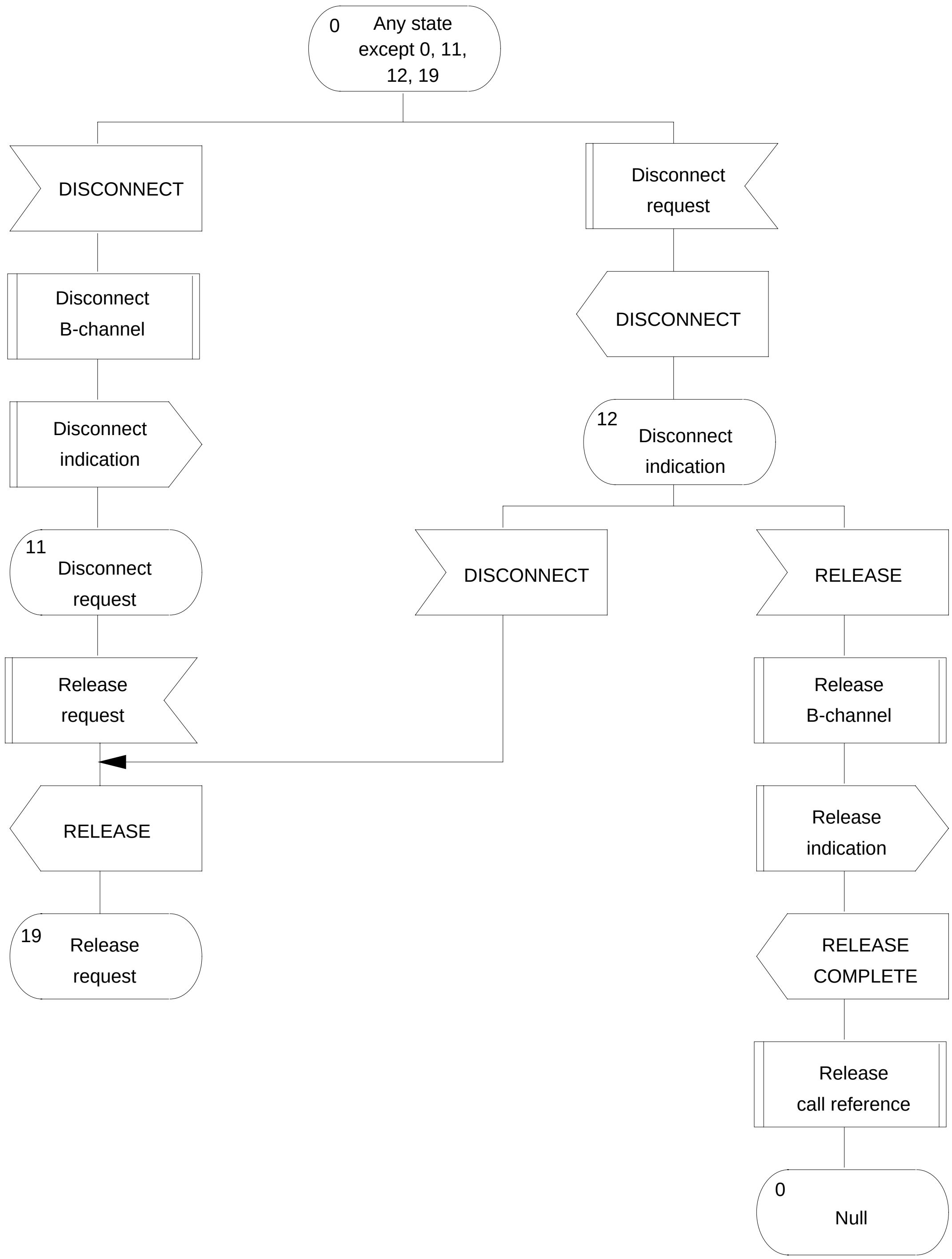


**Figure 4-44 Overview protocol control: Network side (6 of 6)
Clearing procedure (2 of 2)**

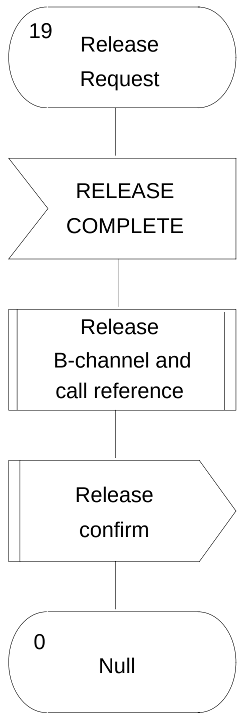


Figure 4-45 Detailed protocol control: Network side (1 of 18)

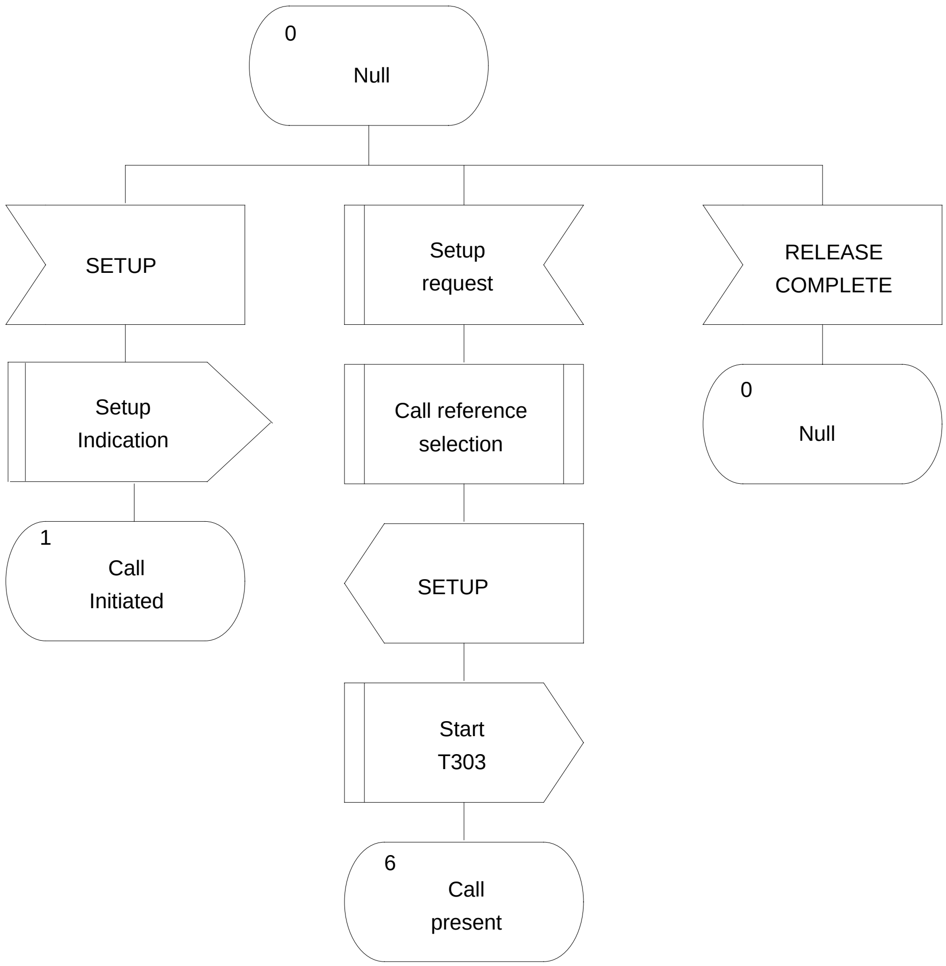


Figure 4-46 Detailed protocol control: Network side (2 of 18)

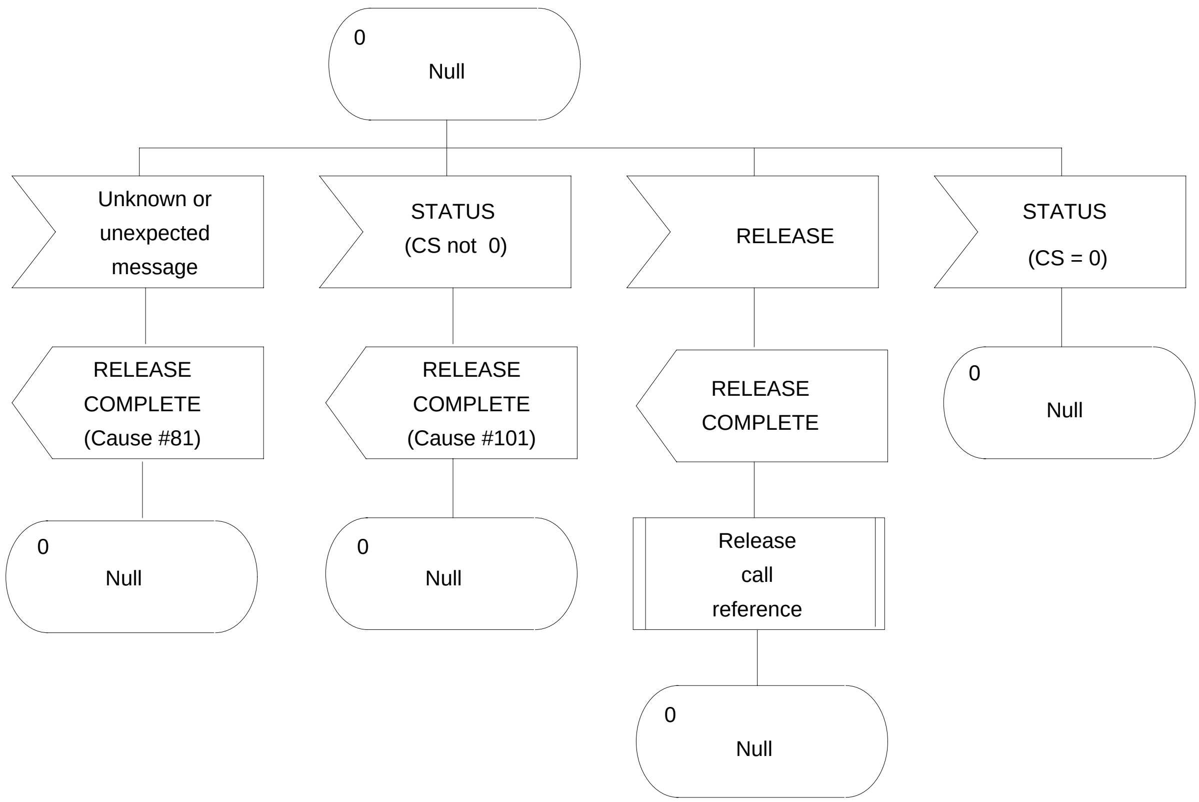


Figure 4-47 Detailed protocol control: Network side (3 of 18)

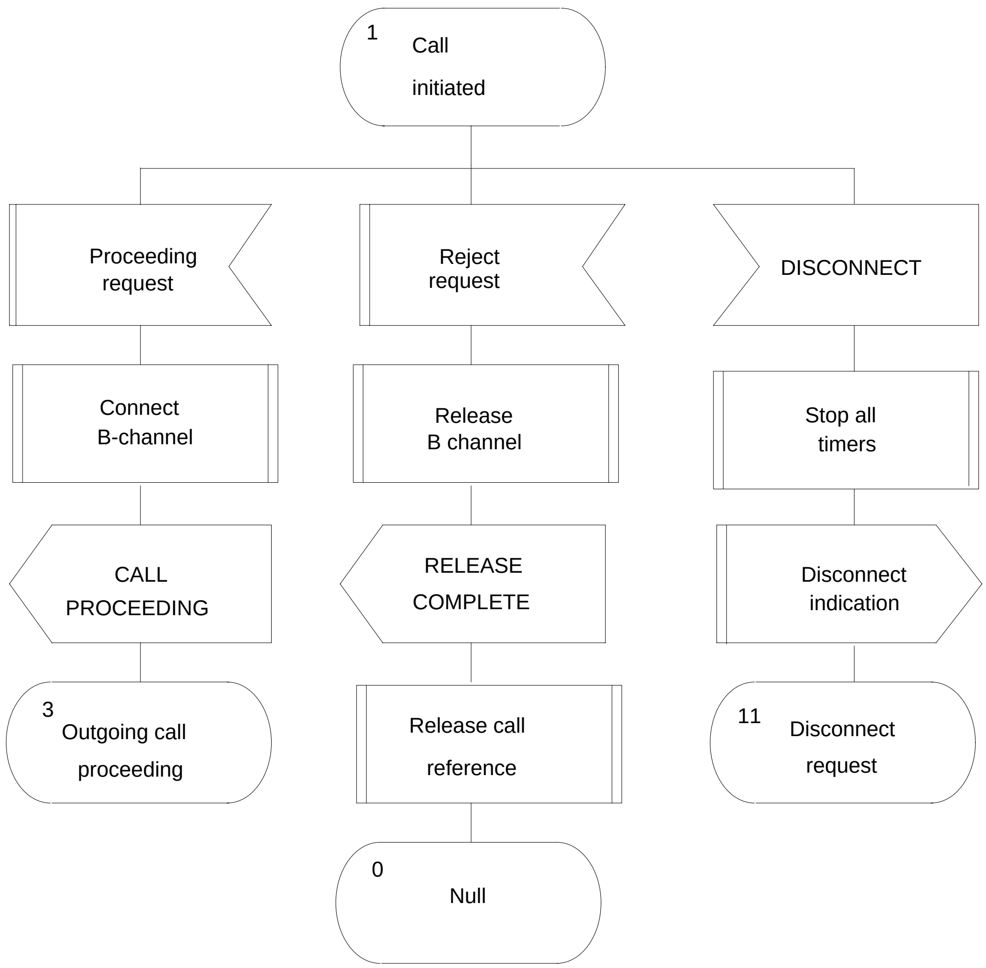


Figure 4-48 Detailed protocol control: Network side (4 of 18)

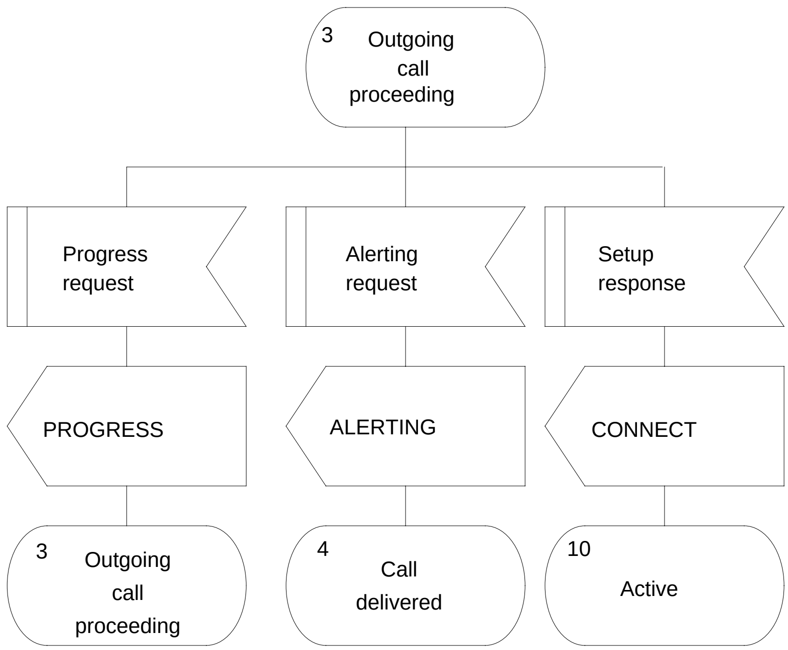


Figure 4-49 Detailed protocol control: Network side (5 of 18)

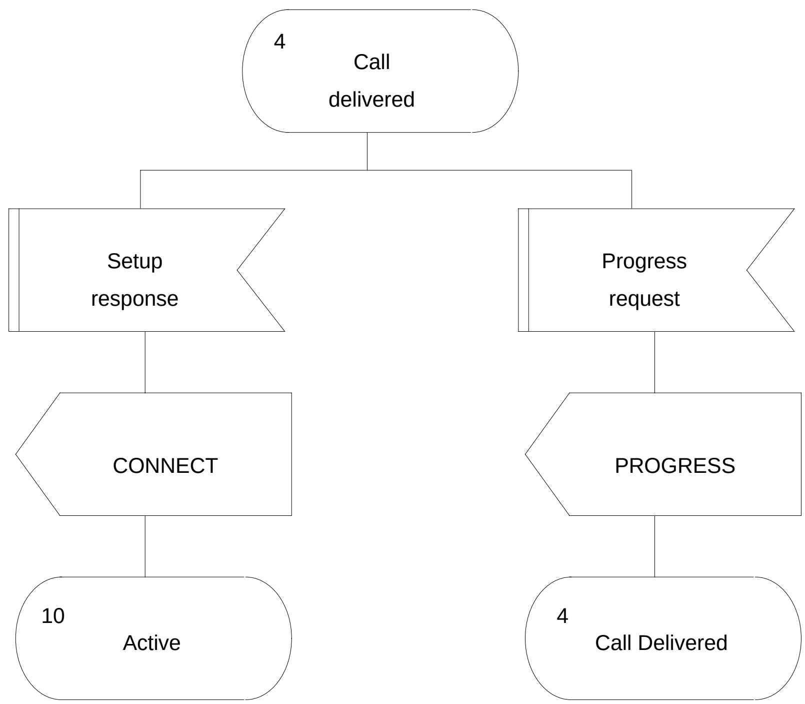


Figure 4-50 Detailed protocol control: Network side (6 of 18)

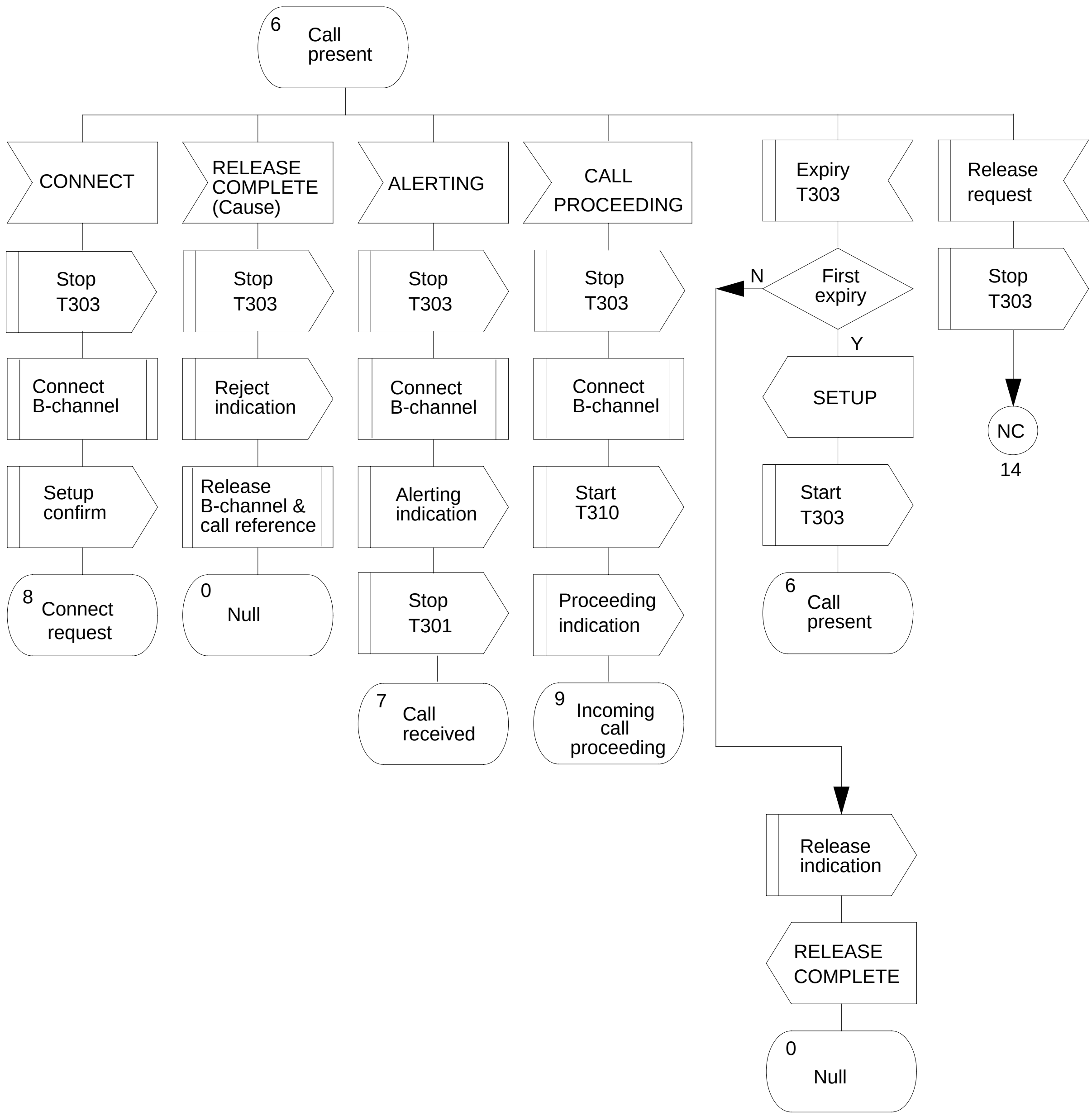


Figure 4-51 Detailed protocol control: Network side (7 of 18)

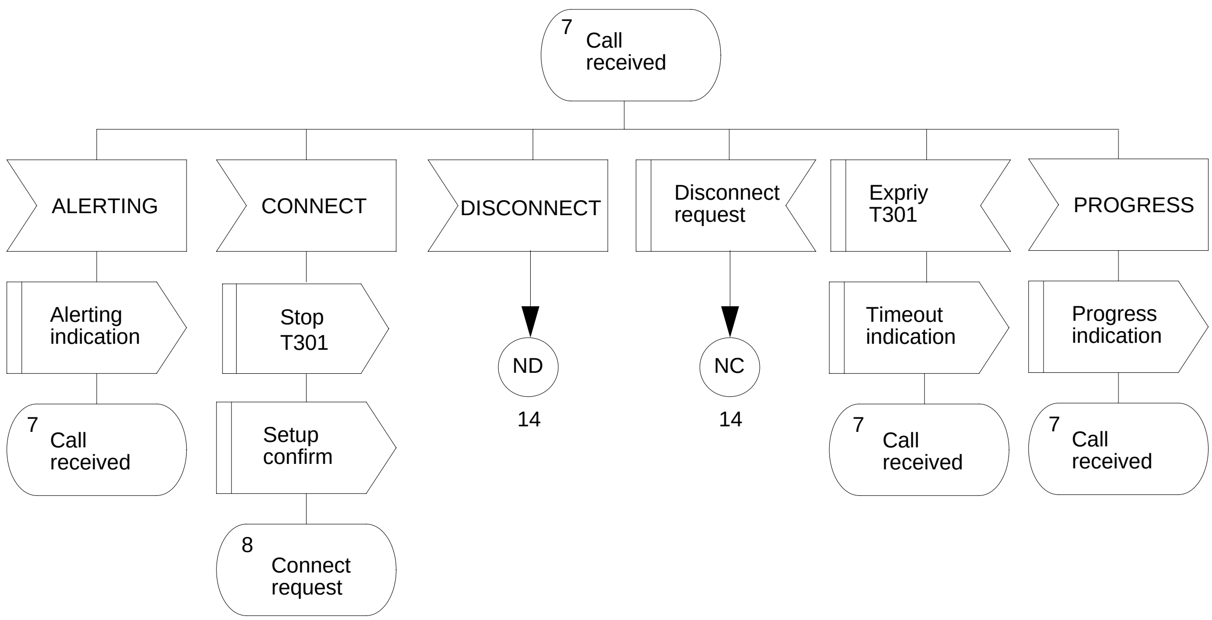


Figure 4-52 Detailed protocol control: Network side (8 of 18)

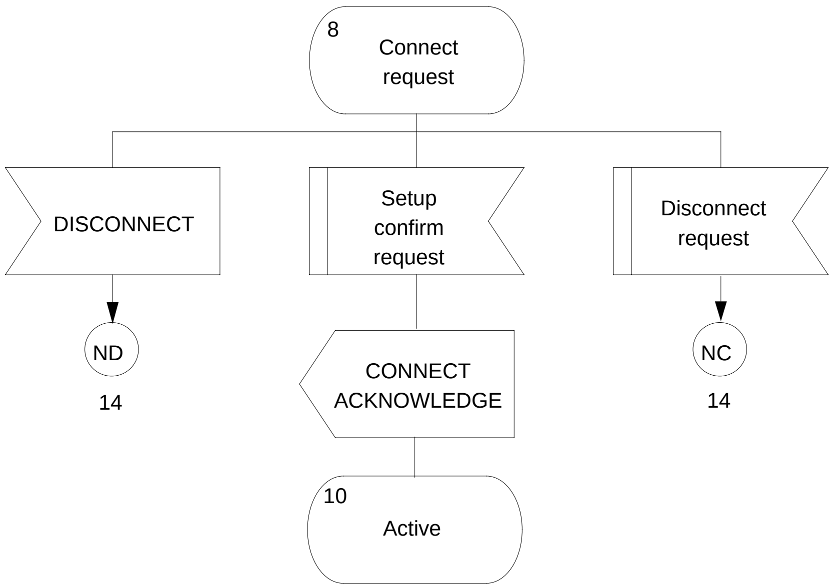


Figure 4-53 Detailed protocol control: Network side (9 of 18)

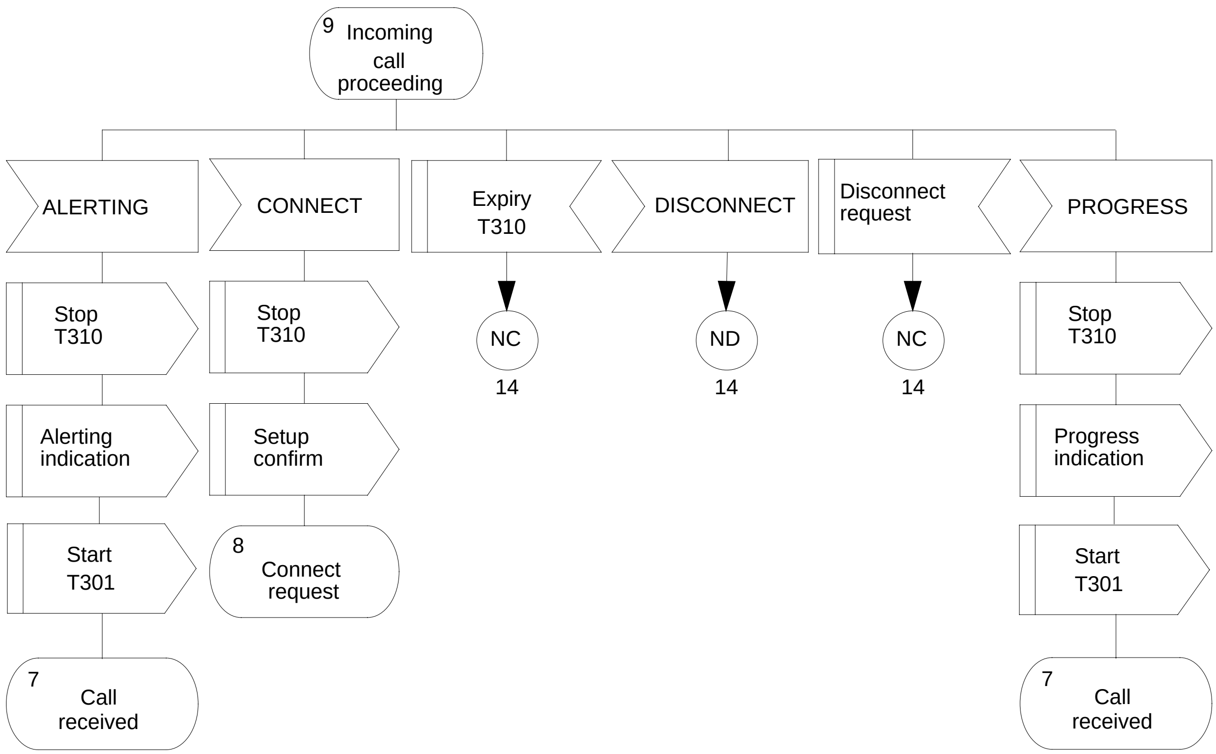


Figure 4-54 Detailed protocol control: Network side (10 of 18)

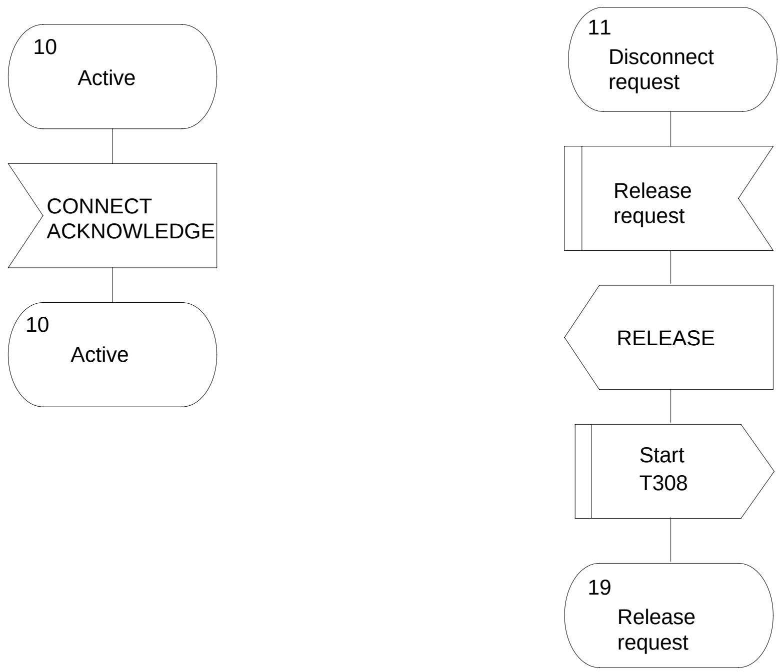


Figure 4-55 Detailed protocol control: Network side (11 of 18)

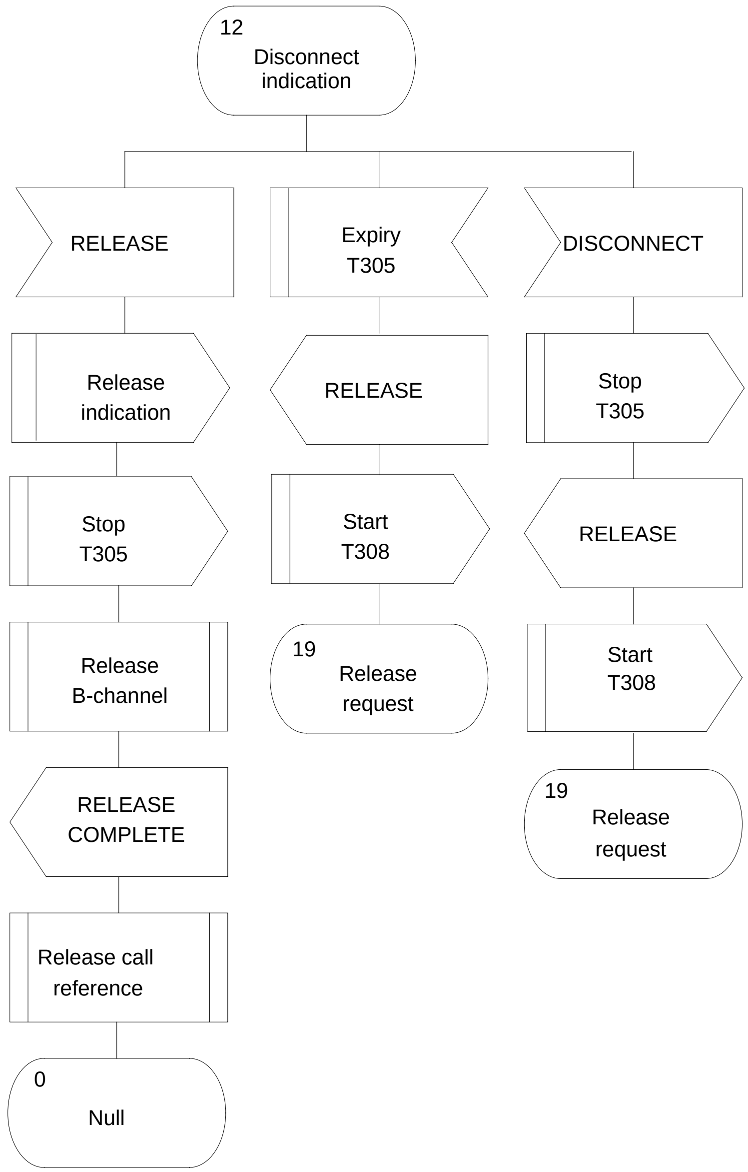


Figure 4-56 Detailed protocol control: Network side (12 of 18)

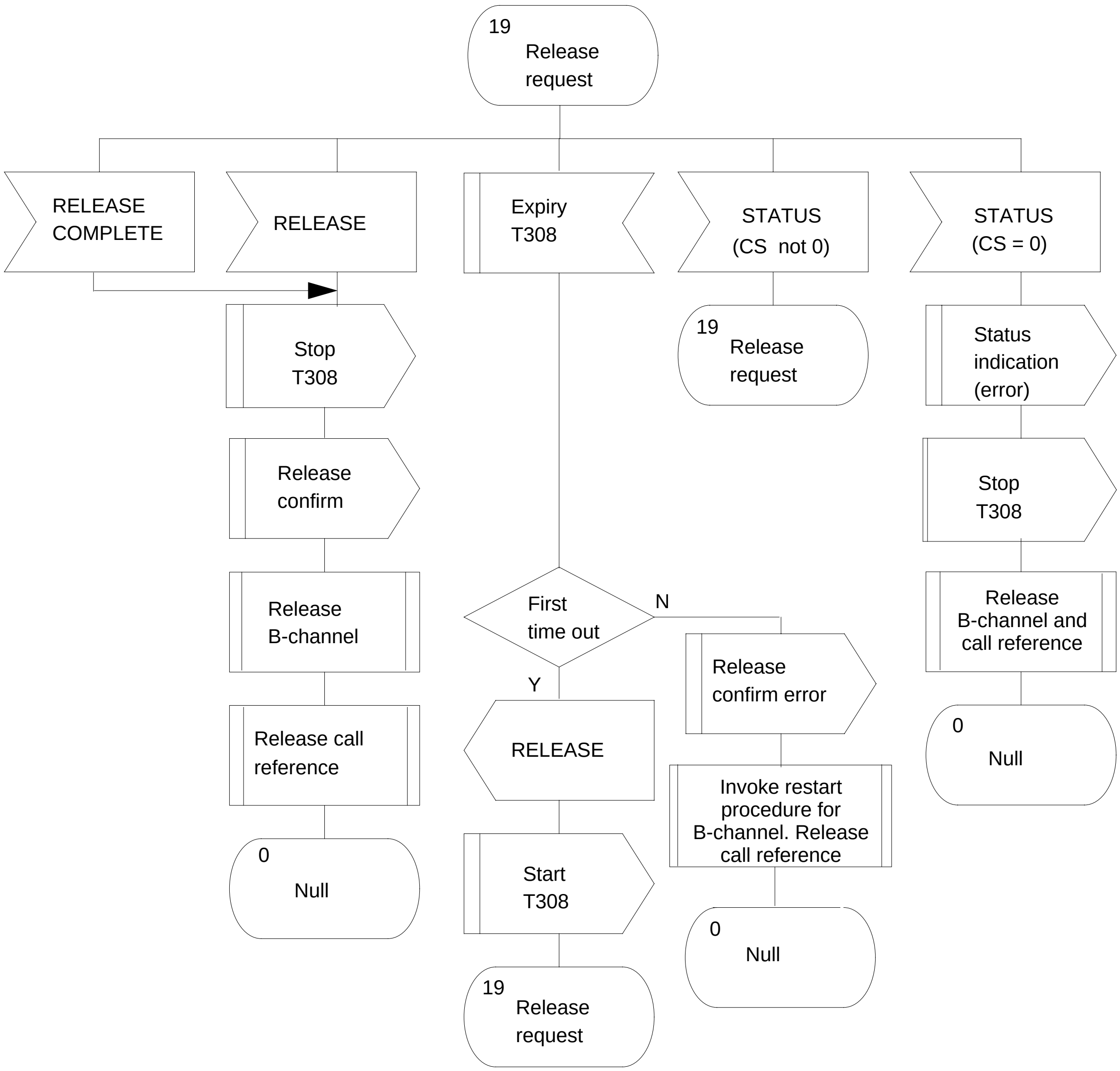


Figure 4-57 Detailed protocol control: Network side (13 of 18)

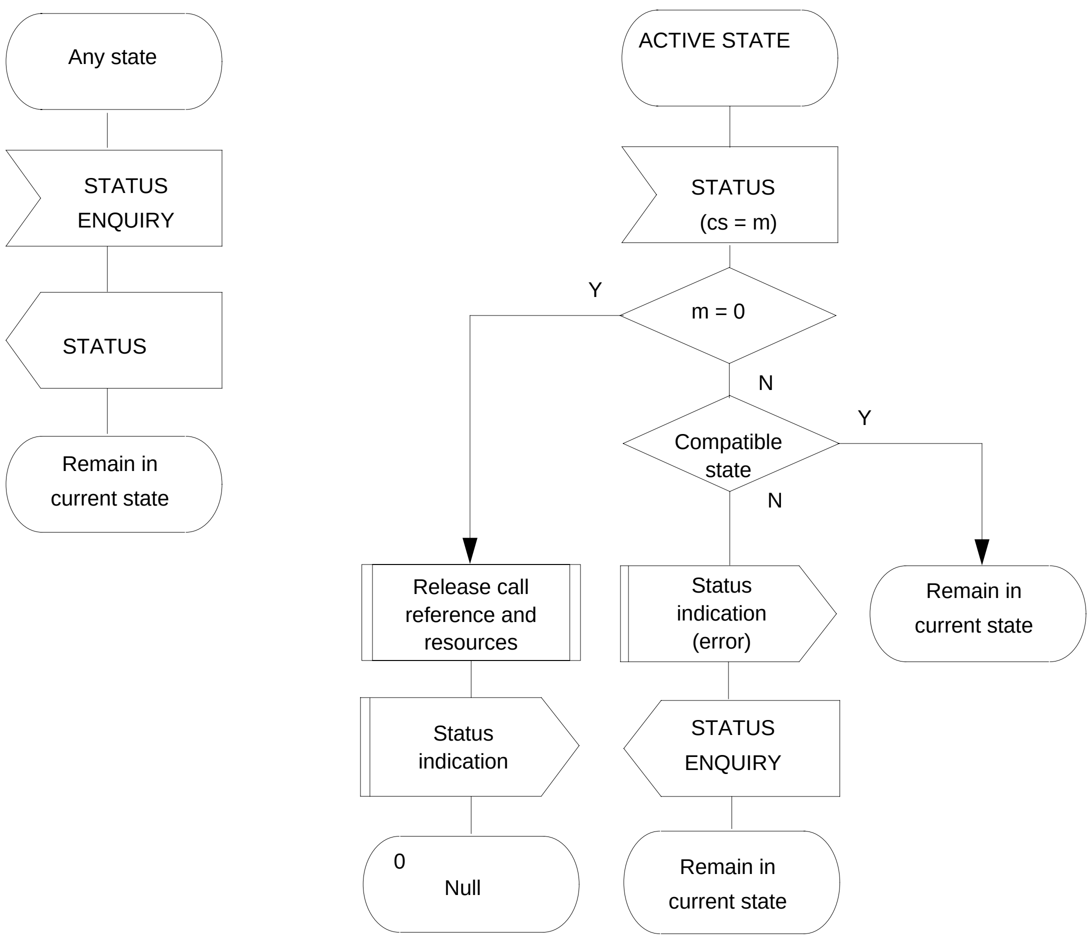


Figure 4-58 Detailed protocol control: Network side (14 of 18)

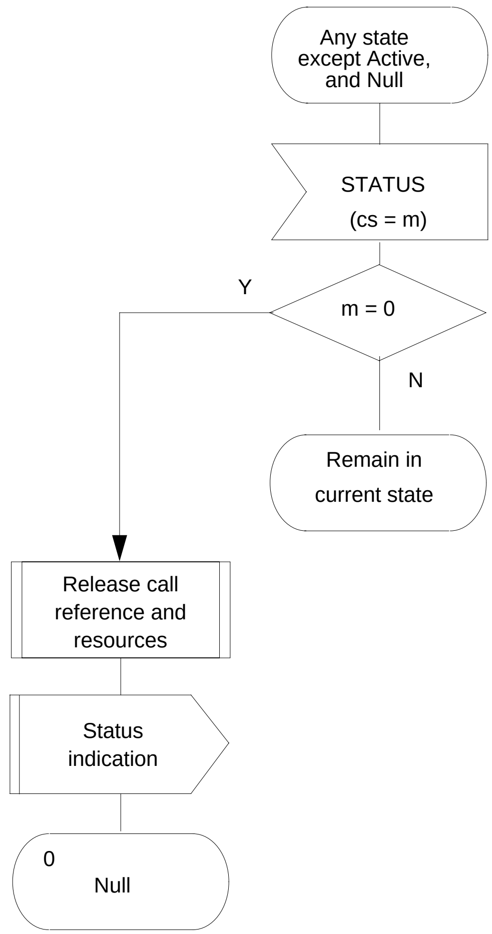


Figure 4-59 Detailed protocol control: Network side (15 of 18)

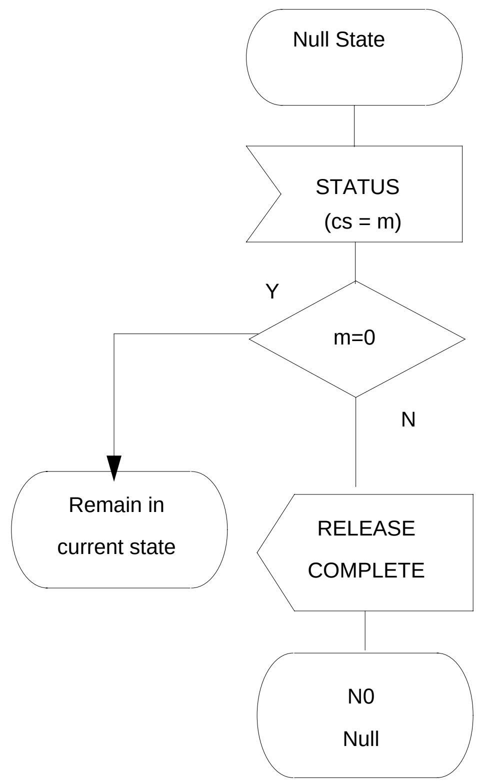


Figure 4-60 Detailed protocol control: Network side (16 of 18)

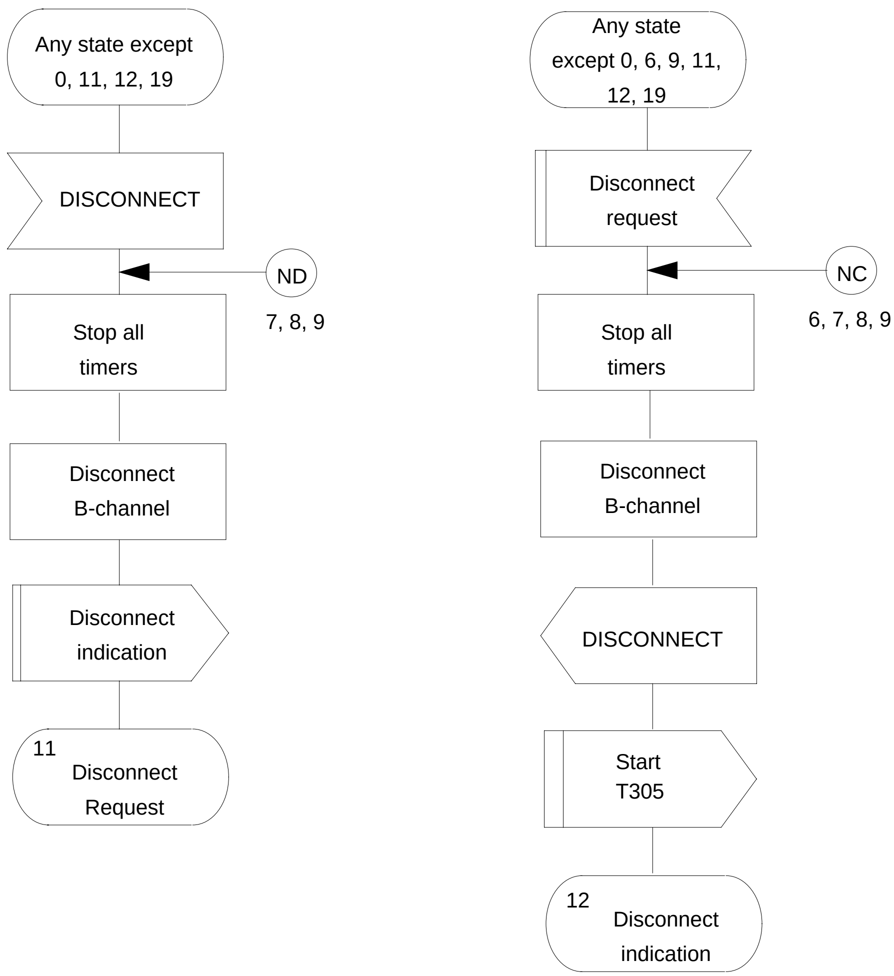
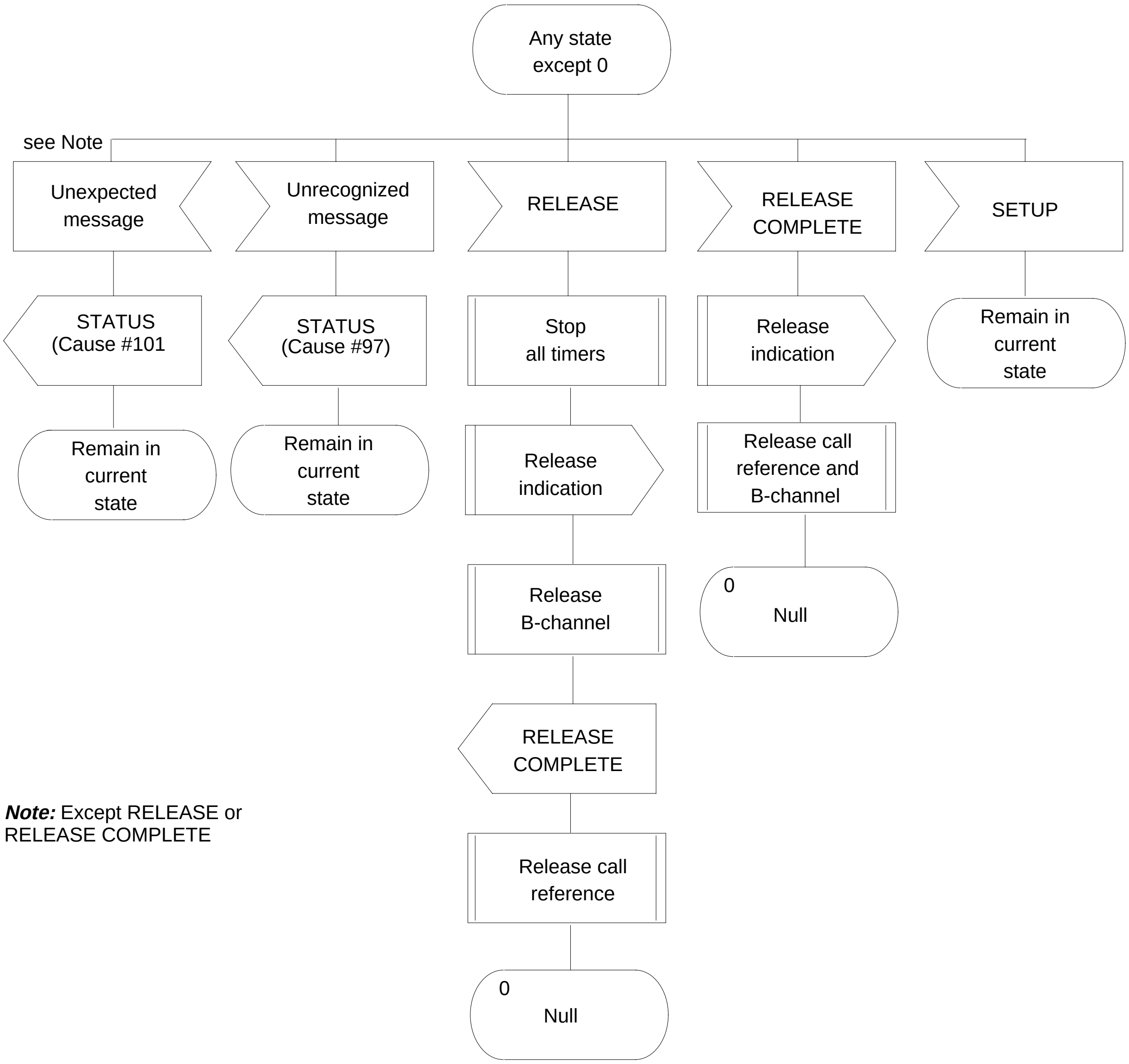
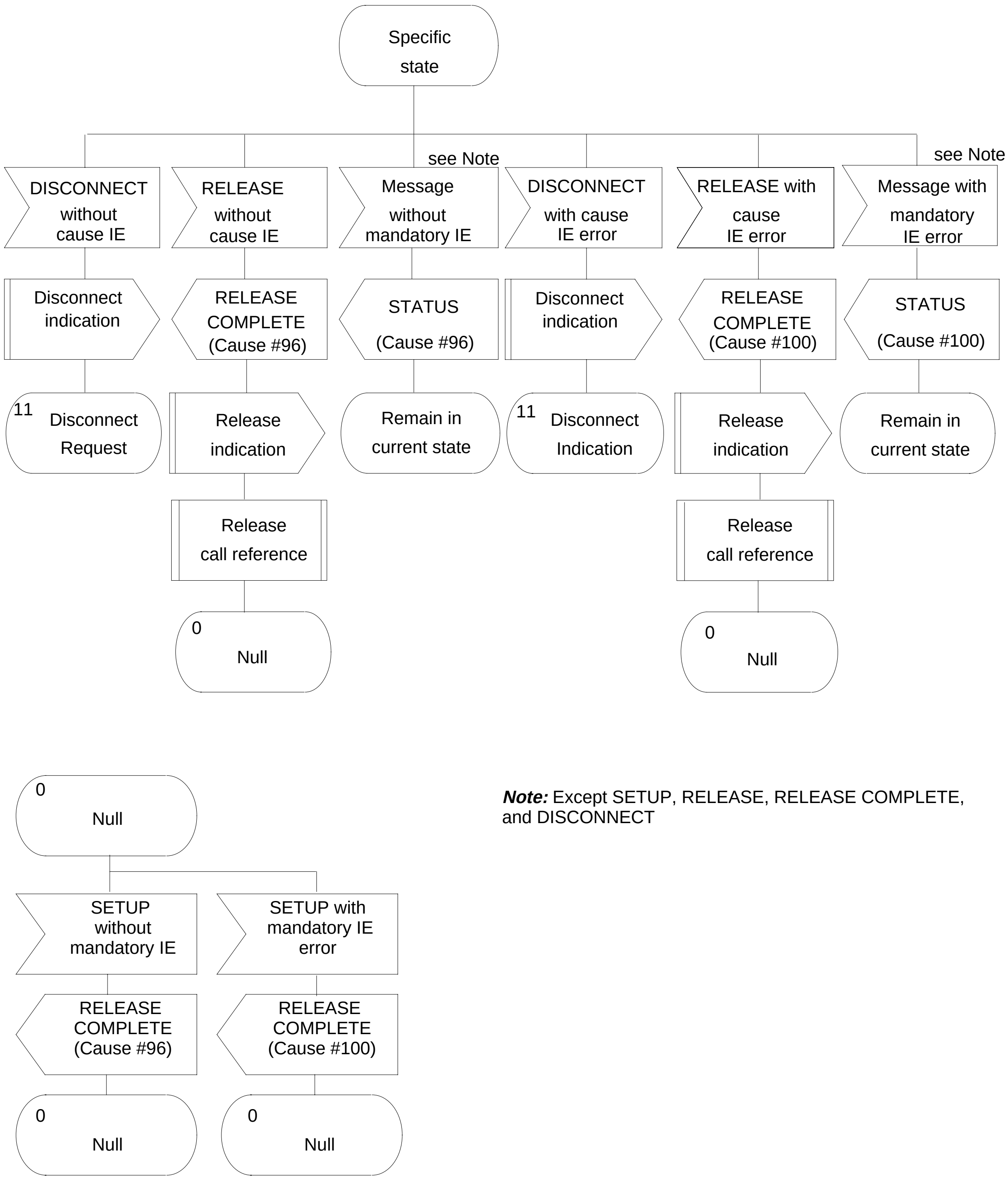


Figure 4-61 Detailed protocol control: Network side (17 of 18)



Note: Except RELEASE or RELEASE COMPLETE

Figure 4-62 Detailed protocol control: Network side (18 of 18)



Note: Except SETUP, RELEASE, RELEASE COMPLETE, and DISCONNECT

9.2 Annex B - Compatibility Checking

9.2.1 Calling side compatibility checking

At the calling side, the network checks that the bearer service requested by the calling user in the *Bearer capability* information element matches the bearer services provided to that user by the network. If a mismatch is detected, the network rejects the call using one of the causes listed in paragraph 5.1.4 on page 185.

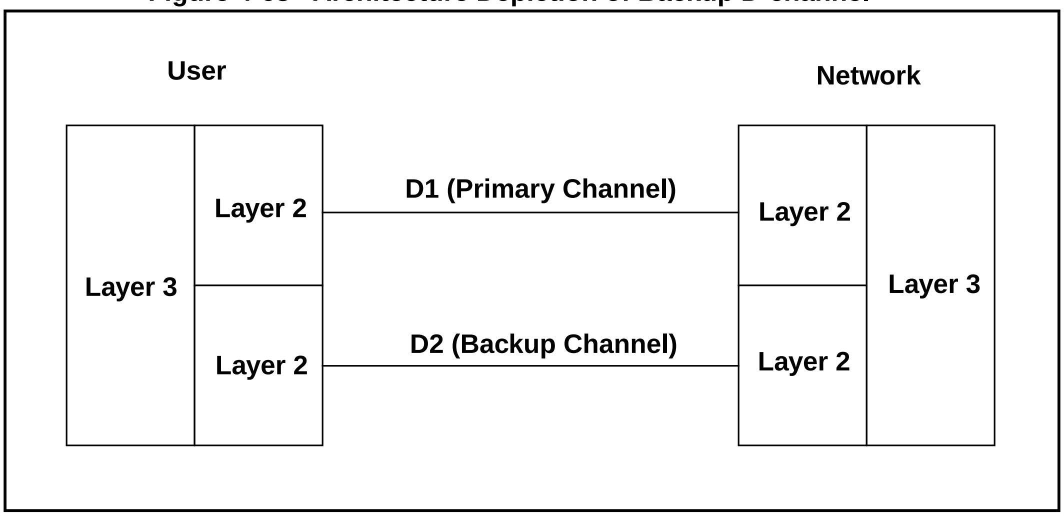
9.2.2 Called side compatibility checking

When the network is providing a bearer service at the called side, the user checks that the bearer service offered by the network in the *Bearer capability* information element matches the bearer services that the user can support. If a mismatch is detected, the user either ignores the offered call or rejects it using *Cause* value #88 “Incompatible destination”.

9.3 Annex C - Backup D-channel service

The D-channel backup procedures are based on the normal availability of two D-channels. Normal operation allows one D-channel to carry layer 3 signaling and the other to act as a reserve in standby. Switching of the D-channels occurs when the D-channel carrying layer 3 signaling fails. The standby D-channel then activates to resume transmission of call-control signaling previously handled by the failed D-channel. Switching between D-channels can also be initiated by manual intervention. This may be done, for example, when the DS1 interface with the active D-channel is to be removed from service temporarily for maintenance. Control of the switch-over event between the two D-channels is done via SERV/SERV ACK messages in the D-channel backup protocol applied between the network and user. Figure 4-63 on page 272 shows the architecture or conceptual depiction of backup D-channel.

Figure 4-63 Architecture Depiction of Backup D-channel



Backup D-channel procedures are initiated by one of the following actions:

- initialization of an ISDN PRI interface
- manually busy one or both D-channels
- manually return one or both D-channels to service
- manual intervention to switch the D-channels
- automatic detection of active D-channel failure, that is, receipt of a DL-Release-Indication primitive from layer 2
- automatically, on receiving a SERV message on the backup D-channel, which must be in the STBY state, containing a Change status information element with a New Status of “In service”.

The procedures in this annex are supplemental to those described in Chapter 4-6: Single D-Channel Maintenance, which describes maintenance procedures for PRI configurations with a single D-channel.

In most cases, the procedures in the following sections work symmetrically for both D1 and D2. In cases where symmetry does not apply, it is explicitly stated. The SERV/SERV ACK messages used in the backup D-channel procedures are independent of the B-channel service messaging.

9.3.1 Backup D-channel states

The DMS switch supports the following backup D-channel MAP states:

- INS — In Service. The D-channel is in the Multiple Frame Established state at layer 2 and is able to carry signaling via layer 3 for call control and/or services.
- WAI — Wait. In this state the maintenance entity has initiated moving the D-channel to the IS state and is waiting for confirmation from the other end of the interface.
- STB — Standby. The D-channel is in the Multiple Frame Established state at layer 2 but is not carrying signaling via layer 3 for call control and/or services.See Note 1.
- CFL — Carrier Fail. The D-channel enters this state when the carrier where the D-channel resides has failed and is unavailable for use.
- LO — Lock Out. A D-channel is in the LO state indicates a failure at layer 2 or lower.
- PMB — Peripheral Man Busy. This state indicates that the D-channel is out of service due to the XPM being manually busied.
- RNR — Remote Not Ready. This state is entered when trying to establish layer 2 on the D-channel and layer 2 establishment fails and times out.
- INI — Initialize. This state is used during an ONP. The D-channels are put in this state on the inactive side before the CM SWACT.
- MB — Manual Busy. The D-channel has been placed in the TEI assigned state by external control and is not available. Any requests for layer 2 establishment will be denied in the MB state. Only manual intervention on the near end can move the D-channel to a more available state.
- SYSB — System Busy. The D-channel is not in Multiple Frame Established state at layer 2. The SYSB state is entered automatically when a D-channel in the IS state is declared failed. While in this state a link establish request (layer 2 establishment) will result in establish denial. See Note 2.

- INB — Installation Busy. This is the D-channel state when it is first provisioned, or when service changes are being made to the interface. In other respects, this state is identical to MB.

Note 1: The STB state is only valid for backup D-channel configurations.

Note 2: The SYSB state representing the MB state in TR1268 is only valid for D-channel backup configurations. It will be shown as LO state on the MAP.

The LO and CFL states are all considered to be out of service (OOS) states in the following sections. The PRI audit periodically attempts to establish layer 2 on the D-channel.

The D-channel will remain in the OOS state until one of the following occurs:

- If a DM is received for a SABME the network will place the link in a OOS state while layer 3 periodically request layer 2 to establish the link
- A non-signaling/external control request is made to disconnect the link, which would place the D-channel in the MB state.

The D-channel will be put in a OOS state after being in the SYSB state once the backup D-channel is in a IS state.

While in the SYSB state or MB state a link request will result in a layer 2 link establishment denial. This means that if a SABME is received in a SYSB state or MB state the DMS switch will respond with a UA immediately followed by a DISC message.

The network will never put D1 and D2 in a (OOS, SYSB) state or a (SYSB, OOS) state.

In the procedures which follow, the states of the two D-channels are indicated in the format “(D1 state, D2 state)”. For example, (IS, STBY).

9.3.2 Timers

The following timers are defined for use by Backup D-channel service.

T309 — This timer is the maximum amount of time allowed for data link re-establish. This timer is started if there are active calls when the data link fails. The default value of this timer for D-channel backup protocol is 90 seconds.

T316 — This timer is the maximum amount of time that layer 3 waits for a response to a REST message used in the B-channel restart procedure. This timer is started when a REST message is sent. The default value of this timer in the network is 120 seconds.

T321 This timer is the maximum amount of time that Layer 3 waits for a response to a *SERVICE* message. The value of this timer in the network is 40 seconds. The value of this timer on the user side is not critical but is recommended to be the same value as in the network.

9.3.3 Backup D-channel protocol

The procedures in this annex use the *SERVICE* and *SERVICE ACKNOWLEDGE* messages. These messages are defined in Section 2 of this specification.

The global call reference is used for all *SERVICE* and *SERVICE ACKNOWLEDGE* messages.

The *Channel identification* information element is described in Section 3 of this specification. Coding of this information element for Backup D-channel procedures follows

- Interface Identifier Present field is set to “Explicit interface identification” or “Implicit interface identification”, as appropriate
- Interface Type field is set to “Primary rate interface”
- Preferred/Exclusive field is not used, and is ignored if received
- D-channel Indicator field is set to “Channel identified is the D-channel”
- Information Channel Selection field is set to “No channel” and is ignored if received.
- Interface Identifier field must be set (present only if the interface is explicitly identified).

The *Change status* information element is coded as follows

- Preference field set to “Channel”
- New Status field set to “In service”

Incorrectly coded *SERVICE* and *SERVICE ACKNOWLEDGE* messages received from the far end are ignored.

9.3.4 Backup D-channel procedures

9.3.4.1 Service changes

In order for the network to allow D-channel service changes the D-channels must be in the INB state. Similarly, the user side should also ensure that layer 3 is not established while service changes are being made.

On the network side, the D-channels must be in the MB state before they can be manually moved to the INB state. Similarly, when the D-channels are in the INB state, it can only be moved to the MB state.

9.3.4.2 Backup D-channel initialization procedure

If the original states of D1 and D2 are (OOS, OOS) the network starts initialization procedures to establish an in service D-channel. To begin the transfer of normal layer 3 messages across the user-network, the interface requires the establishment of, first layer 2 and then layer 3.

Both sides will proceed to bring up D1, the designated primary D-channel (D1) first.

If D1 goes to the Multiple Frame Established state at layer 2 before D2, then the following sequence of events takes place:

- D1 and D2 are in the (OOS, OOS) state
- layer 2 on D1 comes up
- send A SERV (D1=IS) message on D1,
- start timer T321 on D1,
- D2 will be placed in the SYSB state until D1 goes to IS,
- the (WAIT, SYSB) state is entered. Layer 2 establishment request on D2 will be ignored in this state.
- on receipt of a SERV (D1=IS) or a SERV ACK (D1=IS) from the far end before timer T321 expires, stop timer T321 on D1, and stop timer T309 if it is running.
- the network side will place the D-channels in the (IS, OOS) state,
- layer 2 on D2 comes up and,
- the (IS, STBY) state is entered.

If D2 goes to the Multiple Frame Established state at layer 2 before D1 and layer 2 on D1 comes up after D2 is in the IS state, then the following sequence of events takes place:

- D1 and D2 are in the (OOS, OOS) state,
- layer 2 on D2 comes up,
- send A SERV (D2=IS) message on D2,
- start timer T321 on D2,
- the (OOS, WAIT) state is entered.

- on receipt of a SERV (D2=IS) or a SERV ACK (D2=IS) from the far end before timer T321 expires, stop timer T321 on D2, and stop timer T309 if it is running.
- the network side will place the D-channels in the (OOS, IS) state,
- layer 2 on D1 comes up and,
- the (STBY, IS) state is entered.

If D2 goes to the Multiple Frame Established state at layer 2 and layer 2 comes up on D1 while D2 is in the WAIT state, then the following sequence of events takes place:

- D1 and D2 are in the (OOS, OOS) state,
- layer 2 on D2 comes up,
- send A SERV (D2=IS) message on D2,
- start timer T321 on D2,
- the (OOS, WAIT) state is entered. D1 is placed in the OOS state to allow it to come up first if layer 2 establishment occurs on D1 while D2 is in the WAIT state.
- layer 2 on D1 comes up,
- layer 2 on D2 is torn down
- stop timer T321 on D2,
- a service message is sent on D1
- start timer T321 on D1,
- the (WAIT, SYSB) state is entered. Layer 2 establishment request on D2 will be ignored in this state.
- on receipt of a SERV (D1=IS) or a SERV ACK (D1=IS) from the far end before timer T321 expires, stop timer T321 on D1, and stop timer T309 if it is running.
- the network side will place the D-channels in the (IS, OOS) state,
- layer 2 on D2 comes up and,
- the (IS, STBY) state is entered.

9.3.4.3 Verification of an active D-channel

When a SERV(D1=IS) is received on D1, the presently active D-channel, the network sends the far end a SERV ACK (D1=IS) to acknowledge the active status of D1 at its end.

The active and standby states of D1 and D2 remain unchanged.

This procedure is symmetric to D2 as well.

9.3.4.4 Layer 3 failure

Layer 3 failure on either D-channel occurs when layer 3 receives a DL-Release-Indication primitive from layer 2, or layer 3 receives a failure indication from layer 1. When the D-channel is declared failed while the backup D-channel is in STBY state, the failed D-channel will be placed in SYSB state and the D-channels will SWACT. In all other cases the failed D-channel will be placed in LO state. Timer T309 will be started when all D-channels fail and if there are active calls.

9.3.4.5 Layer 3 removal

Layer 3 can be removed from service by manual intervention to move one or both D-channels to the MB state.

When this occurs, the network

- clears all calls if both D-channels are moved to MB state.
- sends a DL-Release-Request primitive to layer 2, if the D-channel state is IS.
- moves the D-channel to the MB state.

If this occurs when the D-channel is in the IS or WAIT state and the other D-channel is in the STBY state, the procedures for D-channel SWACT are followed.

9.3.4.6 Backup D-channel switch-over (SWACT)

The active D-channel can be changed from D1 to D2, or vice versa, when initiated by one of the following actions:

- automatically, on detection of failure of the active D-channel, e.g., layer 2 failure or carrier failure.
- automatically, on receiving a SERV message on the backup D-channel, which must be in the STBY state, containing a Change status information element with a New Status of "In service".
- if a DISC message which requires a response of a UA is received.
- by manual intervention, e.g., manually busying the active D-channel or a manual SWACT request from the MAP.
- If an unsolicited DM is received the switch will respond to the DM (if the f bit=0) with an attempt to re-establish multi-frame operation.

The standby D-channel must be in a STBY state to allow normal SWACT to occur. The initial D-channel state to allow SWACT to occur is (IS, STBY).

Only stable calls will be saved over a D-channel SWACT. Calls that are not active will be lost.

The following steps are followed during SWACT from D1 to D2:

- If D1 is not declared failed, then send a DISC frame and wait for a UA frame or timer T200 time-out and transmission retry to exceed the N200 limit.
- D1 will then be placed in a SYSB state. The D-channel states will become (SYSB, STBY).
- If D2 is in a STBY state, then send a SERV message on D2 requesting an IS state and start timer T321. The states of D1 and D2 become (SYSB, WAIT). If any messages besides SERV and SERV ACK are received while D2 is in the WAIT state they will be ignored.
- If timer T321 expires before receiving a response from the far end on D2 place both D1 and D2 in an OOS state and start initialization procedures.
- If the SERV message on D2 is acknowledged by the far end before timer T321 expires place D1 and D2 in a (OOS, IS) state. Call control messages will be ignored on both D1 and D2 if T321 is running. Timer T321 will be stopped after the SERV (D2=IS) or SERV ACK (D2=IS) is received on D2. Any further SERV messages after timer T321 has stopped will be treated as active D-channel verification.
- When D1 has re-established layer 2, D1 and D2 will be placed in a (STBY IS) state.

In all cases for both D1 and D2, if a SERV ACK is received timer T321 will be stopped.

If a SERV message is received on an in-service D-channel containing a Change status information element with a New Status of “In service”, layer 3 sends a SERV ACK message to the far end, but no other action is taken.

When the backup D-channel is in the STBY state, layer 2 is already established. it is only necessary to establish layer 3, following the procedures in ”9.3.4.2 Backup D-channel initialization procedure”.

If D2 is in an OOS state when D1 is declared failed the network will place D1 in an OOS state and the initialization procedures will be executed on both D1 and D2.

If D2 is in a MB state when D1 is declared failed, D1 will then be placed in an OOS state. D1 and D2 will remain in the (OOS,MB) states until the craftperson places D2 in an OOS state or D1 is recovered from failure.

If D1 and D2 are placed in (STBY, IS) state, the D-channels are available for SWACT again if D2 fails, or a SWACT request from the far end, or a manual SWACT request from the near end is received.

9.3.5 Handling XPM warm SWACT on Backup D-channels

During a XPM warm SWACT, layer 2 goes down on the D-channels. The newly active XPM unit will try to recover all the D-channels and establishes layer 2 on all D-channels. In normal circumstances the D-channel initialization procedure will try to establish D1 first. However, during a XPM warm SWACT recovery, the D-channel that was active before the XPM warm SWACT will be recovered first after the XPM warm SWACT occurs, so that a D-channel SWACT is not caused at the far end, i.e.,

- if the D-channels are in (STBY, IS) state before the XPM warm SWACT, the network should try to recover D2 first;
- if the D-channels are in (IS, STBY) state before the XPM warm SWACT, the network should try to recover D1 first.

When recovering layer 2 on the D-channels in this situation the network side does not want to invoke NI-2 D-channel initialization procedures.

In order to prevent the far end from sensing the XPM warm SWACT we handle D-channel initialization on NI-2 D-channels differently during a XPM warm SWACT recovery, i.e., preventing giving D1 priority over D2.

If layer 2 on the inactive D-channel comes up when the active D-channel is in the WAIT state, the inactive D-channel will be moved to the STBY state.

If a failure occurs on the active D-channel during the D-channel recovery after the XPM warm SWACT, layer 2 on the inactive D-channel will come up and layer 3 will be established on the inactive D-channel. As this requires the inactive D-channel to become the active D-channel, the D-channel initialization procedure will revert back to the normal D-channel initialization procedure as described in “9.3.4.2 Backup D-channel initialization procedure” on page 276.

9.3.6 Coordination of backup D-channel procedures and B-channel restart procedures

A restart cannot be invoked until D-channel initialization procedure is completed, i.e., the active D-channel is in a IS state. In the backup D-channel configuration restart procedures will only be used when D1 and D2 are initialized from an (OOS, OOS) state and when timer T309 is not running. If timer T309 is not running this means that there are no active calls on the interface when the D-channels fail, and a global restart can then be performed to restart the entire link after the D-channel initialization is completed.

If timer T309 is running, the D-channels have been down for less than 90 seconds and there may still be active calls on the interface. The network will not send a global or DS1 restart message which would tear down all active calls. However, if the interface is provisioned with SERV/SERV ACK messaging, the network sends SERV (IS) messages for idle B-channels and SERV (OOS) messages for Near-End Out-Of-Service B-Channels.

During a D-channel SWACT, restart procedures will not be initiated as active calls are supposed to survive a D-channel SWACT.

However, a D-channel SWACT can take place during a B-channel global restart. If this case occurs, after the D-channel SWACT procedure is completed, the restart procedure will continue to be executed based on the status of global restart before the D-channel SWACT occurred:

- if the D-channel SWACT occurs after REST message was sent by the network, the network will then
  - re-send a global REST message on the newly active D-channel,
  - start timer T316,
- if the D-channel SWACT occurs before the REST ACK message was sent by the network, the network will then,
  - send a global REST ACK message on the newly active D-channel,

A XPM warm SWACT can also take place during a B-channel global restart. If this case occurs, the restart procedure will continue to be executed after the XPM warm SWACT procedure has recovered the D-channels. The same approach is taken to continue the B-channel global restart as the case for the D-channel SWACT during a B-channel global restart.

9.3.7 D-channel audit

The PRI D-channel audit is used to detect D-channel failures and to act on D-channel failures if they have occurred (i.e. act on D-channels in LO state, etc.). It runs every 60 seconds.

If the PRI D-channel audit finds a D-channel in the LO state, the audit will try to bring layer 2 up by sending a layer 2 establishment request on the D-channel.

9.3.8 Error handling for maintenance messages

If a SERV or SERV ACK message is received with invalid contents or a missing IE, the error treatment will be to ignore the message.

Maintenance messages transmitted with protocol discriminator other than “0100 0011” (#43) will be ignored.

9.3.9 Layer 3 SDL diagrams

The message flow control for each procedure are described in the following SDL diagrams. These diagrams are not meant to cover every possible scenario that can happen for each maintenance procedure. Refer to previous sections for text descriptions. Is is assumed that B-channel service messaging is subscribed to by the network and B-channels are not carrying calls.

Figure 4-64 Backup D-channel Procedures SDL Diagram - Initialization

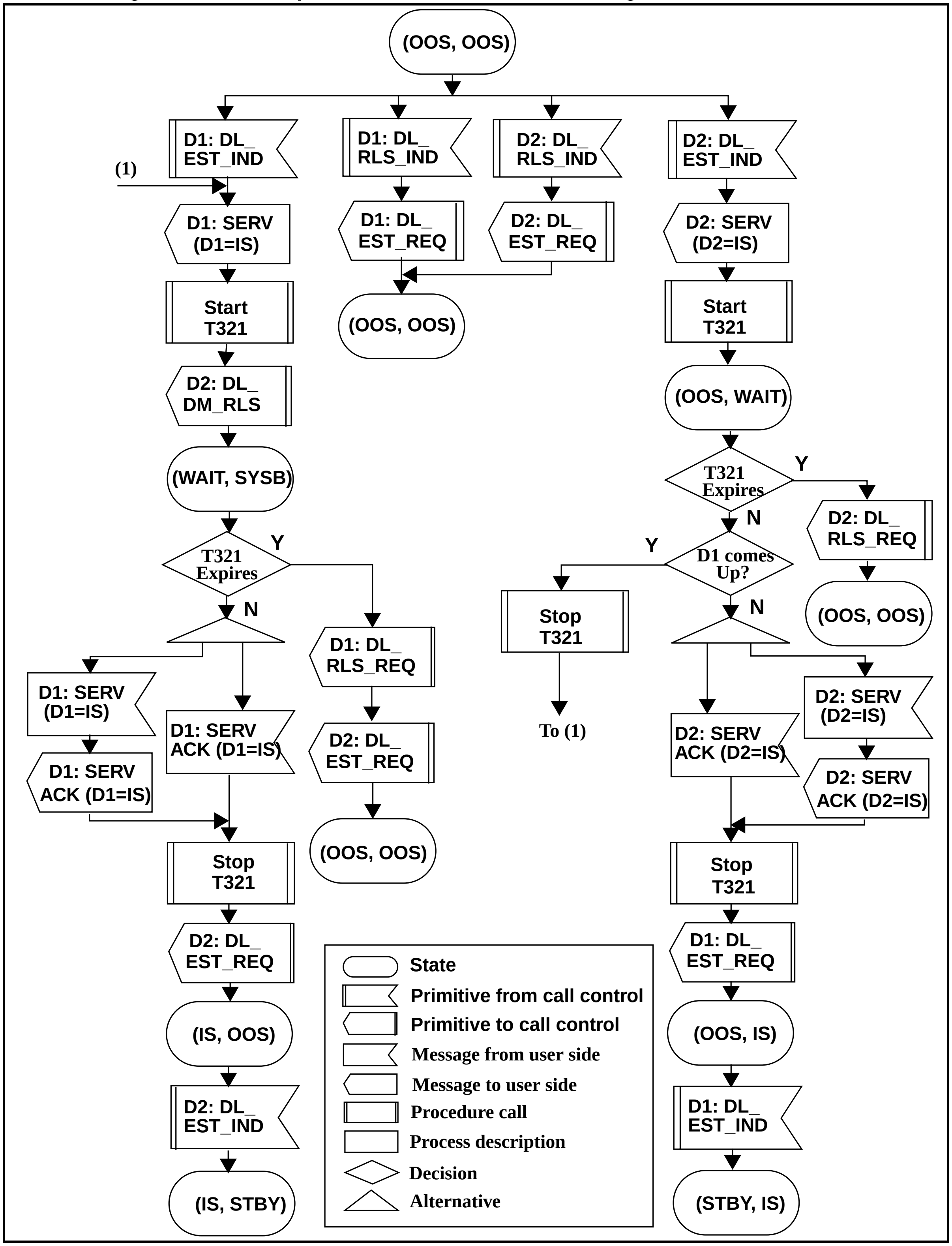
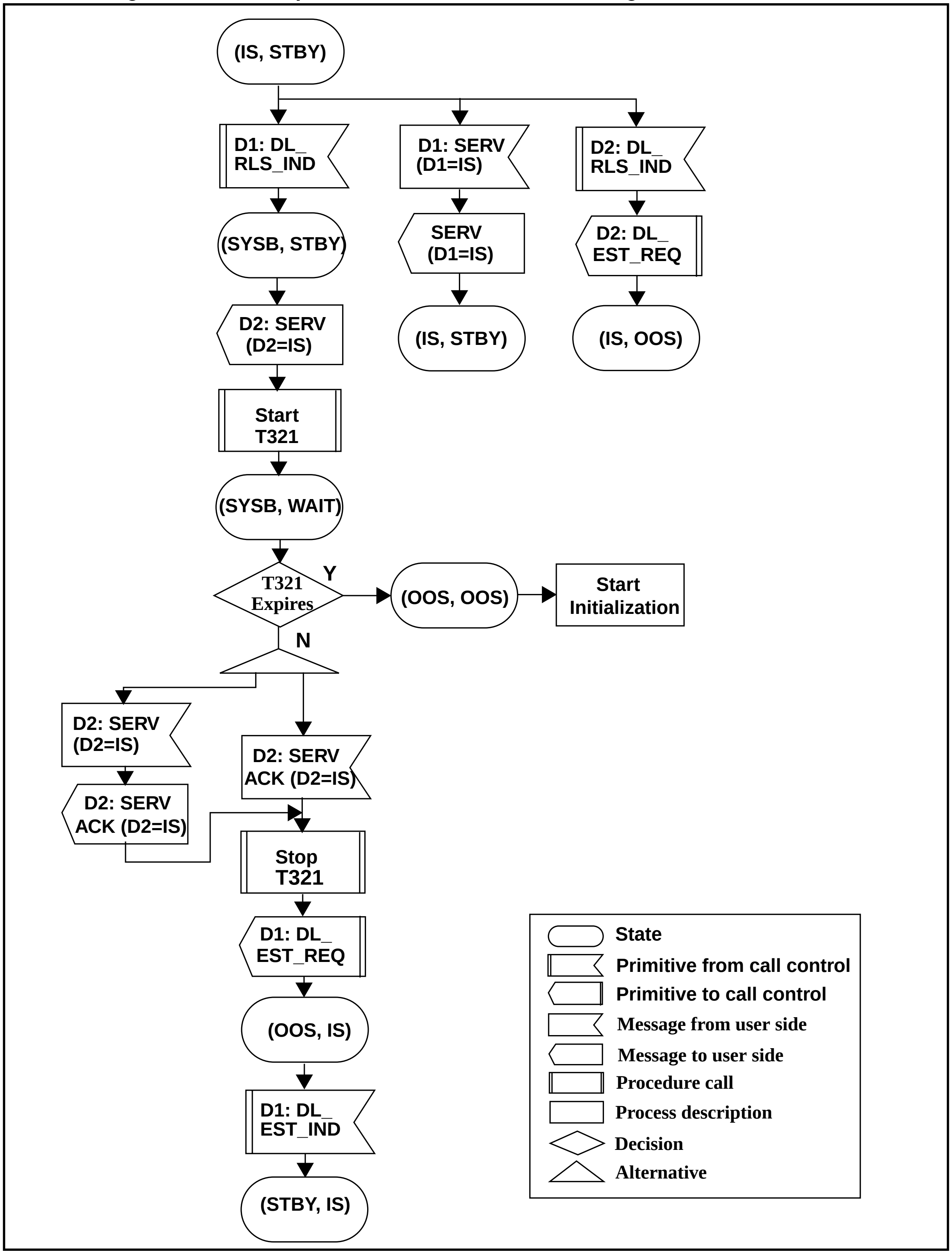


Figure 4-65 Backup D-channel Procedures SDL Diagram - SWACT



9.4 Annex D - Cause and General Location

9.4.1 Cause Definitions

The following list contains definitions for each of the causes values used in this specification.

Normal class

- Cause 1 - Unallocated (Unassigned) Number

  This cause indicates that the destination requested by the calling user cannot be reached because, although the number is in a valid format, it is not currently assigned (allocated).

- Cause 2 - No route to specified transit network

  This cause indicates that the equipment sending this cause has received a request to route the call through a particular transit network which it does not recognize. The equipment sending this cause does not recognize the transit network either because the transit network does not exist or because that particular transit network, while it does exist, does not serve the equipment which is sending this cause.

- Cause 3 - No route to destination

  This cause indicates that the called user cannot be reached because the network through which the call has been routed does not serve the destination desired.

- Cause 6 - Channel unacceptable

  This cause indicates the channel most recently identified is not acceptable to the sending entity for use in this call.

- Cause 16 - Normal call clearing

  This cause indicates that the call is being cleared because one of the users involved in the call has requested that the call be cleared.

- Cause 17 - User busy

  This cause is used when the called user is unable to accept another call because another call or calls is occupying the resources required to handle the new call.

- Cause 18 - No user responding

  This cause is used when a user does not respond to a call establishment message with either an alerting or connect indication within the prescribed period of time allocated.

- Cause 19 - No answer from user (user alerted)

  This cause is used when a user has provided an alerting indication but has not provided a connect indication within a prescribed period of time.

- Cause 21 - Call rejected

  This cause indicates that the equipment sending this cause does not wish to accept this call, although it could have accepted the call because the equipment sending this cause is neither busy nor incompatible.

- Cause 22 - Number changed

  This cause is returned to a user when the called number, indicated by the calling user, is no longer assigned.

- Cause 27 - Destination out of order

  This cause indicates that the destination indicated by the user cannot be reached because the interface to the destination is not functioning correctly. The term “not functioning correctly” indicates that a signaling message was unable to be delivered to the remote user; for example a physical layer or data link layer failure at the remote user, user equipment off-line, etc.

- Cause 28 - Invalid number format (address incomplete)

  This cause indicates that the destination indicated by the calling user cannot be reached because the number is not in a valid format or is not complete.

- Cause 30 - Response to *STATUS ENQUIRY*

  This cause is included in the *STATUS* message when the reason for generating the *STATUS* message was the prior receipt of a *STATUS ENQUIRY* message.

- Cause 31 - Normal, unspecified

  This cause is used to report a normal event only when no other cause in the normal class applies.

Resource unavailable class

- Cause 34 - No circuit/channel available

  This cause indicates that there is no appropriate circuit/channel, presently available, to handle the call.

- Cause 41 - Temporary failure

  This cause indicates that the network is not functioning correctly and that the condition is not likely to last a long period of time. For example, the user may wish to try another call attempt almost immediately.

- Cause 42 - Switching equipment congestion

  This cause indicates that the switching equipment generating this cause is experiencing a period of high traffic.

- Cause 43 - Access information discarded

  This cause indicates that the network could not deliver access information to the remote user as requested.

- Cause 44 - Requested circuit/channel not available

  This cause indicates that the channel requested by the user during local channel negotiation is not currently available. For example, in use or out of service for maintenance.

- Cause 47 - Resources unavailable, unspecified

  This cause is used to report a resource unavailable event only when no other cause in the resource unavailable class applies.

Service or option not available class

- Cause 50 - Requested facility not subscribed

  This cause indicates that the user has not subscribed to this facility and therefore cannot access the facility at this time.

- Cause 54 - Incoming calls barred

  This cause indicates that the called user does not accept the call delivered in the *SETUP* message.

- Cause 57 - Bearer capability not authorized

  This cause indicates that the user has requested a bearer capability which is implemented by the equipment which generated this cause but the user is not authorized to use.

- Cause 58 - Bearer capability not presently available

  This cause indicates that the user has requested a bearer capability which is implemented by the equipment which generated this cause but which is not available at this time.

- Cause 63 - Service or option not available, unspecified

  This cause is used to report a service or option not available event only when no other cause in the service or option not available class applies.

Service or option not implemented class

- Cause 65 - Bearer capability not implemented

  This cause indicates that the equipment sending this cause does not support the bearer capability requested.

- Cause 66 - Channel type not implemented

  This cause indicates that the equipment sending this cause does not support the channel type requested.

- Cause 70 - Only restricted digital information bearer capability is available

  This cause indicates that the user has requested an unrestricted bearer service but that the equipment sending this cause only supports the restricted version of the requested bearer capability.

- Cause 79 - Service or option not implemented, unspecified

  This cause is used to report a service or option not implemented event only when no other cause in the service or option not implemented class applies.

Invalid message class

- Cause 81 - Invalid call reference value

  This cause indicates that the equipment sending this cause has received a message with a call reference which is not currently in use on the user-network interface.

- Cause 82 - Identified channel does not exist

  This cause indicates that the equipment sending this cause has received a request to use a channel not activated on the interface for a call. For example, if a user has subscribed to those channels on a primary rate interface numbered from 1 to 12 and the user equipment or the network attempts to use channels 13 through 23, this cause is generated.

- Cause 88 - Incompatible destination

  This cause indicates that the equipment sending this cause has received a request to establish a call to a destination in which the required attributes cannot be accommodated (for example, data rate).

- Cause 90 - Destination address missing

  This cause indicates that the called party address is missing.

- Cause 95 - Invalid message, unspecified

  This cause is used to report an invalid message event only when no other cause in the invalid message class applies.

Protocol error class

- Cause 96 - Mandatory information element is missing

  This cause indicates that the equipment sending this cause has received a message which is missing an information element which must be present in the message before that message can be processed.

- Cause 97 - Message type non-existent or not implemented

  This cause indicates that the equipment sending this cause has received a message with a message type it does not recognize either because this is a message not defined, or defined but not implemented, by the equipment sending this cause.

- Cause 99 - Information element non-existent or not implemented

  This cause indicates that the equipment sending this cause has received a message which includes information elements not recognized because the information element identifier is not defined or it is defined but not implemented by the equipment sending the cause. However, the information element is not required to be present in the message in order for the equipment sending the cause to process the message.

- Cause 100 - Invalid information element contents

  This cause indicates that the equipment sending this cause has received an information element which it has implemented, however, one or more of the fields in the information element are coded in a way which has not been implemented by the equipment sending this cause.

- Cause 101 - Message not compatible with call state

  This cause indicates that the equipment sending this cause has received a message such that the procedures do not indicate that this is a permissible message to receive while in the call state, or that a *STATUS* message was received indicating an incompatible call state.

- Cause 102 - Recovery on timer expiry

  This cause indicates that a procedure has been initiated by the expiry of a timer in association with error handling procedures.

- Cause 111 - Protocol error, unspecified

  This cause is used to report a protocol error event only when no other cause in the protocol error class applies.

Interworking class

- Cause 127 - Interworking, unspecified

  This cause indicates that there has been interworking with a network which does not provide causes for actions it takes. Thus, the precise cause for a message which is being sent cannot be ascertained.

9.4.2 General Location

General location indicators describe the location of the source of the information element. Examples of information elements that contain General location indicators include Cause and Progress.

General location indicators supported include:

- User
- Private network serving the local user (PRNSLU)
- Public network serving the local user (PUNSLU
- Transit network (TN)
- Public network serving the remote user (PUNSRU)
- Private network serving the remote user (PRNSRU)
- International Network (INT)
- Network beyond the interworking point (NBIWP)

While the cause or progress value remains the same as it travels across various networks, the location indicator is a relative value which may be changed as it travels across various networks. (see ANSI T1.650-1995).

The location indicator may be changed by the DMS in the User to Network direction or in the Network to User direction or the location indicator may be passed unchanged. If a change is made, it is made to provide the receiver of the information with accurate source location information. The two tables that follow describe DMS behavior when (1) the CPE sends a location indicator to the DMS and (2) when the DMS receives location information that must be sent to the CPE.

Table 4-39 General Location from the CPE

General Location (from the CPE)	DMS Action Before Passing Toward the Other Party
User	No change
Private network serving the local user	Change to “Private network serving the remote user”
Private network serving the remote user	No change
any other location	Change to “User”

Table 4-40 General Location from the Network

General Location (from the Network)	DMS Action Before Sending Toward the CPE
User	No change
Private network serving the local user	Change to “Private network serving the remote user”
Public network serving the local user	Change to “Public network serving the remote user” (Note 1)
Transit network	No change
Private network serving the remote user	No change
International network	No change
Network beyond interworking point	No change
any other location	Change to “Public network serving the remote user”

Note 1. If the equipment directly connected to the network side of the PRI is the source of the location “Public network serving the local user” then “Public network serving the local user” is delivered to the CPE.

Chapter 5-1: Services Introduction

The ISDN Primary Rate Interface (PRI) services described in this section are those offered by the DMS-100 (the network) to a PRI user (for example, an AIN IP or PBX) on an NTNI interface.

The PRI services fall into the following two categories

- call processing services
- administration/maintenance services

Call processing services are normally used during call establishment and release.

Administration/maintenance services are normally associated with equipment provisioning, administration and control of an ISDN PRI. The PRI administration/maintenance services are described herein are in addition to other DMS product specific OAM services.

1.1 PRI call processing services

1.1.1 Calling number and redirectory number screening

For PRI origination, Calling Party Number (CPN) and Redirecting Number Delivery (RN) Screening are available as a single option on a per ISDN PRI basis.

1.1.2 Calling number delivery and redirecting number delivery

The Calling Number Delivery (CND) and Redirecting Number Delivery services provide information to the terminating circuit.

For PRI termination, CND and RND are available as a separate options on a per ISDN PRI basis. The options allow delivery “Never, Always, or Screened”. The default for CND and for RND is “Screened”.

When “Never” is selected, the calling number and redirecting number information elements are not delivered.

When the CND (and/or RND) service option selected is “Always”, the numbers will be contained in the *Calling party number (and/or Redirecting number)* information elements in the *SETUP* message, unless the numbers are not available. The numbers are not available when a call is routed over certain existing signaling systems (for example, MF). If a call encountered interworking, the *Calling party number (and/or Redirecting number)* information element is sent with an indication of “number not available” and no digits.

When the CND (and/or RND) service option selected is "Screened", and the calling party’s privacy indicator allows the number to be displayed, the number will be delivered with the presentation indicator set to “allow”. But if the calling party’s privacy indicator has requested that the number not be displayed, the *Calling party number (and/or Redirecting Number)* information element will be delivered with the presentation indicator set to “restricted” and the number will not be delivered.

1.1.3 Equal access

The Equal Access service provides PRI users with equal access to carrier networks (for example, IEC networks) for public network calls. Equal Access shall support access to intraLATA and interLATA carriers.

1.1.3.1 Transit network selection on a per call basis

Transit network selection on a per call basis allows the user to specify the preferred carrier on each call. The carrier selection may be accomplished by using the equal access dialing plan in the *Called party number* information element (for example, 10XXX+ dialing) or by including a *Transit network selection* information element in the *SETUP* message.

1.1.3.2 Default transit network selection

A default carrier is selected by the network if a carrier is not explicitly provided by the user in the call setup request and one is needed for the call. In this case, the network will provide the default carrier to which to route the call. The default carrier is selectable for each PRI.

1.1.4 Special number services

The Special Number services enable a PRI user to access any special number services available in the public network. These special numbers may not conform to any of the numbering plans. As such they are specified in the public network dialing plan to access certain network services (for example, “0” for operator services and “411” for directory information).

The special number digits are sent by the user in the *Called party number* information element in a *SETUP* message. The called party number will be coded as conforming to the E.164 numbering plan (for example, an NPI of

“E.164” and a type of number of “unknown”). The TON of “International” is not supported on special numbers.

All special numbers accessible to public network subscribers can be accessed over PRI. These include

- 411
- 911
- 611
- 1-800
- 1-900

1.1.5 Two B-Channel Transfer service

The Two B-Channel Transfer (TBCT) service is not available on the OC-3 fiber interface. TBCT allows the user (controller) on a PRI to request the Stored Program Control Switch (SPCS) to connect two independent calls on the user’s interface. The two calls may be on a single PRI interface or on different PRI interfaces in the same PRI serving group. If the SPCS accepts the request, the circuits to that controller are released from the calls and the other two users are directly connected. Billing for the two original calls continues in the same manner as if the transfer had not occurred and the controller of the transfer was still connected to both calls. If subscribed to Notification to the Controller, the SPCS sends the controller a NOTIFY message when the transferred call eventually clears.

1.1.6 Call-By-Call service

The Call-By-Call service provides the capability to convey signalling information over an ISDN Primary Rate Interface (PRI) that indicates, on a per-call basis, the specific service type associated with the call. Service types supported include Foreign Exchange (FX), Tie Trunk, OUTWATS, INWATS, Hotel/Motel, Selective Class Of Call Screening (SCOCS), and Public Network.

1.1.7 Calling Name

Calling Name is a terminating circuit service. The service delivers the calling party’s name toward the called party (for this document, the called party is connected to the DMS-100 via an NTNI PRI).

The DMS-100 considers several factors to determine if the calling name will be delivered. Some of these factors include; whether the terminating PRI has subscribed to calling name delivery, whether the calling line number presentation is allowed, whether the calling line number is available, and whether the calling name can be successfully retrieved.

1.1.8 Dialable Wideband Service

The Dialable Wideband Service (DWS) is not available on the OC-3 fiber interface. DWS is also called Switched Fractional DS1 (SWF-DS1) and Multi-rate ISDN by various groups in the industry.

DWS provides the ability to establish PRI, on-demand, nx64 kbps calls. An nx64 kbps call is a call with a rate that is a multiple of 64 kbps. The multiple 'n' is within the range of 2 to 24. The procedure for establishing DWS calls is similar to the procedure for establishing a basic 64 kbps circuit switched ISDN call. The PRI interface allows DWS calls to originate or terminate at the CPE. The DWS described in this specification is for calls that originate or terminate on an NTNI PRI interface from another NTNI PRI interface, an NTNA PRI interface or an ISUP CCS7 interface. The NTNA PRI interface is covered in a separate document.

Typically, ISUP CCS7 trunks transport calls between switches for IntraLATA and InterLATA calls, and several DWS-specific extensions have been incorporated into the ISUP IntraLATA and InterLATA signalling protocols.

1.1.9 Message Service

Message service is not available on the OC-3 fiber interface. Message Service allows subscribers to retrieve messages that were previously left for them. Subscribers to the message service are referred to as client users. Client users can select any call forward variant such as call-forward-busy, call-forward-don't-answer, etc. to route incoming calls to a Message Storage and Retrieval (MSR) system. The MSR is connected to the SPCS via NTNI PRI.

When a call is forwarded by a client user to the MSR, the client user's number is delivered to the MSR. Typically the MSR provides a personalized greeting from the client user and stores the caller's message.

When a message is waiting to be retrieved, the MSR sends a PRI D-channel message to the SPCS requesting that the client user's message waiting indicator be activated. After the network has activated the message waiting indicator, the SPCS sends an acknowledgement message to the MSR.

The client user can directly call the MSR to retrieve waiting messages. Typically the MSR requires the client user to provide a user ID and password via in-band signaling. However, since these in-band signals are transparent to the SPCS and network, they will not be described herein.

When all messages have been retrieved, the MSR sends a PRI D-channel message to the SPCS requesting that the client user's message waiting indicator be deactivated. After the network has deactivated the message waiting indicator, the SPCS sends an acknowledgement message to the MSR.

1.1.10 B-Channel Packet

B-Channel Packet service is not supported on the OC-3 fiber interface. One or more B channels of an NTNI PRI can be provisioned for B-Channel Packet service. The B channel(s) must be provisioned at subscription time. Note that "on-demand" B-Channel Packet call service (i.e. using the PRI's D channel to setup packet bearer capability calls) is not supported.

When a PRI's B channel is configured for B-Channel Packet service, the channel is connected to the DMS Packet Handler (DMS PH). The DMS PH processes X.25 packets that are carried in the B channel.

1.2 Administration/maintenance services

1.2.1 Backup D-Channel

The Backup D-Channel service increases the reliability of signaling for non-facility associated signaling, that is, when a single D-channel is used to provide call control signaling for more than one DS-1 interface. This service provides a procedure for employing a standby D-channel which is used if the primary D-channel fails. All active calls are maintained during the switch-over to the standby D-channel, assuming the associated B-channels remain functional.

The Backup D-Channel service is available as an option on a per ISDN PRI basis. See Chapter 4-9 paragraph 9.3 on page 272 of this specification for further information on this service.

1.2.2 Restart Signaling

Please refer to section 5.7 on page 200.

1.2.3 B-Channel Availability

Please refer to section 7.2 on page 227 through section 7.4 on page 228.

Chapter 5-2: Calling number delivery

The procedures for Calling Number Delivery (CND) service cover the requirements for both when the PRI user provides a calling number as part of a call setup request and when the network delivers a calling number as part of a call setup request. These procedures include the requirements for calling party number privacy.

The procedures for CND service are consistent among PRI, BRI, Centrex and public network users. For interworking with CLASS CND service, the entire PRI is considered by the network to be one user, that is, there is no differentiation among individual users on a PRI.

The calling party's number is included in the *SETUP* message in the *Calling party number* information element. The *SETUP* message is described in Chapter 2-3 paragraph 3.1.10 on page 117 and the *Calling party number* information element is described in Chapter 2-4 paragraph 4.5.7 on page 148 of this specification.

2.1 Receipt of a call setup request from the calling PRI user

On receipt of a call setup request from a PRI user, the subsequent action is dependent on the values in the *Calling party number* information element (CPN), the *Redirecting Number* information element, and whether CPN/RN screening is subscribed.

2.1.1 User includes Calling Party Number Information Element

The digit string in the user provided CPN must be IA5 characters. For public network calls from a CPE it is recommended that the user at least provide the Listed Directory Number (LDN) of the CPE.

The octet containing the Privacy Indicator (PI) and Screening Indicator (SI) is optional.

2.1.1.1 User includes the PI and SI

Where the PI received from the CTE is "Number not available" then the PI will remain "Number not available".

Where the PI received from the CTE is 'Presentation prohibited' and screening results in retention of a network provided (NP CPN) number for presentation then the PI of the NP CPN shall be set to 'Presentation prohibited' regardless of the setting of the per interface privacy parameter.

Where the PI received from the CTE is 'Presentation prohibited' and either the unscreened number (UPNS CPN) or the passed screened number (UPPS CPN) is to be retained for presentation, then the PI of the UPNS CPN or UPPS CPN shall be set 'Presentation prohibited'.

Where the PI received from the CTE is 'Presentation allowed' and screening results in retention of a network provided (NP CPN) number for presentation then the PI of the NP CPN shall be set to the subscribed interface privacy indication.

Where the PI received from the CTE is 'Presentation allowed' and either the unscreened number (UPNS CPN) or the passed screened number (UPPS CPN) is to be retained for presentation, then the PI of the UPNS CPN or UPPS CPN shall be set to 'Presentation allowed'.

2.1.1.2 User does not include the PI and SI

If no number privacy indication is received from the CTE in the CPN, the subscribed interface privacy value shall be used to determine the privacy status of the call.

The network sets the SI to “User-provided, not screened”.

2.1.2 *Calling party number* information element omitted

The network sets calling party information as follows

- the numbering plan identifier (NPI) is set to “E.164”
- the type of number (TON) is set to “National”
- the network supplies the default CPN for the call type for the interface
- the PI is set to the subscribed interface privacy value (i.e. if calling number digits are datafilled for the interface, PI is set to “Presentation allowed” otherwise, PI is set to “restricted”).
- the SI is set to “Network provided”

2.1.3 User includes *Redirecting Number* information element

If no number privacy indication is received from the CTE in the RN then the subscribed per interface privacy value shall be used to determine the privacy status of the call with the following two exceptions: a) where no RN is provided and an RFR is provided the PI value is set to 'Number not available' and b) where no RN and RFR are provided (no RNIE provided) no privacy indication is required.

For screening cases UPPS, UPFS and UPNS where the CTE generated PI is 'Presentation prohibited' the PI of the UPPS RN, UPFS RN or UPNS RN shall be set to 'Presentation prohibited'. Similarly, in the case where the CTE generated PI is 'Presentation allowed' the PI of the UPPS RN, UPFS RN or UPNS RN shall be set to 'Presentation allowed'.

Where two instances of RN information are received the privacy setting for each redirecting number is determined independently according to the above procedures. Privacy processing is performed for the first instance of RN (associated with the original instance of CF) followed by the second instance of RN (associated with the latest instance of CF).

2.2 Progress of calling party information through the network

The calling party information provided by the user, and possibly as altered by the procedures in section 2.1 on page 299, is normally passed unmodified through the network to the terminating network switch. Exceptions to this general rule are described below.

2.2.1 Interworking

When a call terminates to a non-ISDN network which is not capable of transporting the CPN, RN, PI, or SI information, this information is discarded. For example, this can occur when interworking with an MF trunk.

When a call originates from a non-ISDN network which does not support the CPN, RN, PI, or SI information, the terminating ISDN network may be able to reconstitute the CPN, and possibly the PI and SI. This can be done since some non-ISDN networks are capable of transporting a calling party number. Otherwise, the ISDN network sets the PI to “Number not available”, the SI to “Network provided”, and the CPN is omitted.

When a call originates from (or terminates to) an ISDN trunk using ISUP signalling, the CPN, RN, PI, and SI information is passed between the PRI and the ISUP trunk.

2.3 Delivery of a call setup request to the called PRI user

The delivery of the CPN is determined by the availability of the calling number, the call’s Presentation Indicator (PI) as described above and by the called interface’s subscription to CND and RND. Note that CND and RND are separate subscription items.

If calling party information and/or redirecting number information are delivered, they are delivered in the *Calling party number* information element and *Redirecting Number* information element in the *SETUP* message sent to the called user.

The network uses the following procedure to determine whether the CPN should be delivered to the terminating user:

- CND subscription is "Always"

  CPN digits, if available, are always delivered over the PRI, even if the PI is "Presentation restricted". If unavailable, the TON/NPI will be coded to “Unknown”, the PI to “number not available”, and the digits are omitted..

- CND subscription is "Never"

  A Calling party number information element is not delivered over the PRI, regardless of the PI value.

- CND subscription is "Screened"

  CPN digits, if available, are delivered over the PRI only if the PI is "Presentation allowed". If unavailable, the TON/NPI will be coded to “Unknown”, the PI to “number not available” and the digits are omitted.

The network uses the following procedure to determine whether the RN should be delivered to the terminating user:

- RND subscription is “Always”

  RN digits, if available, are always delivered over the PRI, even if the PI is “Presentation restricted”. If no RN information is available, an RN information element is not delivered. If RFR is provided and RN digits are not available, the RNIE shall be delivered with the TN/NPI value coded as 'unknown', the PI coded as 'number not available', the RFR value shall be coded as received and RN digits omitted.

- RND subscription is “Never”

  A *Redirecting number* information element is not delivered over the PRI, regardless of the PI value.

- RND subscription is “Screened”

  RN digits, if available, are delivered over the PRI only if the PI is “Presentation allowed”. If no RN information is available, an RN information element is not delivered. If RFR is provided and RN digits are not available, the RNIE shall be delivered with the TN/NPI value coded as 'unknown', the PI coded as 'number not available', the RFR value shall be coded as received and RN digits omitted.

2.4 Compliance to TR-1187

The Calling Number Delivery service is based upon Bellcore's TR-1187 Issue 1 and Revision 1 documents dated March 1992. These documents describe message flow and message content. The NTNI product has the following restrictions (that are required in TR-1187):

- CPN Provision Necessary is not supported
- CPN code check of TON values supported is limited to International, National, and Local and the code check of NPI value is limited to support of ISDN Numbering Plan (E.164)
- Two Number Delivery is not supported
- Discard Control is not supported
- Two calling party information elements is not supported
- CPN and RN Subaddress are not supported
- International number in data numbering plan is not supported
- Subscriber number in private numbering plan
- Abbreviated number in private numbering plan
- Detailed and Aggregate Recording for Calling Party Subaddress Delivery

Chapter 5-3: Equal access

Equal Access service allows a PRI user to select a specific carrier for calls to the public network. Not all calls require carrier selection, depending on the geographical separation between the calling and called parties and regulatory requirements.

Equal Access service can be used in conjunction with any call setup request, whether it is an ordinary basic call or there are interactions with other supplementary services.

Carrier selection can be performed by the PRI user in one of the following ways

- on a per call basis
- subscribed default
- network-determined

In the ISDN, the carrier code provided explicitly by the user or selected by default, is conveyed and used for routing until the point of entry into the selected carrier network, at which point it is typically discarded.

The Equal Access service will support equal access for interLATA or intraLATA carriers. Separate interLATA and intraLATA PICs can be assigned to a PRI.

This section describes how Equal Access service can be accessed by PRI users.

3.1 Transit network selection on a per call basis

The PRI user can specify that a specific carrier (for example, inter-exchange carrier) be used on a per call basis. This is accomplished by including a *Transit network selection* (TNS) information element in the *SETUP* message.

The equal access dialing plan consists of special prefix digits before the public number of the called station. For example "10XXX" in the U.S., where "XXX" is the code assigned to the selected carrier. In addition to 10-digit public numbers, “10XXX-0+” or “10XXX-0-” dialing can be used to reach a carrier’s operator service. Other special numbers to reach other carrier services may also be available, but these are beyond the scope of this specification.

If a TNS is included in the *SETUP* message, it is coded as follows

- Type of Network Identification - “National”
- Network Identification Plan - “Carrier identification code”
- Network Identification Characters - the 3 or 4 digit code of the selected carrier, coded as IA5 characters (leading zeros are significant and must be included)

If a TNS is included in the *SETUP* message, but the call (as indicated by the *Called party number* information element) does not require carrier routing to complete, the TNS is ignored by the network.

3.2 Default transit network selection

If the user does not include a *Transit network selection* information element (TNS) in the *SETUP* message, and the call must be routed via a carrier , a default carrier will be selected by the originating network switch. For public calls only, the default carrier can be

- subscribed to by the customer, on an interface basis
- if there is no customer or interface subscription default, a network-determined default is used

For private calls, the default carrier is selected through translations. The subscribed default carrier for private and public calls may be different.

3.3 Interworking

The Equal Access service supports interworking with non-ISDN public network facilities, in those networks which support equal access. That is, the carrier identification code is carried in the non-ISDN portion of the public network (for example, Feature Group D signaling).

3.4 Error Procedures

If a carrier selection is required for a call, and the user the carrier identification code in the TNS information element is incorrect in the *SETUP* message, the network clears the call by sending a *RELEASE COMPLETE* message with a *Cause* information element containing *Cause* value #2 “No route to specified transit network”.

Chapter 5-4: Special number services

4.1 Special Number Services Description

Each special number service is handled in a specific manner within the network. In general, the special numbers do not conform to any numbering plan, therefore their meaning is determined by the network supplying PRI service. Use of the special number routes the call to the requested service.

This specification does not specify in detail how to provide these services as there are no specific PRI requirements. Access to these services is via the public network dialing plan, as coded in the *Called party number* information element in the *SETUP* message.

> ***Note:*** The TON of "International" is not supported on special numbers.

There may be charges for the Special Number Services as tariffed by the network provider. PRI users may wish to consult with their local network provider before using these services.

4.2 Examples

Special Number Services can include, but are not necessarily limited to, the following

- 411 directory information
- 611 repair service
- 911 emergency
- 1-800 automatic reverse charging for toll calls
- 1-900 special business services

Chapter 5-5: Two B-Channel Transfer

5.1 Two B-Channel Transfer Service Description

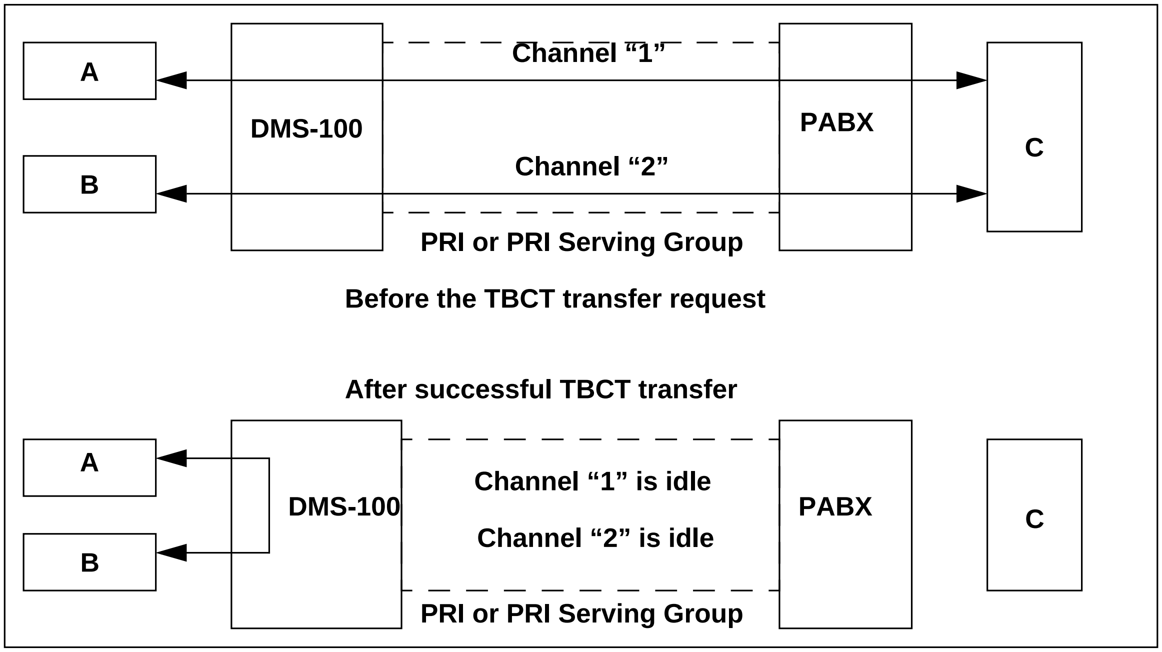
Two B-Channel Transfer (TBCT) is not supported on the OC-3 fiber interface. TBCT is a service that applies to two busy B-channels on a single PRI interface or two different PRI intefaces in the same serving PRI group. The service allows the user side of a PRI to request a transfer from the network side. A successful transfer results in the freeing of the two previously busy B-channels and the interconnection, by the network side, of the two associated circuits.

For example, assume that subscriber A on the network side of a PRI interface is associated with a call using B-channel “1” of the PRI and that subscriber B on the network side of the same PRI interface is associated with a call using B-channel “2”. Before the existance of TBCT, the user side of the interface could only transfer subscriber A to subscriber B by performing the transfer on the user side of the interface; keeping channels “1” and “2” busy until the transferred call finally releases. The TBCT service lets the user side request a network side transfer which frees channels “1” and “2”.

The service allows the two B channels to be located in different PRI interfaces if the interfaces are associated with the same PRI serving group. For transfers involving two PRI interfaces in the same PRI serving group, the D channel carrying the request message implies one of the PRI interfaces and message must also contain a D Channel Identifier to identify the second PRI.

The user side (PABX or Controller) requests the transfer by sending a Facility message to the network side (DMS-100). The Facility message will contain a call reference for one of the calls and a Facility Information Element with the Protocol Profile coded for “ROSE”. The Facility Information Element will contain an Invoke component coded with an Enhanced ExplicitECTExecute operation object identifier and a link id coded with the second call reference.

Figure 5-1 Two B-Channel Transfer



The DMS-100 checks that the PRI interface has subscribed to TBCT and checks the call states, agents involved, bearer capabilities, and verifies that the transfered call will have supervision (will be able to disconnect). For example, transfer will be denied when neither call has been answered. If the checks are unsuccessful, the transfer is denied and a Facility message with a Return Error component containing an Error Value is sent to the user side indicating the problem. If the checks are successful, the DMS-100 sends a Facility message with a call reference (the call reference of the original transfer request) and a Return Result component to the user side. After sending Return Result, the DMS-100 then connects the new call involving subscribers A and B and initiates clearing of the two old calls with the user side by sending two separate DISConnect messages.

Billing for the original two calls continues in the same manner after the transfer occurs as if the transfer had not occurred and the user side (PABX or controller) was still connected to both calls.

If the controller has subscribed to Notification to the Controller, the DMS will send the controller a NOTIFY message when the transferred call eventually clears.

5.2 Compliance to GR-2865

The TBCT service is based upon Bellcore's GR-2865 Issue 2 document which describes message flow and message content. The NTNI product has the following restrictions (that are required in GR-2865):

- An “Active Transfers Counter” is not supported
- A “Transfer Requests in Current Period Counter” is not supported
- Transfer is denied if subscriber A or B is an attendant console, or a MADN or multiparty line in the alerting state.
- Transfer is denied if either call was originated by the controller using a private dial plan
- Two byte invoke ids are not supported. One byte invoke ids are supported
- Only one (the first) Facility Information Element in a message is supported
- Notification to Transferred Users is not supported
- Checking for duplicate invoke IDs is not done.

Chapter 5-6: Call-By-Call Service

6.1 Call-By-Call Service Description

The Call-By-Call service provides the capability to convey signalling information over an ISDN Primary Rate Interface (PRI) that indicates, on a per-call basis, the specific service type associated with the call. On call origination, the CPE includes a service request in the SETUP message to select a particular call-by-call service. If a service request is not included in the SETUP message, the call is treated as a public network call in accordance with TR-1268. When the SETUP message is received from the CPE, the switch checks that the request is valid and establishes the requested call.

On call termination, the switch verifies that the request is valid and sends the CPE a SETUP message with an indication of the service treatment requested. If no indication is included, the CPE is expected to treat the call as a public network call.

Note that calls routed over a PRI supporting the Call-By-Call service will be subject to call throttling, as implemented using Simulated Facility Groups (SFGs). Note that the Bellcore SFG function is called Virtual Facility Group (SFG) within Nortel. In this document, VFG is interchangable with SFG. Before a call is allowed to proceed, SFG counters are examined to verify that additional calls of this type are allowed. When the call is established, the SFG is incremented and when the call is cleared, the SFG is decremented. Separate SFGs are available for FX, Tie Trunk, OUTWATS, INWATS, Hotel/Motel, and public call types. Separate SFGs are available for outgoing and incoming call directions.

The individual Call-By-Call services supported are described in the paragraphs that follow.

6.1.1 Call-By-Call Foreign Exchange (FX)

The requirements for Call-By-Call Foreign Exchange (FX) Selection are specified in Section 3.1.1.1 of TR-1270. The following paragraphs provide an overview of these requirements - for a more detailed description of the Bellcore requirements, refer directly to the appropriate section in TR-1270.

The Call-By-Call Foreign Exchange (FX) service provides CPE with access to/from dedicated foreign exchange facilities on a per call basis, where the dedicated FX facilities are configured between the DMS-100 and a distant office. In this way, the distant office (referred to as the Foreign Exchange) serves as the local exchange for the CPE.

6.1.1.1 Foreign Exchange Origination

To originate a call to a non-ISDN Foreign Exchange facility, the CPE sends a SETUP message.

The SETUP message contains a Network Specific Facilities (NSF) Information Element which requests that the call be routed to a specific FX facility or FX facility group. The Length of Network Identification will be coded for "local service provider" with octets 3.1 and 3.2 omitted. The NSF shall also be coded to indicate a Feature/Service field of “Service”, a Facility Code Value of “FX”, and a Service Parameter of the “FX Facility Number”.

The SETUP message also contains a Called Party Number Information Element with the Type of Number / Network Plan Identification coded as “International/ISDN, National/ISDN, Local/ISDN, or Unknown/Unknown”. While the Called Party Number Information Element Type of Number / Network Plan Identification is verified by the DMS-100 before allowing the call to continue, routing is actually based upon the FX Facility Number in the NSF Information Element.

The SETUP message may also contain a Transit Network Selection Information Element coded with a carrier identification code and/or an Operator Service Access Information Element coded with operator routing information if required for the call.

The switch seizes the requested FX circuit and sends a CALL PROCeeding message to the calling CPE. The switch outpulses the called digits based upon the Called Party Number Information Element then sends the calling CPE a PROGress message with an indication that the call is not end-to-end ISDN. Since FX circuits do not provide answer supervision, the switch completes the call path (cuts through) and sends a CONNect message to the CPE immediately after the PROGress message.

6.1.1.2 Foreign Exchange Termination

When the switch detects incoming ringing on an FX circuit, the switch checks its database to determine the associated circuit. When the associated circuit is a PRI interface, a SETUP message is sent from the network side to the user (CPE) side.

The SETUP message will contain a Progress Indicator coded to indicate that the call is not end-to-end ISDN.

The SETUP message will also contain an NSF Information Element. The Length of Network Identification will be coded for "local service provider" with octets 3.1 and 3.2 omitted. The NSF shall also be coded to indicate a Feature/Service field of "Service", a Facility Code Value of "FX", and a Service Parameter of the "FX Facility Number".

The SETUP message will contain a Called Party Number Information Element coded without called party digits and coded to show that the number is an “Unknown Number in an Unknown Numbering Plan”.

When the CPE returns a CONNect message, the switch completes the call connection and goes off-hook toward the FX facility.

6.1.2 Call-By-Call Tie Trunk

The requirements for Call-By-Call Tie Trunk Selection are specified in Section 3.1.1.2 of TR-1270. The following section provides an overview of these requirements - for a more detailed description of the Bellcore requirements, refer directly to the appropriate section in TR-1270.

The Call-by-Call Tie Trunk Selection feature allows CPE to request on a per call basis that a call be routed over a specific non-ISDN Tie Trunk facility or a specific group of non-ISDN Tie Trunk facilities. This feature also allows a call terminating from a non-ISDN Tie Trunk facility to be offered to CPE with an indication of that specific facility or facility group.

Tie Trunk facilities support two modes of operation: senderized mode (in which the switch collects and screens the called digits) or non-senderized mode (in which the switch does not collect the called digits). For Tie Trunk calls operating in the non-senderized mode, in-band information is directly exchanged between the CPE and the far-end switch.

6.1.2.1 Tie Trunk Origination

To originate a call to a non-ISDN Tie Trunk facility, the CPE sends a SETUP message.

The SETUP message contains a Network Specific Facilities (NSF) Information Element which requests that the call be routed to a specific Tie Trunk facility or Tie Trunk facility group. The Length of Network Identification will be coded for "local service provider" with octets 3.1 and 3.2 omitted. The NSF shall also be coded for a Feature/Service field of "Service", a Facility Code Value of "Tie Trunk", and a Service Parameter of the "Tie Trunk Facility Number".

The SETUP message also contains a Called Party Number Information Element with the Type of Number / Network Plan Identification coded as "Subscriber Number / Private Numbering Plan or Unknown/Unknown". For calls routed over a senderized Tie Trunk facility, 1 to 24 digits shall be included in the Called Party Number Information Element's Digits field. For calls routed over a non-senderized Tie Trunk facility, no digits shall be included in the field. While the Called Party Number Information Element's Type of Number / Network Plan Identification and number of digits are verified by the DMS-100 before allowing the call to continue, routing is actually based upon the Tie Trunk Facility Number in the NSF Information Element.

The SETUP message shall contain neither a TNS nor an OSA Information Element. If either is present the setup request will be denied.

Upon locating an idle facility in the requested Tie Trunk facility group, the switch shall send a CALL PROCeeding message to the originating CPE, send a seizure signal on the selected Tie Trunk facility and (for senderized Tie Trunks only) outpulse the called party digits. The switch shall cut through the connection in both directions and send a PROGress message to the CPE. After the receipt of answer supervision from the Tie Trunk facility, the switch shall send a CONNect message to the CPE.

6.1.2.2 Tie Trunk Termination

When the switch detects in incoming seizure on a Tie Trunk, the switch checks its database to determine the associated PRI interface. Note that the PRI, to which the call is routed, is predetermined based on subscription parameters held in the switch database. If the call is allowed to proceed, the switch shall collect the digits from the Tie Trunk facility (for senderized Tie Trunks only), select a B-channel, and send a SETUP message to the CPE.

The SETUP message will contain a Progress Indicator coded to indicate that the call is not end-to-end ISDN.

The SETUP message contains a Network Specific Facilities (NSF) Information Element. The Length of Network Identification will be coded for "local service provider" with octets 3.1 and 3.2 omitted. The NSF shall also be coded for a Feature/Service field of "Service", a Facility Code Value of "Tie Trunk", and a Service Parameter of the "Tie Trunk Facility Number".

The SETUP message contains a Called Party Number Information Element coded to indicate an "Unknown Number" in an "Unknown Numbering Plan". For calls received over senderized Tie Trunks, the switch shall include all of the collected digits. For calls received over non-senderized Tie Trunks, no digits shall be included in the Digits field.

After successful channel selection, the switch shall cut through the connection in both directions. When the CPE returns a CONNect message, the switch provides answer supervision to the Tie Trunk.

6.1.3 Call-By-Call OUTWATS

OUTWATS is associated with a call in one direction; from the user side (CPE) over the PRI interface toward the network side (switch).

The requirements for Call-By-Call OUTWATS Selection are specified in Section 3.1.1.3 of TR-1270. The following section provides an overview of these requirements - for a more detailed description of the Bellcore requirements, refer directly to TR-1270.

The Call-by-Call OUTWATS Selection feature allows the CPE to request on a per call basis that a call be treated as an OUTWATS call. The following are three variants of OUTWATS that are supported. IntraLATA OUTWATS, InterLATA OUTWATS and banded OUTWATS.

IntraLATA OUTWATS is provided by the local service provider, whereas banded OUTWATS and InterLATA OUTWATS are provided by a carrier other than the local service provider.

If IntraLATA competition exists, the procedures for requesting IntraLATA OUTWATS from a service provider other than the local carrier are the same as the procedures for requesting InterLata OUTWATS.

Banded OUTWATS calls that cross LATA boundries are routed to the InterLATA Exchange Carrier (IEC) associated with the requested band. The IEC associated with a band is specified at subscription time.

To originate an OUTWATS call, the CPE sends a SETUP message to the switch.

The SETUP message contains an NSF Information Element. The Length of Network Identification will be coded for “local service provider” for IntraLATA OUTWATS with octets 3.1 and 3.2 omitted. However, the Length of Network Identification with octets 3.1 and 3.2 included will be coded for banded and InterLATA OUTWATS (where octet 3.2 is coded to the InterExchange Carrier Identification Code). The NSF shall also be coded for a Feature/Service field of "Service" and a Facility Code Value of "OUTWATS". The Service Parameter shall be coded for IntraLATA OUTWATS to “zero”, or for banded OUTWATS to a band value of “1 to 126”, or for InterLATA OUTWATS this field is not included".

The SETUP message also contains a Called Party Number Information Element. If an unknown number in an unknown number plan is coded, the digits may not be coded as a carrier access code (i.e. 10xxx) for banded or IntraLATA OUTWATS.

If an unknown number in an unknown number plan is coded in the Called Party Number Information Element, an Operator Service Access Information Element may not be included in the SETUP message.

For banded and IntraLATA OUTWATS, a Transit Network Selection (TNS) Information Element may not be included. For InterLATA OUTWATS, if a TNS Information Element is included, the carrier must match the carrier specified in the NSF Information Element.

The switch checks the SETUP message for valid coding and denies invalid requests. A valid SETUP request results in normal call processing procedures between the CPE and the switch. The outgoing call is routed via public network facilities.

6.1.4 Call-By-Call INWATS

INWATS is associated with a call in one direction; from the network side (switch) over the PRI interface toward the user side (CPE). The Call-By-Call INWATS service allows calls to be terminated on the CPE with an INWATS indication on a per call basis.

The requirements for Call-By-Call INWATS Selection are specified in Section 3.1.1.4 of TR-1270. The following section provides an overview of these requirements - for a more detailed description of the Bellcore requirements, refer directly to the appropriate section in TR-1270.

The switch determines that a call is INWATS by examination of the called party number's subscription data. If a B channel is available the switch sends the CPE a SETUP message.

The SETUP message contains a NSF Information Element. The Length of Network Identification will be coded to zero with octets 3.1 and 3.2 omitted. indicating "local service provider". The NSF shall also be coded for a Feature/ Service field of "Service", a Facility Code Value of "INWATS", and the Service Parameter field is not included.

After sending the SETUP message, normal call processing procedures are followed between the CPE and the switch.

6.1.5 Call-By-Call Public Network

Call-By-Call Public Network call direction may be from the network side (switch) to the user side (CPE) or in the opposite direction. Call-By-Call Public Network calls are established using a SETUP message. The SETUP message does not contain an NSF Information Element.

6.1.6 Call-By-Call Hotel/Motel

Call-By-Call Hotel/Motel service selection is associated with a call in one direction; from the user side (CPE) over the PRI interface toward the network side (switch).

The Call-by-Call Hotel/Motel service selection allows the CPE to request, on a per call basis, that a call be treated as an Hotel/Motel call. The Hotel/Motel service provides hotels and/or motels with detailed billing information soon after the call is completed. Hotel/Motel calls are automatically routed to the Operator Services System (OSS), which provides the billing information to the AMA system and to a billing system that forwards the billing information to the originating hotel or motel after the call is completed.

To initiate the call, the CPE sends a SETUP message to the SPCS. The SETUP message contains a Network Specific Facilities (NSF) Information Element with a Network Identification Plan coded to indicate the local service provider or a valid Carrier Identification Code (CIC). The NSF shall also be coded for a Feature/Service field of "Service". The NSF shall be coded for a Facility Coding Value of “Hotel/Motel Service Selection”. The Service Parameters field will not contain any band information.

The switch shall follow the screening procedures specified in Section 3.2.3 of TR-1397. Screening shall be performed on the Called Party Number, Transit Network Selection and Operator System Access (OSA) IEs.

Upon routing the call in accordance with Section 3.2.4 of TR-1397, the switch shall send a CALL PROCeeding message to the originating CPE.

Both MF and CCS7 outgoing trunk types are supported for completion of Hotel/Motel originated calls. The switch shall send the billing number associated with the PRI to the OSS as the ANI (when MF signalling is used) or in the Charge Number Parameter (when CCS7 signalling is used).

The billing number sent to the operator or utilized for AMA shall be determined as a result of either a Hotel / Motel Bill DN or as the result of calling number screening, or as the interface Bill DN. In some cases all three of these methodologies for determining the Bill DN could be datafilled. Thus the priority for determining the Bill DN is as follows. For calls incoming with the Hotel / Motel identifier, if a Service Specific Bill DN is datafilled, this Bill DN shall take precedence over all other Bill DNs. If no Bill DN is provided for these services, the Bill DN shall be determined by the results (either PASSED SCREENING or FAILED SCREENING) of screening. If Screening has not been assigned to the interface, the Interface Bill DN shall be utilized.

Calls are cleared using standard procedures described in TR-1268.

6.1.7 Selective Class Of Call Screening

Call-By-Call Selective Class of Call Screening (SCOCS) selection is associated with a call in one direction; from the user side (CPE) over the PRI interface toward the network side (switch).

The Call-by-Call SCOCS selection allows the CPE to request on a per call basis that a call be associated with a particular SCOCS class of service, where multiple SCOCS services can be supported on a given PRI. The SCOCS service automatically routes calls to an Operator Services System (OSS) where routing and billing restrictions are determined. SCOCS calls are typically originated from hospital rooms, dormitories, hotels, prisons, etc.

To initiate the call, the CPE sends a SETUP message to the SPCS. The SETUP message contains a Network Specific Facilities (NSF) Information Element with a Network Identification Plan coded to indicate the local service provider or a valid Carrier Identification Code (CIC). The NSF Feature/Service field is coded for "Service". The NSF Facility Coding Value is coded for "Selective Class of Call Screening Service Selection". The Service Parameters field will contain the SCOCS service identifier (a number between 0 and 1023).

The switch shall follow the screening procedures specified in Section 3.2.3 of TR-1397. Screening shall be performed on the Called Party Number, Transit Network Selection and Operator System Access (OSA) IEs.

The switch shall associate the SCOCS service identifier contained in the SETUP message with a class of service code. This code shall used by the switch during call routing.

Upon routing the call in accordance with Section 3.2.4 of TR-1397, the switch shall send a CALL PROCeeding message to the originating CPE.

Both MF and CCS7 outgoing trunk types are supported for completion of SCOCS originated calls. The switch shall send the billing number associated with the PRI to the OSS as the ANI (when MF signalling is used) or in the Charge Number Parameter (when CCS7 signalling is used).

The billing number sent to the operator or utilized for AMA shall be determined as a result of either a SCOCS Bill DN or as the result of calling number screening, or as the interface Bill DN. In some cases all three of these methodologies for determining the Bill DN could be datafilled. Thus the priority for determining the Bill DN is as follows. For calls incoming with the SCOCS identifier, if a Service Specific Bill DN is datafilled, this Bill DN shall take precedence over all other Bill DNs. If no Bill DN is provided for these services, the Bill DN shall be determined by the results (either PASSED SCREENING or FAILED SCREENING) of screening. If Screening has not been assigned to the interface, the Interface Bill DN shall be utilized. Note that for SCOCS, a variety of SCOCS codes could use different Bill DNs from the same PRI.

Calls are cleared using standard procedures described in TR-1268.

6.2 Compliance to TR-1270

The Call-By-Call service is based upon Bellcore's TR-1270 Issue 1, May 1992, document plus Bulletin 1, December 1993. The Hotel/Motel and SCOCS selection is further described in TR-NWT-001397, Issue 1, December 1993, ISDN PRI Call-by-Call Hotel/Motel and Selective Class of Call Screening (SCOCS) Service Selections. These documents describe the message flow and message content. The NTNI product has the following restrictions (that are required in TR-1270):

- Throttling is controlled by Simulated Facility Groups (vs Virtual Facility Groups in TR1270)
- Separate two-way SFGs are not supported (incoming and outgoing only)
- SFG overflow is not supported
- Tie Trunk senderized service supports 1-24 digits (vs 1-25 in TR1270)
- On terminating calls to the CPE, the switch does not support Calling Party Number Subaddress, Called Party Number Subaddress, or Redirecting Number Subaddress information elements.
- Access to IXC Services, are not supported

Chapter 5-7: Calling Name

7.1 Calling Name Description

The Calling Name service provides the network with the capability to send name information to the terminating circuit when offering a call. For this interface specification document, the terminating circuit is an NTNI PRI.

On call termination the SPCS marks the presentation indicator of calling party name to align with the calling number, i.e. if the calling number is set to “presentation allowed” the calling party name presentation indicator is set to “presentation allowed” or if the number is prohibited the name is prohibited.

Often the calling party is served by a different SPCS than serves the terminating PRI. In such call configurations, ISUP signaling is required between the switches to transport the calling name presentation indicator. The originating SPCS codes the calling name presentation indicator in the generic name parameter of the IAM message. NOTE: if the terminating SPCS is a DMS-100, the received calling number presentation indicator is examined and used to determine the calling name presentation indicator. If the generic name parameter contains the calling name, the DMS-100 uses the name.

The SPCS that serves the terminating PRI examines the interface’s parameters to determine whether calling name delivery is subscribed. The calling name will only be delivered if the PRI is subscribed to the service.

The SPCS that serves the terminating PRI must have an available calling number from which to determine the calling name. If a calling party number is available, then this number is used in a database query. Otherwise, the SPCS concludes that the calling name is unavailable.

When the calling number is available, and interface is subscribed to calling name delivery, and the calling name presentation indicator is “allowed”, then a name database query is initiated. The query may be a TCAP query to an external database or a local database. If the result of the query is successful, the calling name is coded in a Facility information element and sent to the PRI.

If the number presentation indication is restricted, a Facility information element is sent to the CPE indicating that the name is restricted. If the number presentation is allowed but the terminating SPCS has been unable to obtain the calling name, a Facility information element is sent to the CPE indicating that the name is not available.

When the Calling Name is delivered, it is delivered using the Common Element Procedures requirements as defined in GR-2823-CORE.

7.2 Compliance to GR-1367-CORE

GR-1367-CORE Issue 1 and Revision 1 define the ISDN Calling Name Service for a Primary Rate Interface (PRI) in the public network. These documents describe the message flow and message content. The NTNI product supports the public network (not private network) requirements with the following restrictions:

- delivery of Redirecting Name is not supported
- Subscription Usage Sensitive Pricing Billing is not supported.

Chapter 5-8: Dialable Wideband Service

8.1 DWS Description

DWS service is not available on the OC-3 fiber interface. DWS provides the ability to establish PRI, on-demand, nx64 kbps calls. An nx64 kbps call is a call with a rate that is a multiple of 64 kbps. The multiple 'n' is within the range of 2 to 24. The procedure for establishing DWS calls is similar to the procedure for establishing a basic 64 kbps circuit switched ISDN call. DWS calls are supported only on NTNI PRI, NTNA PRI, and ISUP CCS7 interfaces. This document describes the NTNI PRI interface.

Subscription options of Fixed, Floating, and Flexible are supported.

For originating DWS calls from a PRI, the subscriber includes an indication of the requested bandwidth in the Channel Identification and Bearer Capability information elements in the SETUP message. The originating exchange routes the call based on translations of the called party number and bearer capability.

For interoffice calls, several DWS-specific extensions have been incorporated into the ISUP IntraLATA and InterLATA signalling protocols. The originating exchange generates an Initial Address Message (IAM) that indicates the requested bandwidth in the User Service Information (USI) parameter. At all stages of the call (i.e. originating access, interoffice, terminating access), the call must remain within the boundary of a single T1.

For terminating DWS calls, if the PRI has subscribed to the requested bandwidth, the exchange includes an indication of the requested bandwidth in the SETUP message sent to terminating CPE.

The DWS call request cannot be completed unless all of the switches in the path between the originating PRI and the terminating PRI support DWS service. If any of the switches in the path cannot support the call, the call is not established and the calling PRI is provided with a "release cause" which indicates that the bearer capability is not implemented end-to-end. In addition, the called PRI must support the requested DWS call, otherwise the call is not established and the calling PRI is provided with a "release cause" which indicates that the bearer capability is not authorized.

8.2 Compliance to TR-NWT-001203

TR-NWT-001203, Issue 2, December 1992 plus Revision 1, July 1993 plus Revision 2, December 1993 plus Revision 3, May 1994 define the DWS requirements for National ISDN. These documnents describe the message flow and message content. The NTNI product has the following restrictions:

- DWS calls are not supported to/from non-ISDN interfaces
- Continuity checking requests will not be supported on DWS ISUP trunks

Chapter 5-9: Message Service

9.1 Description

Message service is not supported on the OC-3 fiber interface. Message service involves a Message Storage and Retrieval (MSR) system, an SPCS connected to the MSR, client user terminal equipment connected to an SPCS, and, for network wide message waiting indication, one or more STPs to interconnect the SPCSs via TCAP.

9.1.1 System Setup

Before Message service is available to the client user, the SPCS and the MSR databases must be populated. MSR database discussion is beyond the scope of this document. The SPCS database items fall into three categories; (1) NTNI PRI parameters for the interface toward the MSR, (2) client user parameters for the interface toward the client user, and (3) a response timer parameter for the interface toward other switches.

9.1.1.1 NTNI PRI Datafill for MSR

NTNI PRI interfaces can be configured with a subscription option which allows the interface to control message waiting indicators. Datafill is required to show how the MSR is connected to the SPCS; via a single NTNI PRI link (23B+D), via multiple NTNI PRI links using NFAS, or via multiple NTNI PRI interfaces grouped using the PRI Serving Group concept. One of the three available B-channel search algorithms must be datafilled. Special Handling of Presentation Restricted Numbers (SHPRN) must be datafilled. The DN(s) associated with the MSRID must be configured. The maximum number of outstanding MWI requests associated with the MSR as well as the maximum number of simultaneous NCAS connections that will be supported on each interface must be specified in the SPCS database.

9.1.1.2 Client User Datafill

Client user interface configuration involves; assigning audible and/or visual message waiting indication and assigning the type of call forwarding. For NA012 or newer releases, client users can be located on the same DMS that serves the MSR, or on a PBX that is connected via NTNA PRI to the DMS that serves the MSR, or on a switch that is connected via TCAP to the DMS that serves the MSR.

9.1.1.3 DMS Datafill

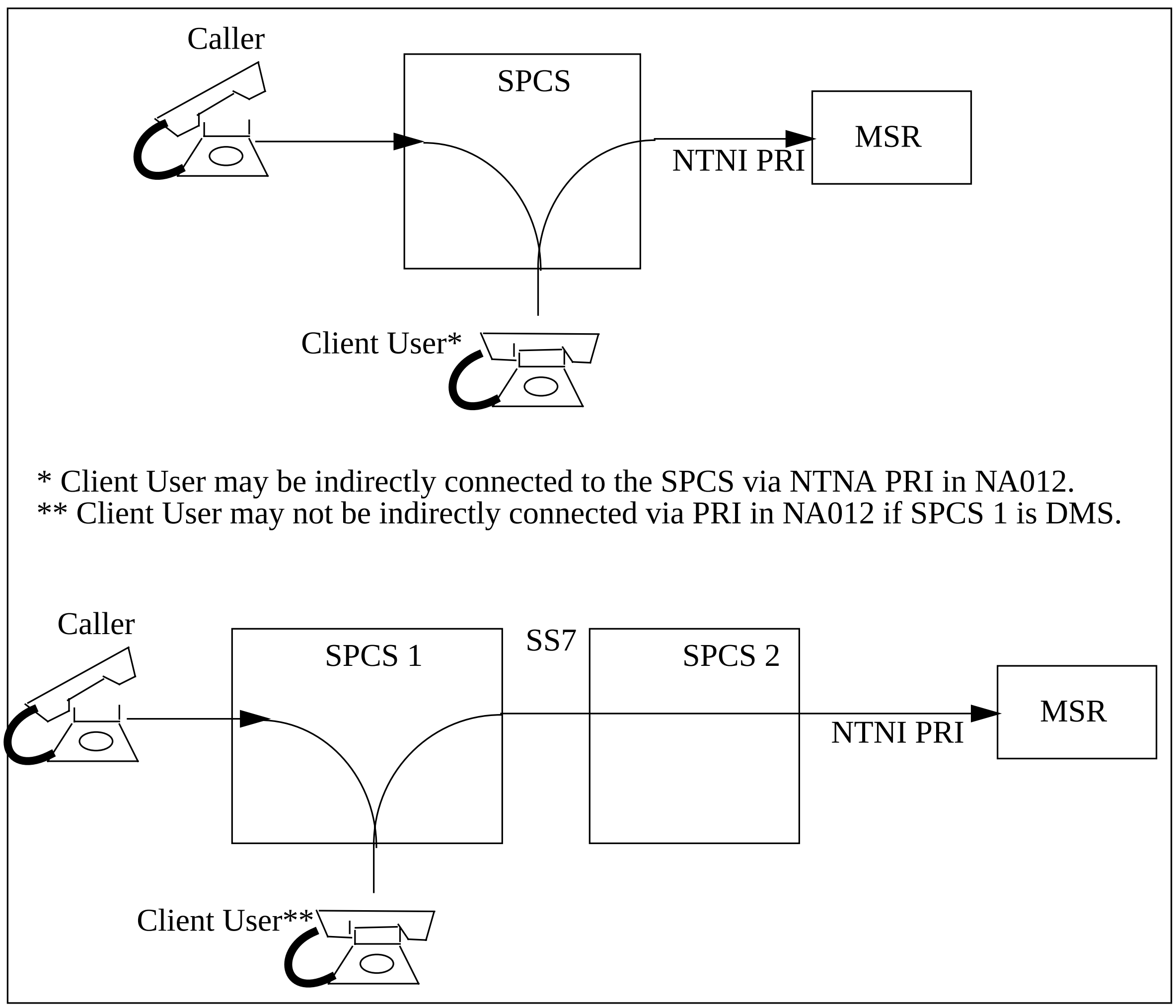
The DMS that serves the MSR must be datafilled for a timer which limits the amount of time the DMS will wait for a response from another switch before returning an error to the MSR. In addition, the maximum number of outstanding MWI requests allowed per switch must be datafilled in the DMS.

9.1.2 The Message Storage Call

Please refer to “Figure 5-2 The Message Storage Call” on page 326. A caller places a call to a client user, then is forwarded to the MSR. When the MSR subscribes to redirecting number delivery and calling number deliver, the client user’s number and calling number are provided to the MSR. Typically, a personalized greeting is given to the caller. The MSR answers the call.

The caller may or may not elect to leave a message for the client user. If the caller does not leave a message, the caller simply releases the connection to the MSR and no further message service action occurs. If the caller leaves a message, the MSR initiates message waiting indicator activity as described in the next section.

Figure 5-2 The Message Storage Call



9.1.3 NCAS Connection

The MSR requests the activation or deactivation of a message waiting indicator via a Non-Call Associated Signalling (NCAS) connection. To establish an NCAS connection, the MSR sends a *Setup* message with the *Bearer Capability*, *Called Party Number*, and *Channel Identification* information elements coded for NCAS;

- *Bearer Capability* - octet 3 coded for “other international standard” and “unrestricted digital information” and octet 4 coded for “circuit mode” and “NCAS”
- *Called Party Number* - no called party number digits are coded, which indicates the NCAS connection termination point is the serving SPCS
- *Channel Identification* - octet 3 coded for the “D-channel”

Normally, in response to the MSR’s request for an NCAS connection, the DMS sends a *Call Proceeding* then a *Connect* message and enters the active state. While in the active state, the DMS may receive one or more message waiting indicator requests (activation or deactivation) before the MSR initiates clearing of the NCAS connection. Message waiting indicator requests are described in the next sub-section.

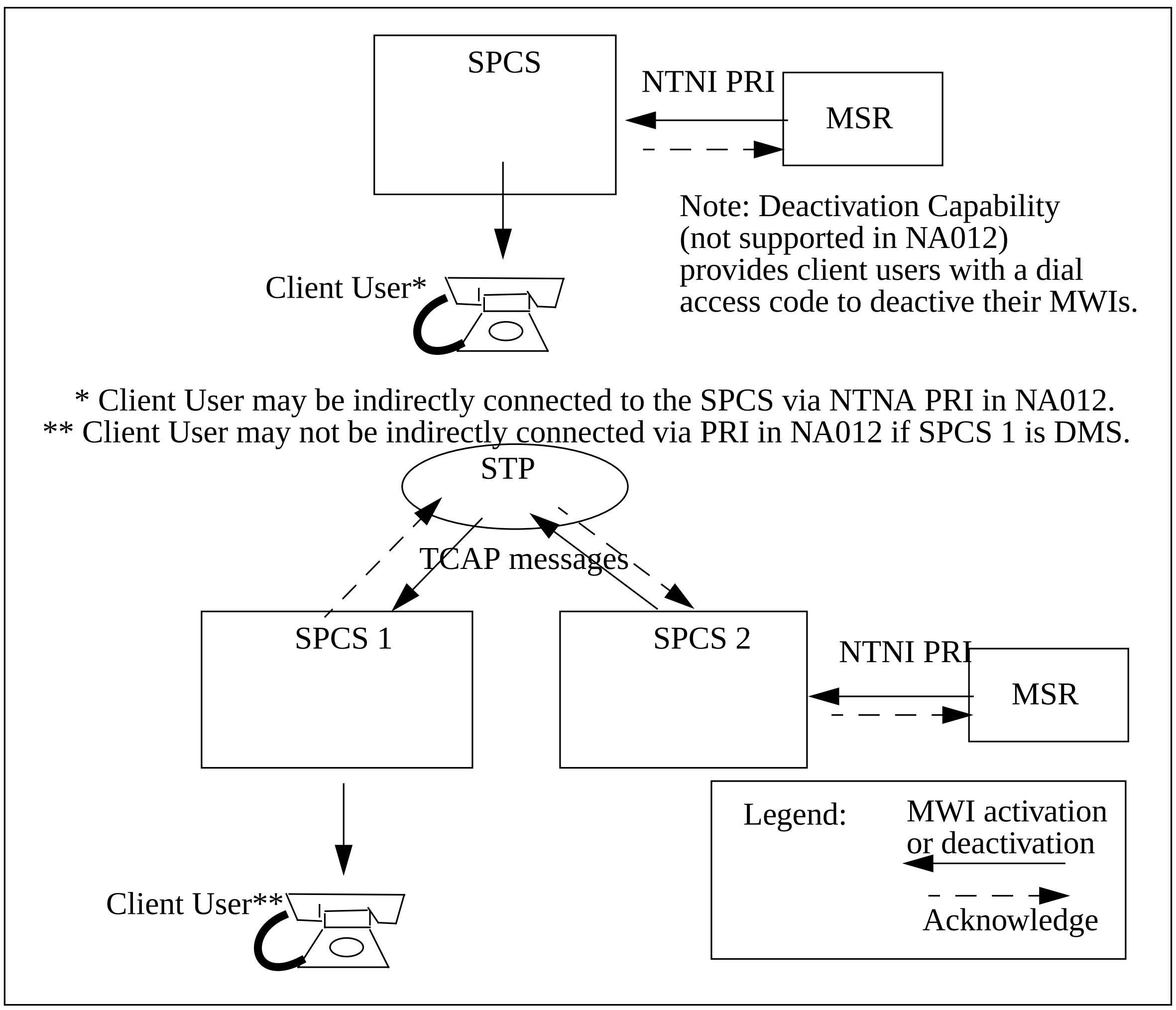
For abnormal situations, in response to the MSR’s request for an NCAS connection, the DMS follows the procedures described in section 10 of GR-2823-CORE. Examples of abnormal situations that result in the DMS sending a *Release Complete* message include; the MSR requesting more NCAS connections than its subscription maximum, the *Setup* message was missing mandatory information elements, or the *Setup* message contained invalid coding of mandatory information elements.

In NA012, note that the DMS does not initiate the setup of an NCAS connection toward the MSR, nor does the DMS initiate the clearing of an active NCAS connection.

9.1.4 Message Waiting Indicator Activation

Please refer to “Figure 5-3 Message Waiting Indicator” on page 328. When a caller leaves a message for a client user, the MSR sends a *Facility* message with a *Facility* information element coded with the client user’s DN (called the “Destination DN”) and an “activate” control type. Optional arguments in the request may include; Bearer Capability, MSRID, Calling DN, Timestamp, and MWI type. If an MSRID is included, it is screened against a default associated with the PRI interface. The SPCS applies the appropriate message waiting indicator (audible and/or visual) to directly connected client users or, for indirectly connected client users, the SPCS signals the PBX (via NTNA PRI) or SPCS (via TCAP) that serves the client user. After directly served client users have been processed locally, or acknowledgement has returned from the client user SPCS or PBX, the SPCS sends the MSR a *Facility* message coded to indicate the success or failure of the request.

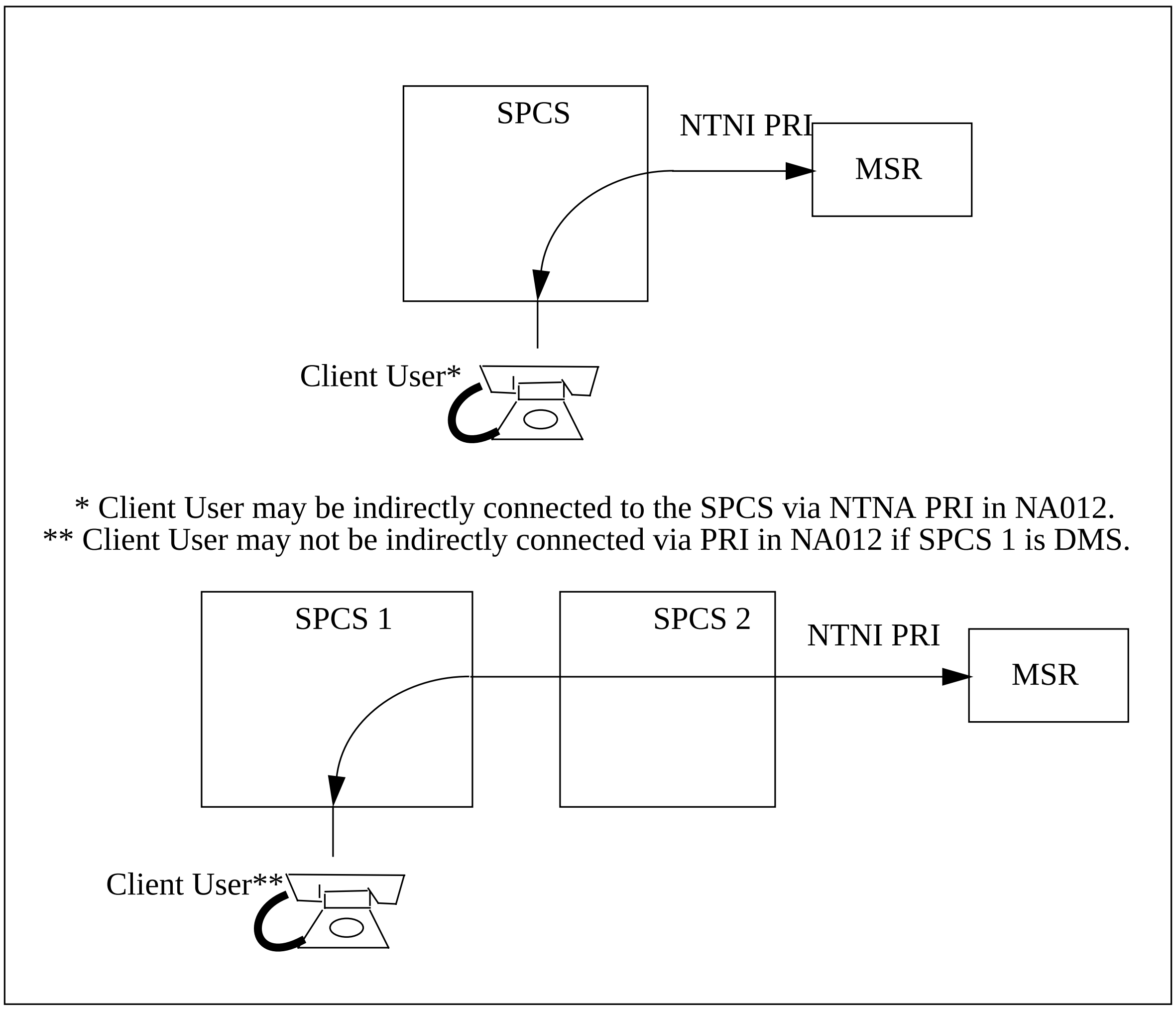
Figure 5-3 Message Waiting Indicator



9.1.5 The Message Retrieval Call

Please refer to “Figure 5-4 The Message Retrieval Call” on page 329. The client user can call the MSR to retrieve messages at any time from any location. Typically, the client user calls the MSR after receipt of a message waiting indicator. The calling number may or may not be delivered to the MSR depending upon the call specifics. The job of verifying the identity of the client user is transparent to the SPCS and is the responsibility of the MSR. Client user identity verification is normally handled via the telephone keypad (using user identification codes and passwords). When all messages have been retrieved, the MSR will communicate to the SPCS that the message waiting indicator to the client user should be deactivated. The deactivation message path is the same as the activation message path shown earlier in“Figure 5-3 Message Waiting Indicator” on page 328.

Figure 5-4 The Message Retrieval Call



9.1.6 Message Waiting Indicator Deactivation

Please refer to "Figure 5-3 Message Waiting Indicator" on page 328. When the MSR recognizes that a client user has retrieved their messages, the MSR sends a *Facility* message with a *Facility* information element coded to indicate the client user's DN (called the "Destination DN") and a "deactivate" control type. Optionally, the MSRID may also be included. If the MSRID is included it is screened against a default MSRIDs associated with the PRI interface.

For directly served client users, the SPCS deactivates the message waiting indicator (audible and/or visual). For indirectly served client users, the SPCS signals the PBX or SPCS that serve the client user and wait for a response. After directly served client users have been processed locally, or acknowledgement has returned from the client user SPCS or PBX, the SPCS sends the MSR a *Facility* message coded to indicate the success or failure of the request.

9.2 Compliance to GR-866-CORE

GR-866-CORE ISDN Message Service Generic Switching and Signaling Requirements, Issue 1 dated July 1995 provides the requirements for Message service. The document describes the message flow and message content. The NTNI product has the following restrictions:

- The DMS does not support sending audible ringback tone for the MSR (the MSR is expected to supply audible ringback tone until it sends *Connect*).
- B-channel negotiation procedures are not supported.
- Initiation of NCAS connections toward a PRI is not supported.
- NCAS connection release is not initiated by the DMS.
- Only voice bearer capability is supported for message waiting indicators.
- The DMS does not support periodic update of message waiting indicators.
- Deactivation Capability is not supported.
- For message waiting indicator activity, separate intrastate and interstate recording is not supported.
- The DMS does not support TCAP "Treatment 3" as described in GR-606-CORE which requires routing TCAP messages via specific (preferred) SS7 networks.
- Arguments "MWI Type","Timestamp", and "Calling Number" can be received by the DMS in a message waiting indicator request from the MSR, however, these parameters are not forwarded to the client user.
- For TCAP, the VMSR identifier parameter is populated with the MSR DN.
- For TCAP, the Calling party DN parameter is not populated.
- For TCAP, the message waiting indicator is sent with an MTP priority of 1.

- The DMS does not support the maintenance nor traffic requirements described in [310] and [314] in GR-866-CORE.
- The DMS does not support a client user connected to the DMS via NTNI (GR-2942-CORE) in NA012.
- The DMS interface toward the client user is beyond the scope of this NI-NI PRI interface specification, therefore, client user restrictions are not listed herein.
- The DMS does not support a list of MSRID’s per MSR PRI interface but does support a default MSRID per MSR PRI interface.

Chapter 5-10: B-Channel Packet

10.1 Introduction

B-Channel packet is not supported on the OC-3 fiber interface. One or more B channels of an NTNI PRI can be provisioned for B-Channel Packet service. The B channel(s) must be provisioned at subscription time. Note that “on-demand” B-Channel Packet call service (i.e. using the PRI’s D channel to setup packet bearer capability calls) is not supported.

When a PRI’s B channel is configured for B-Channel Packet service, the channel is nailed-up to the DMS Packet Handler (DMS PH). The DMS PH processes X.25 packets that are carried in the B channel. The packet services are provided by the DMS PH.

- DMS PH is a packet handler for the DMS product family that provides a full featured X.25 packet services for PRI B channels and BRI B and D channels. It is an integral component of the DMS switch, capable of providing Bellcore TR compliant packet services.
- The DMS PH provides the protocol engines (X.25/X.75/X.75') required for packet switching. It relies on the common DMS operations, maintenance and provisioning systems to provide all OA&M functions.
- For PRI B-Channel Packet service, the DMS PH provides packet mode access for X.25 terminal equipment using 1988 CCITT LAPB at layer 2 and 1988 CCITT X.25 at layer 3.

The B-Channel Packet service does not support:

- PMD services available On-Demand to user-network B-channels (CCITT Recommendation X.31 Case B). Specifically:
  - On-demand B-channel connections (Call Origination)
  - On-demand B-channel connections - Conditional Notification (Call Termination)

10.2 Physical Layer Description

Rate adaption is necessary for terminal equipment operating at speeds less than 64 kbps. The CPE is responsible for the rate adaption protocol and procedures necessary to convert the received user-side packets to the 64 kbps rate of the PRI B-channel physical layer and to convert the received 64 kbps rate packets (from the DMS PH) to the rate of the user-side equipment.

The preferred method of rate adaption for B-Channel Packet service is HDLC interframe flag stuffing as specified by 1988 CCITT Recommendation X.31. This method is supported by the DMS PH for X.25 LAPB services.

10.3 Data Link Layer Description

The data link layer, layer 2, for B-Channel Packet service is fully compatible with CCITT 1988 (Blue Book) X.25 - LAPB and Bellcore TR-TSY-000301.

CCITT Recommendation X.25 defines several LAPB system parameters without specifying their values. The following values will be supported by the DMS PH which are in compliance with TR-TSY-000301.

- Timer T1 specifies the period after which transmission of any frame may be repeated:
  - — the default value for T1 is 2 seconds
  - — adjustment range from 1-20 seconds
  - — adjustment increment = 0.5 seconds
- Timer T2 indicates the time available before the acknowledging frame must be initiated to ensure its receipt by the DTE or DCE. The parameter T2 range is 0 - 0.4 s.
- Idle channel Timer T3 is a time period for which LAPB may stay idle before channel state condition is passed to the packet layer for failure procedures. The value of T3 varies from 1-30 seconds, in 1 second increments, with a default value of 5 seconds.
- The maximum number of bits in an information frame (excluding flags and 0 bits inserted for transparency) is specified by parameter N1, and is set at 2120 bits, for a maximum packet size of 265 octets.
- The maximum number of attempts to complete a successful transmission is specified by parameter N2, with the following values:
  - — default of 3
  - — adjustment range from 2-15
  - — adjustment increment = 1
- The maximum number of outstanding (unacknowledged) I-frames (k) shall be:

— 7 and 127 for modulo 8 and 128 frame sequencing respectively

— adjustment range from 1-7 (modulo 8) and 8-127 (modulo 128)

— adjustment increment = 1

— the default value would be modulo 8 with a link level window size of 7

10.4 Network Layer Description

10.4.1 General considerations

The network layer, layer 3, procedures implemented by the DMS PH conform to CCITT Recommendation X.25, and Bellcore technical recommendations as defined in TR-TSY-000301 and TR-846.

In this subsection, the term DTE/DCE interface, as described in Recommendation X.25, refers to the single logical link (specified by LAPB) within a B-channel.

In general, ISDN X.25 users have access to the same packet mode services as dedicated X.25 users in a Public Packet Switching Network (PPSN) as described below:

- Initially, provision (semi-permanent) B-channel X.25 packet mode data services at subscription time.
- For PMD transfer across the DTE/DCE interface, there must be a logical link on the desired channel. If an incoming call arrives at the DMS PH, destined for a B-channel with no logical links established between terminal and DMS PH, the PH clears the incoming call by sending a 'clear indication' packet to the calling DTE.
- After a logical link is established by exchanging SABM (or SABME) and UA, the DMS PH sends a 'Restart Indication' packet to the terminal to initialize the network layer before processing any Call Request packets.
- The DMS PH supports a very comprehensive set of packet level facilities. The facilities supported include most of the 1988 X.25 optional facilities.

10.4.2 Types of calls

There are two types of packet mode data calls available to B-Channel Packet service users on the user-network interface; Switched Virtual Call (SVC) and Permanent Virtual Circuit (PVC) calls.

- A virtual circuit is the bi-directional association between two DTEs over which all data transfer takes place.

- When a packet mode data call is established between two DTEs, the combination of logical channels and switch resources used is termed a virtual circuit.
- Virtual circuits differ from conventional circuits in that network bandwidth is allocated only when data or control packets are actually being transferred.

10.4.2.1 Switched Virtual Call (SVC)

Switched Virtual Call allows a user to set up a virtual circuit for the transfer of data on as “as-needed” basis. The virtual circuit is established only for the duration of the call. A DTE initiates the call setup procedure when it has data to transfer to another DTE. When communications are complete, call clearing procedures are used to disconnect the virtual circuit connection. Note that these procedures are X.25 network layer procedures and should not be confused with establishment/release of the PRI B-channel.

10.4.2.2 Permanent Virtual Circuit (PVC)

A permanent virtual circuit is a permanent association between two DTEs. Each end has a logical channel pre-assigned for the PVC. The PVC setup information is stored as datafill in the DMS PH. A PVC is established as soon as the system comes up, thus eliminating call setup and clearing by the DTE.

10.4.3 Logical Channels

The network layer of X.25 provides for concurrent operation of several calls over a single logical link. This is accomplished by the use of logical channels. The maximum number of simultaneous calls possible on a logical link corresponds to the number of logical channels provisioned for that link.

Four types of logical channels and their ranges must be chosen at subscription time. This selection should be based upon the number of simultaneous calls or users to be permitted on a particular access line. Over assignment of logical channels not only wastes switch resources, but may allow degradation of response time if the access link is over-used.

The four types of logical channels are:

- PVC logical channels
- one-way incoming logical channels for SVCs
- two-way logical channels for SVCs
- one-way outgoing logical channels for SVCs.

The ranges are:

- DMS PH supports up to 512 logical channels on a B-channel.

- Logical channel 0 is reserved for control packets that affect the entire interface (restart and diagnostic packets).
- The logical channel range defined may reside anywhere between 1-4095 and the range must be continuous.

When initiating a call the DTE selects the highest numbered free logical channel for an outgoing call and the DCE selects the lowest numbered free channel for an incoming call. This procedure is defined to minimize call collision probability.

10.4.4 Sequenced data transfer

Sequenced data transfer means that data packets are delivered to the user in the same sequence as they were transmitted, and without duplication or loss. Both modulo 8 and modulo 128 packet sequence numbering are supported.

10.4.5 X.25 facilities

The following services are supported for X.25:

- Incoming Calls Barred
- Outgoing Calls Barred
- One-way Logical Channel Incoming
- One-way Logical Channel Outgoing
- Non-standard Default Packet Sizes
- Non-standard Default Window Sizes
- Default Throughput Class Assignment
- Flow Control Parameter Negotiation
- Throughput Class Negotiation
- Closed User Group
- Closed User Group with Outgoing Access
- Closed User Group with Incoming Access
- Closed User Group with Outgoing Acesss/Incoming Access
- Fast Select and Fast Select Acceptance
- Reverse Charging and Reverse Charging Acceptance
- RPOA Selection
- RPOA Selection Barred
- IC Preselection
- Hunt Group

- Called Line Address Modified Notification (CLAMN)
- Transit Delay Selection and Indication

10.5 X.25 subscription parameters

The following parameters are provisioned for layer 2 and are provisioned against a B-channel;

- Link Level Frame Sequencing - Modulo 8 or 128 (default Modulo 8)
- Link Level Window Size - 1 thru 7 Modulo 8, 1 thru 60 Modulo 128 (default 7)
- Ack Timer (T1) - 1 thru 20 seconds (default 2 seconds)
- Response Timer (T2) - 0 thru 0.4 seconds (default 0.02)
- Idle Channel Timer (T3) - 1 thru 30 seconds (default 5 seconds)
- Max. retransmissions (N2) - 2 thru 15 (default 3)

The following parameters are provisioned for layer 3 and are provisioned against a B-channel;

- Packet Level Sequencing - Modulo 8 or 128 (default Modulo 8)
- Starting Logical channel number - 1 thru 4095 (default 1)
- Number of PVCs - 0 thru 511 (default 0)
- Number of one-way incoming logical channels - 0 thru 511 (default 0)
- Number of non-restricted channels - 1 thru 511 (default 1)
- Number of one-way outgoing logical channels - 0 thru 511 (default 0)

The following are provisioned for optional user facility parameters and are provisioned against a B-channel;

- Outgoing calls barred - Yes or No (default No)
- One -way incomming LC subscribed - Yes or No (default No)
- One-way outgoing LC subscribed - Yes or No (default No)
- Non-standard default packet size - Yes or No (default No)
- Incoming maximum packet size - 16, 32, 64, 128, 256 (default 128)
- Outgoing maximum packet size - 16, 32, 64, 128, 256 (default 128)
- Non-standard default window size - Yes or No (default No)
- Incoming packet layer window size - 1 thru 7, 1 thru 127 (default 2)

- Outgoing packet layer window size - 1 thru 7, 1 thru 127 (default 2)
- Default TC assignment - Yes or No (default No)
- Incoming default TC assignment - 75, 150, 300, 600, 1200, 2400, 4800, 9600, 19,200, 48000, 64000 (default 9600)
- Outgoing default TC assignment - up to 65 kbps (default None)
- Flow control parameter negotiation - Yes or No (default No)
- Throughput class negotiation - Yes or No (default No)
- Closed user group subscription - Yes or No (default No)
- Fast select acceptance - Yes or No (default No)
- Reverse charging acceptance - Yes or No (default No)
- RPOA selection barred - Yes or No (default No)
- IC preselection - Yes or No (default No)
- Outgoing calls barred - Yes or No (default No)

10.6 Compliance

The following are not supported:

- The assignment of B-channel packet on the 24th channel on a DS1
- NUI Override
- Local charging prevention - Yes or No (default No)
- Packet sizes greater than 256 octets
- When establishing a link layer connection, the PH shall use the layer 2 characteristics assigned to the DN associated with the layer 2 initialization. The DMS PH uses the primary DN.
- An objective is to support more than 100 CUGs on an X.25 interface. If the PH supports more than 100 CUGs for an interface, the PH shall support the extended format of the CUG and/or CUG/OA selection facilities.
- The PH shall support the Reverse Charging Barred facility as a configuration option on an X.25 direct interface. An interface configured for this facility shall clear any call requesting reverse charging.
- The PH shall support the local charging prevention facility as a configuration option on an X.25 direct access interface in conformance with Section 6.20 of Recommendation X.25.
- It is an objective that the PH shall support the extended format of the RPOA selection facility on an X.25 interface that is not configured for the RPOA selection barred facility.

- The network, when able to do so, shall allocate available resources and route the call such that the transit delay applicable to that call does not exceed the desired value.
- The Echo Station shall be internal to the PH. The DMS PH is not compliant with the Echo Station requirements or objectives.
- The PH shall support the following DTE facilities as specified in Annex G of X.25: Calling Address Extension, Called Address Extension, Minimum Throughput class, End-to-End Transit delay, Priority, Protection, Expedited Data Negotiation.

Appendix A: List of terms

AIN
Advanced Intelligent Network

ANSI
American National Standards Institute

B-channel
A 64 kbit/s channel that carries customer information such as voice calls, circuit switched data, or packet switched data. A distinguishing characteristic is that a B-channel does not carry signaling information for control of circuit switching by the ISDN.

BC
Bearer capability

BCD
Binary coded decimal

bit/s
bits per second

BRI
ISDN Basic Rate Interface

Carrier
An organization that provides telecommunications services to the public.

CCITT
International Telephone and Telegraph Consultative Committee

CCS7
Common channel signaling system no. 7

CDN
Called party number

CIC
Carrier Identification Code

CLASS

Custom Local Area Signaling Services

CND

Calling Number Delivery

CO

Central office

CPD

Call Processing Delayed

CPE

Cutomer Premises Equipment.

CPN

Calling party number information element

CTX

Centrex

D-channel

A channel that is primarily intended to carry signaling information for ISDN switching. For the primary rate interface, the D-channel transmission rate is 64 kbit/s.

DID

Direct inward dialing

DL

Prefix for communication primitives between Layer 3 and Layer 2.

DN

Directory number

DOD

Direct outward dialing

DS-1 () or DS1

Digital signal level 1 - digital signal transmitted at the nominal transmission rate of 1.544 Mbit/s.

E.164

CCITT Recommendation for the ISDN/telephony numbering plan.

ECSA

Exchange Carriers Standards Association

ET

Exchange termination

FX

Foreign Exchange line

IA5

International alphabet No. 5

ID

Identification or identifier

IE

Information element

IEC

Inter-exchange carrier

INB

Installation Busy

INWATS

Inward Wide Area Telephone Service (800 service)

IP

Intelligent Peripheral

IRQ

Information request information element

IS

In Service

ISA

Integrated Services Access

ISDN

Integrated services digital network

ISO

International organization for standardization

ISUP

CCS7 ISDN user part

ITA

Integrated Trunk Access

L1

Layer 1

L2

Layer 2

L3

Layer 3

LATA

Local Access and Transport Area

LDN

Listed directory number

MB

Manual Busy

MF

Multiple frequency (analog) signaling

MSN

Meridian Switched Network (formerly ESN)

MSR

Message Storage and Retrieval

NCAS

Non-Call Associated Signaling

Network channel terminating equipment (NCTE)

Network channel terminating equipment (NCTE) is a device that connects to the network on one interface and to terminal equipment on another interface.

NI

The network interface (NI) is the point of demarcation between the network and the customer interface.

NI (NT-NI)

National ISDN requirements as specified by Bellcore. The term NT-NI refers to Northern Telecom's Integrated Services Digital Network (ISDN) Primary Rate Interface (PRI) user-network interface, based upon National ISDN specifications, between the Northern Telecom ISDN DMS-100 switch and the user side equipment.

NPI

Numbering plan identification

NSF

Network specific facilities information element

NT1

A functional group that provides the physical layer functions for access line termination.

NT2

A functional group that provides protocols above layer 1 for DS-1 path termination. For example, a private branch exchange (PBX) has an NT2.

OCN

Original called number information element

OOS

Out Of Service

OUTWATS

Outward Wide Area Telephone Service

PBX or PABX

Private branch exchange or private automatic branch exchange

Physical interface

An interface at the Layer 1 level of the open system interface (OSI) reference model.

PI

Presentation indicator

Primary rate interface (PRI)

A term used to describe a DS-1 rate access to an ISDN network that supports standard combinations of channels with a 1536 kbit/s payload.

PTS

Per trunk signaling

RDN

Redirection number information element

Reference point

A conceptual point at the conjunction of two non-overlapping functional groups. In a specific access arrangement, a reference point may correspond to a physical interface between pieces of equipment, although this is not always necessary. In some arrangements, there may be more than one physical interface associated with a reference point.

REJ

REJect

Ri

Reference number

ROSE

Remote Operation Service Element

SABME

Set Asynchronous Balanced Mode Extended

SCP

Service Control Point

SI

Screening indicator

T1 line

A full duplex digital transmission facility that is composed of two twisted metallic pairs and regenerators that carry one DS-1 signal.

TBCT

Two B-Channel Transfer

TCAP

CCS7 Transaction Capabilities Application Part

TE

Terminal equipment

TEI

Terminal endpoint identifier

TIE

Tie trunk

TNS

Transit network selection information element

TON

Type of number

ZCS

Zero code suppression

Appendix B: Index

Digital Switching System

NT-NI Primary Rate User-Network Interface Specification

Document number: NIS-A233-1
Product Release: NA012
Document Release:05.03
Date: Aug. 3, 1999

NORTEL
NORTHERN TELECOM