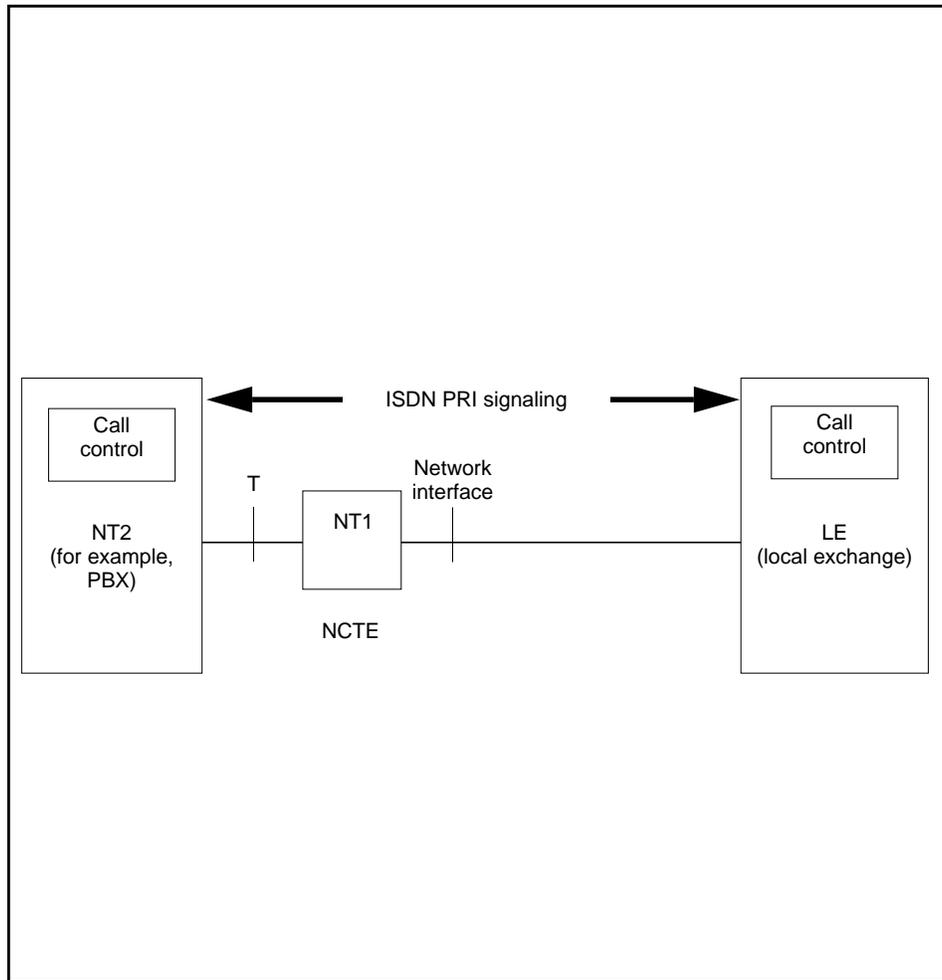Digital Switching Systems
INS Net 1500
Primary Rate Interface Specification

ABSK006   Standard 08.04   March 1998

NORTEL
NORTHERN TELECOM

Digital Switching Systems
INS Net 1500
Primary Rate Interface Specification

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Revision history

This new standardized version of the DMS-100 INS Net 1500 primary rate interface specification will be used to track all subsequent development of this protocol. This document supersedes a series of documents issued to Northern Telecom's customers. This section is used to track the major factual changes made to this specification.

March 1998
ABSK006   Standard   Version 08.04
- Release ABSK006 v.08.04 from Release ABSK006 v.08.03
- Chapter 20, remove blank pages throughout this section.

March 1998
ABSK006   Standard   Version 08.03
- Release ABSK006 v.08.03 from Release ABSK006 v.08.02
- Standardized template according to Corporate Standard 1700.03.

February 1998
ABSK006   Standard   Version 08.02
- Release ABSK006 v.08.02 from Release ABSK006 v.08.01
- Technical changes
  — Chapter 20: Section 20.3.4, "Clearing initiated by the network" on page 244, cleaned up description of clearing when tones or announcements are provided by the network.
  — Chapter 22: Cleaned up all SDL diagrams to ensure they have the same line thickness.

February 1998
ABSK006   Standard   Version 08.01
- Release ABSK006 v.08.01 from Release ABSK005 v.07.05
- Separated NIS A220-1 into two different NIS documents.

— NIS A220-1 contains the following information:

– Physical layer specification (Layer 1)
– Data-link layer specification (Layer 2)
– Call-control signalling specification (Layer 3)
– Supplementary services specification

— NIS A220-2 contains the following information:

– Interworking specification

• Technical changes

— Chapter 1: Removed all interworking references.

— Chapter 18: Section 18.1.5, "Disconnect" on page 176, added the Progress Indicator to Table 17 "Disconnect message content".

— Chapter 20: Section 20.3.4, "Clearing initiated by the network" on page 244, added a description of clearing when tones or announcements are provided by the network.

— Chapter 21: Section 21.1, "Introduction" on page 265, added a description of timer T306 to Table 31 "Timers on the network side of the interface".

— Chapter 22: Revised the layer 3 SDL diagrams to show call clearing when tones or announcements are provided by the network.

November 1997
ABSK005   Standard   Version 07.05

This version contains technical changes as follows:

• Release ABSK005 v.07.05 from Release ABSK005 v.07.04

• Technical changes

— Correct PCL name prior to releasing document to customer.

November 1997
ABSK005   Standard   Version 07.04

This version contains technical changes as follows:

• Release ABSK005 v.07.04 from Release ABSK005 v.07.03

• Technical changes

— Chapter 27, Section 27.2.10, "ISUP Suspend (SUS) and Resume (RES) messages" on page 390, refined the diagrams for clarity.

— Chapter 27 Section 27.2.10.1, "ANSI7+ ISUP SUSPEND timer value" on page 392, refined the section for clarity.

November 1997
ABSK005 Standard   Version 07.03

This version contains technical changes as follows:

- Release ABSK005 v.07.03 from Release ABSK005 v.07.02

- Technical changes

  — Chapter 27, Table 81 "Cause mapping: ANSI7+ ISUP to INS 1500" on page 400, added the ISUP cause value 8 as AUTOVON trunk only cause value.

  — Chapter 27, Table 81 "Cause mapping: ANSI7+ ISUP to INS 1500" on page 400, updated note 5: added the ISUP cause value 8.

October 1997
ABSK005 Standard   Version 07.02

This version contains technical changes as follows:

- Release ABSK005 v.07.02 from Release ABSK005 v.07.01

- Technical changes

  — Chaper 27, Table 80 "Cause mapping: INS 1500 to ANSI7+ ISUP" on page 398, updated note 5: refined the statement for cause location mapping for clarity.

August 1997
ABSK005 Standard   Version 07.01

This version contains technical changes as follows:

- Release ABSK005 v.07.01 from Release ABSK003 v.06.03

- Technical changes

  — Chapter 25, add a footnote indicating that Northern Telecom does not support the INS 1500-to-NT NA PRI interworking at this time.

  — Chapter 26, add a footnote indicating that Northern Telecom does not support the INS 1500-to-NT NA PRI interworking at this time.

June 1997
ABSK003 Standard   Version 06.03

This version contains technical changes as follows:

- Release ABSK003 v.06.03 from Release ABSK003 v.06.02

- Technical changes

  — Chaper 27, Table 80 "Cause mapping: INS 1500 to ANSI7+ ISUP" on page 398, updated note 5.

March 1997
ABSK003   Standard   Version 06.02

This version contains technical changes as follows:

- Release ABSK003 v.06.02 from Release ABSK003 v.06.01

- Technical changes

  — Chapter 21, Table 31 "Timers on the network side of the interface" on page 265, row T306: change to Not Applicable (N/A).

  — Chapter 27, Table 81 "Cause mapping: ANSI7+ ISUP to INS 1500" on page 400, added note 6: The ISUP cause value 00 is mapped to PRI cause value 127.

  — Chapter 27, Add new Section 27.2.10, "ISUP Suspend (SUS) and Resume (RES) messages" on page 390.

  — Chapter 27 move Section 27.3.8 to Section 27.2.10.1, "ANSI7+ ISUP SUSPEND timer value" on page 392.

October 1996
ABSK003   Standard   Version 06.01,

This version contains technical changes and is released under a new standard name (ABSK003), replacing the BCS numbers. Summary of changes is as follows:

- Release ABSK003 v.06.01 from Release BCS36 v. 05.03

- Technical changes

  — Chapter 19, Figure 66 "Called party number information element" on page 203

    – Type of number (octet 3)—0 0 0 (was 0 0 1)

  — Chapter 19, Figure 66 "Called party number information element" on page 203; Note on page 210 now reads as follows:

    – DMS-100 ignores any digit after 30th (was 24th)

    – DMS-100 does not send more than 30 digits (was 24)

  — Chapter 19, Figure 68 "Calling party number information element" on page 206; Note 2 of last three notes on page 213 now reads as follows:

    – DMS-100 ignores any digit after 20th (was 12th)

    – DMS-100 does not send more than 20 digits (was 12)

  — Chapter 20, section 20.3.3.1, "Cause screening" on page 250

    – Modified

  — Chapter 20, Section 20.6.1, "Sending Restart" on page 251

    – Replace third paragraph from last,

      starting (old) "The network restricts..", with

      starting (new) "After two unsuccessful attempts . ."

— Chapter 24, changes to Figure 130 "SDL diagram for calling line identification presentation/restriction at originating exchange" on page 326

— Chapter 27, changes to Figure 147 "Message flow sequence diagram: successful call setup procedures (part 1 of 3)" on page 377

— Chapter 27, changes to Figure 148 "Message flow sequence diagram: successful call setup procedure (part 2 of 3)" on page 378

— Chapter 27, changes to Figure 149 "Message flow sequence diagram: successful call setup procedures (part 3 of 3)" on page 379

— Chapter 27, changed table headlines to Table 61 "CPG to Alerting mapping: ANSI7+ ISUP to INS 1500" on page 384

— Chapter 27, changed table headlines to Table 62 "Connect to ANM mapping: INS 1500 to ANSI7+ ISUP" on page 385

— Chapter 27, changes to Table 80 "Cause mapping: INS 1500 to ANSI7+ ISUP" on page 398

— Chapter 27, changes to Table 81 "Cause mapping: ANSI7+ ISUP to INS 1500" on page 400

— Chapter 27, changes in Table 85 "Backward indicator to Progress indicator mapping: ANSI7+ ISUP to INS 1500" on page 404

— Chapter 27, added new section 27.3.8, "Overriding ANSI7+ ISUP SUSPEND (n) timer value" on page 400, including

    – Figure 153 "SUSPEND (n) timer reception handling during Answered state" on page 400

    – Figure 155 "SDL diagram: SUSPEND (n) message reception handling" on page 393

September 1996
BCS36 Standard Version 05.03

To conform with the Nortel's latest technical documentation standard, a simplified book format has been created. This also facilitates automatic compilation and easier referencing to technical content.

Editorial changes were also incorporated.

The new chapter numbering in version 05.03, as compared to version 05.02, is as follows:

<u>Chapter Renumbering</u>:

<u>BCS36</u>, version <u>05.03</u>	<u>BCS36</u>, version <u>05.02</u>
PART I, Introduction	**Section 1, Introduction**
Chapter 1: Overview of PRI services	Chapter 1-1: Overview of PRI services
PART II, Physical layer specification—Layer 1	**Section 2: Layer 1 specification for primary rate interface**
Chapter 2: Layer 1 introduction	Chapter 2-1: Layer 1 Introduction
Chapter 3: General information	Chapter 2-2: General information
Chapter 4: Electrical specification	Chapter 2-3: Electrical specification
Chapter 5: Frame formats	Chapter 2-4: Layer 1 frame formats
Chapter 6: Clear channel capability	Chapter 2-5: Layer 1 clear channel capability
Chapter 7: Maintenance	Chapter 2-6: Layer 1 maintenance
Chapter 8: Connector arrangements	Chapter 2-7: Layer 1 connector arrangements
PART III, Data link layer specification—Layer 2	**Section 3, Layer 2 specification for primary rate**
Chapter 9: Layer 2 introduction	Chapter 3-1: Introduction to Layer 2
Chapter 10: Frame structure	Chapter 3-2: Layer 2 frame structure
Chapter 11: Elements of procedure	Chapter 3-3: Layer 2 elements of procedure
Chapter 12: Elements of layer to layer communications	Chapter 3-4: Layer 2 elements of layer to layer communications
Chapter 13: Definition of peer-to-peer procedures	Chapter 3-5: Definition of peer-to-peer procedures for Layer 2
Chapter 14: Occurrence of MDL-Error-Indication	Chapter 3-6: Occurrence of MDL-Error-Indication
Chapter 15: Layer 2 SDL diagrams	Chapter 3-7: Layer 2 SDL diagrams
PART IV, Call control signaling—layer 3	**Section 4, Layer 3 call control signaling**
Chapter 16: Layer 3 introduction	Chapter 4-1: Introduction to Layer 3
Chapter 17: Overview of call control	Chapter 4-2: Layer 3 overview of call control

Chapter Renumbering: (continued)

BCS36, version **05.03**	**BCS36**, version **05.02**
Chapter 18: Message function definitions	Chapter 4-3: Layer 3 message function definitions
Chapter 19: Message formats	Chapter 4-4: Layer 3 message formats
Chapter 20: Call control procedures	Chapter 4-5: Layer 3 call control procedures
Chapter 21: List of system parameters	Chapter 4-6: Layer 3 list of system parameters
Chapter 22: Layer 3 SDL diagrams	Chapter 4-7: Layer 3 SDL diagrams
PART V, Supplementary services	**Section 5, Supplementary services**
Chapter 23: Supplementary services introduction	Chapter 5-1: Introduction
Chapter 24: Supplementary services	Chapter 5-2: Supplementary services
PART VI, INS-1500 Interworking specifications	**Section 6, INS-1500 Interworking specifications**
Chapter 25: Interworking introduction	Chapter 6-1: Introduction to interworking
Chapter 26: INS 1500-to-NT NA PRI interworking	Chapter 6-2: INS 1500-to-NT PRI interworking
Chapter 27: INS 1500-to-ANSI7+ ISUP interworking	Chapter 6-3: INS 1500-to-ANSI7+ ISUP interworking
Chapter 28: INS 1500-to-PTS trunk interworking	Chapter 6-4: INS 1500-to-PTS trunk interworking
List of terms	Appendix A: List of terms

March 1995
BCS36   Standard   Version 05.02

Chapter 1-1, Overview of PRI, was replaced with the correct information for DMS-100 INS Net 1500 primary rate interface.

Tables 6-49 and 6-50 were modified.

The footers were changed throughout to reflect version 05.02. The date of this reissue was changed to March 1995.

Change bars for version 05.02 have been added to those which were left in for version (Release) 05.01.

October 1994
BCS36   Standard   Version 05.01

The following changes, identified by change bars, have been made:

- **Cause screening**

  A screening facility has been added to map locally significant causes received by the terminating interface to more generalized ones.

- **Inband treatment subscription**

  A capability has been added to provide inband treatment for calls originating on a PRI interface.

- Minor editorial changes.

  Note: Change bars have been manufactured for figures, and must be deleted separately when required.

January 1994
BCS35   Standard   Version 04.01 (3rd issue)

All references to direct inward dialing were changed to direct dialing inward. All references to DID were changed to DDI.

Added a row at the bottom of Table 4-5 to discuss the *Progress indicator* information element.

Changed the second paragraph after Figure 4-3 to say that the *Call reference* information element is two octets long instead of one or two octets long.

Added mention of reserved bit in last sentence of first paragraph on page 4-37.

Added reference to Note 1 beside octet 6 and 7 in Figure 64.

Added a third note on page 4-51. The note is about digits in the CGN IE that are considered invalid.

Changed Ext. 1 to Ext. 0/1 on octet 3 in Figure 61.

Removed mention of bit 0 from D-channel indicator, and bits 0 and 1 from Information channel selection in Figure 62.

Added a note on page 4-68. The note gives the maximum number of digits that may be included in the *Keypad facility* information element.

Added a note on page 4-72. The note says that the network will reject any received *Progress indicator* value other than "#2 Destination address in non-ISDN."

Clarified Note 2 in Figure 78.

Removed the paragraph below the first Note 3 in Figure 6-6.

Corrected cause values in Table 6-50.

August 1992
BCS34   Standard   Version 3 (2nd issue)

Change 2nd sublist item in Section 2, Layer 1, Chapter 2-4, Para 4.4, pg 2-15. Polynomial coefficients reported in wrong order.

Added cross reference to Table 3-4 in first paragraph of Section 3, Layer 2, Chapter 3-6, Para 6.1, pg 3-57.

Corrected introductory text to *Notify* and *Progress* messages in Section 4, Layer 3, Chapter 4-3, Para 3.1.6 and 3.1.7, pgs 4-18 and 4-19. *Notify* is sent only by user, *Progress* is only sent by network.

Corrected error in Note 1 of paragraph 4.5.12 in Section 4, Layer 3, Chapter 4-4. (Internal should be Interface)

Corrected error in slot map table in Section 4, Layer 3, Chapter 4-4, Para 4.5.12 on pg 4-63. (1554 bits should read 1544 bits).

Added statement that Progress indicator information element #2 could be returned, in addition to #1, when call leaves ISDN environment. See para 5.1.5 in Section 4, Layer 3, Chapter 4-5 on pg 4-78.

Added statement that Progress indicator information element #3 could be returned, in addition to #1, when call enters non-ISDN environment . See para 5.2.5 in Section 4, Layer 3, Chapter 4-5 on pg 4-84.

Rearranged notes in Figure 4-24 in Section 4, Layer 3, Chapter 4-5, Para 5.6.3 on pg 4-96.

Corrected headings for timer values in Table 4-22 in Section 4, Layer 3, Chapter 4-6, Para 6.1 on pg 4-107. Changed timer T309, T310, T316, and T317 defaults from 30, 10, 30, and 20 sec to 90, 180, 120, and 100 seconds, respectively..

Corrected SDL drawing. Section 4, Layer 3, Chapter 4-7, Figure 4-38 on pg 4-125. Also removed annotation "zz" on other SDLs in this Chapter.

Corrected figure cross reference in Section 5, Supplementary services, Chapter 5-2, para 2.1 on pg 5-5.

Changed wording in 3rd para of Para 2.5.1 in Section 5, Supplementary
services, Chapter 5-2 on pg 5-12. ("noting" to "referencing")

June 1992
BCS 34   Standard   Version 2 (Issue 1)

Issue 2—Standard—Corrections made to Sections 1 through 4 of the
specification. In addition, Section 5, "Supplementary services" and Section 6,
"Interworking specification" added to the document

March 1992
BCS34   Standard   Version 1 (Draft)

Issue 1—Draft—Supersedes document NIS A211-1, version 3 for Layers 1
and 2, and AG2505.AA08 for Layer 3.

Layer 1

Isolated pulse template (Figure 10 "Isolated pulse template") updated to
reflect the changes in the CCITT Q.920 and Q.921 Recommendations.

Layer 2

Paragraph 11.6.3 "Set asynchronous balanced mode extended (SABME)
command". A data link layer entity confirms acceptance of a SABME
command by transmitting a UA response at the first opportunity. In the
previous version, a DM response could also be transmitted. This has been
deleted to conform to the CCITT recommendations.

In Chapter 12: "Elements for layer-to-layer communication", the primitives
MDL-Assign -Indication and *MDL-Error-Response* have been added to
conform to the CCITT recommendations.The text associated with this table
has also been updated to correspond with these additions.

Figure 32 "SDL states 1" has been modified to indicate the actions resulting
from changes in state as follows:

• Change between state 5 to state 7: LAP established

• Change between state 7 to state 6: Release requested

• Change between state 6 to state 4: LAP release completed.

Layer 3

Paragraph 19.5.7 "Called party number" has been updated to include
information with respect to the numbers of digits (12) that the DMS-100 is able
to accept and send in this information element. This is the same number that
were previously noted in the Called party number information element.

Paragraph 19.5.12 "Channel identification". The slot map octet numbering
scheme has been modified so that it corresponds to the scheme in the CCITT
Recommendations.

In paragraph 20.8.6 "Mandatory information element errors", subparagraph "Mandatory information element content error", it has been noted that information elements received with a length in excess of their maximum will be treated as an information element with content error, and a *Status* message with Cause #43 (User information discarded) will be returned.

In paragraph 20.8.7 "Non-mandatory information element errors", sub-paragraph "Unrecognized information elements", it has been noted that if more than one unrecognized information element is received, the diagnostic field only includes the identifier of the first such element.

In the next sub-paragraph "Non-mandatory information element content error"it has been noted that information elements received with a length in excess of their maximum will be treated as an information element with content error, and a *Status* message with Cause #43 (User information discarded) will be returned.

In paragraph 20.8.8 "Data link reset", the action in the event of a call being in an active phase has been added.

The procedures in paragraph 20.8.9 "Data link failure"have been updated to include calls that are in an active state.

The procedures in paragraph 20.8.10 "Status enquiry procedure"have been further clarified to match the implementation on the DMS-100.

Timer 317 has been added to the Layer 3 user side list of system parameters in Table 32 "Timers on the user side of the interface (see Note)".

General corrections applied to the Layer 3 SDL diagrams, specifically, Figure 115 "Detailed protocol control: network side (4 of 18)".

Annex E and its information has been moved into the Interworking section.

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Chapter 20: Call control procedures   231

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About this document

This document specifies the integrated services digital network (ISDN) primary rate interface (PRI) user-network interface between the Northern Telecom ISDN DMS-100 switch and user equipment. Refer to Figure 1 "ISDN PRI service".

Figure 1   ISDN PRI service
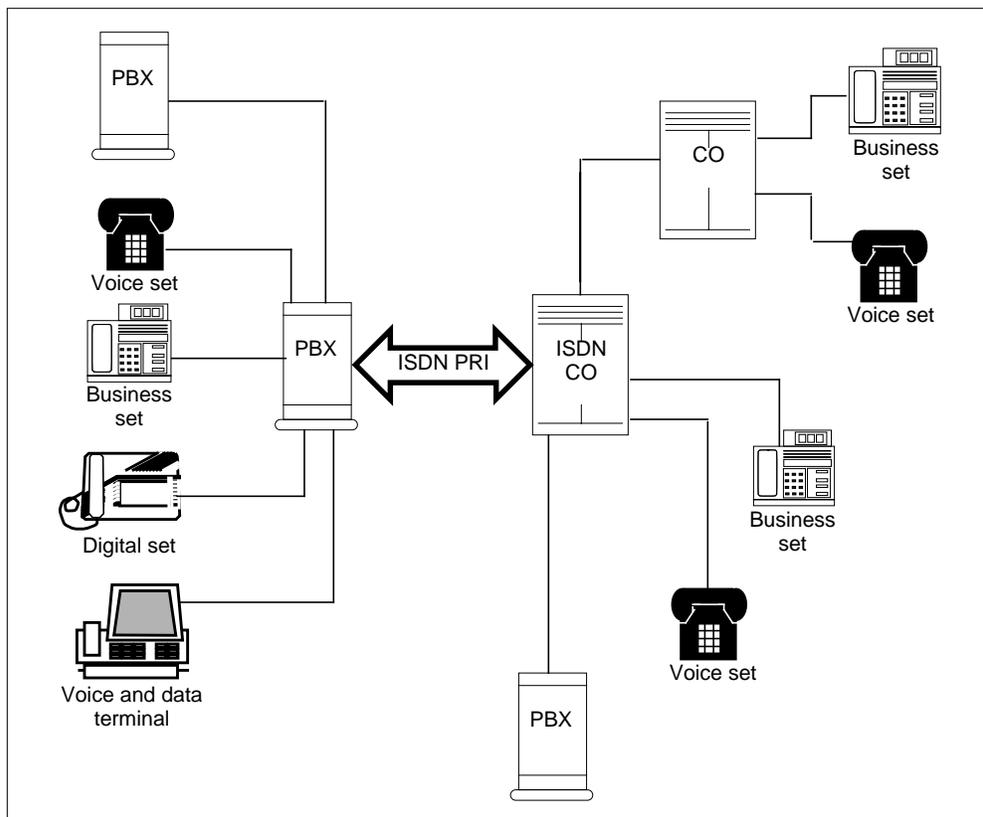
Scope

This specification describes the distribution of services across a network, highlighting the connectivity between a central office (CO) and a private branch exchange (PBX). This provides the basis for the definition of ISDN call-control for PBX to CO applications and, hence, the signaling protocol requirements for PRI.

In the definition of PRI services, full consideration has been given to the requirements to provide end-to-end service for all users (for example, the need to connect a station user on a PBX to another station user on a CO or Centrex switch).

Structure of document

This specification contains the following five sections.

- Part I: Introduction

- Part II: Physical layer specification—Layer 1

- Part III: Data-link layer specification—Layer 2

- Part IV: Call-control signaling specification—Layer 3

- Part V: Supplementary services specification

Service compatibility

The intent of the PRI service definition is to develop the ISDN primary rate signaling protocol so that it conforms, as closely as possible, to the current directions being taken in national and international standards bodies (for instance, TTC and CCITT).

Standards

This specification is a subset of the *NTT INS Net 1500 Service Interface Specification, volumes 1 through 3, dated June 16, 1989*. The standards and specifications with which the various sections of this specification comply are listed below.

- Layer 1 specification

  — NTT INS NET 1500 Service Interface Volume 2, part 2 *Primary rate user-network interface Layer 1 specification (Rev 1 1989)*

  — ANS T1.408, *ISDN primary rate—customer installation metallic interfaces Layer 1 specification (T1E1/89-46R6)*

  — ANS T1.403, *Carrier to customer installation —DS-1 metallic interface specification, 1989*

  — CCITT Recommendation I.431, *Primary rate user-network interface-Layer 1 specification*

- Layer 2 specification

- — NTT INS NET 1500 Service Interface Volume 2, part 3 *Primary rate user-network interface Layer 2 specification (Rev 1 1989)*

- — CCITT Recommendation Q.920(I.440), *ISDN user-network interface data-link layer—general aspects*

- — CCITT Recommendation Q.921(I.441), *ISDN user-network interface data-link layer specification*

- — ANS T1.602, *ISDN signaling specification for application at the user-network interface— Layer 2 specification*

- — 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*

- Layer 3 specification

  - — NTT INS NET 1500 Service Interface Volume 3 *Primary rate user-network interface Layer 3 specification (Rev 1 1989)*

  - — CCITT Recommendation Q.930(I.450), *ISDN user-network interface layer 3—general aspects*

  - — CCITT Recommendation Q.931(I.451), *ISDN user-network interface Layer 3—specification*

  - — ANS T1.607, *Layer 3 signaling specification for circuit switched bearer service*

- Supplementary services specification

  - — NTT INS NET 1500 Service Interface Volume 3 *Primary rate user-network interface Layer 3 specification (Rev 1 1989)*

Part I: Introduction

Chapter 1: Overview of PRI services

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. 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 control or signaling information.

The transmission rate of a 23B+D PRI is 1544 kbit/s which is equivalent to a DS-1. A D-channel may also support the signaling requirements of B-channels on other DS-1s 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. The one D-channel provides the signaling for all the B-channels.

1.2 Network configurations

PRI plays two roles in a private branch exchange (PBX) to central office (CO) connection:

- PRI provides access services in a switched telephone network.

  This definition of a switched telephone network is very broad. It may consist of private and public networks that may be owned by more than one utility.

- PRI distributes services in a logical private network between PBXs with optional networking with central exchange (Centrex) users. From this perspective, the PBX is thought of as a network node like a CO.

  Services are distributed over PRI the same way that they are distributed within the public network, for instance, between COs over CCS7.

For a summary of these functions, see Figure 2 and Figure 3.

Figure 2 PRI provides access to the switched telephone network
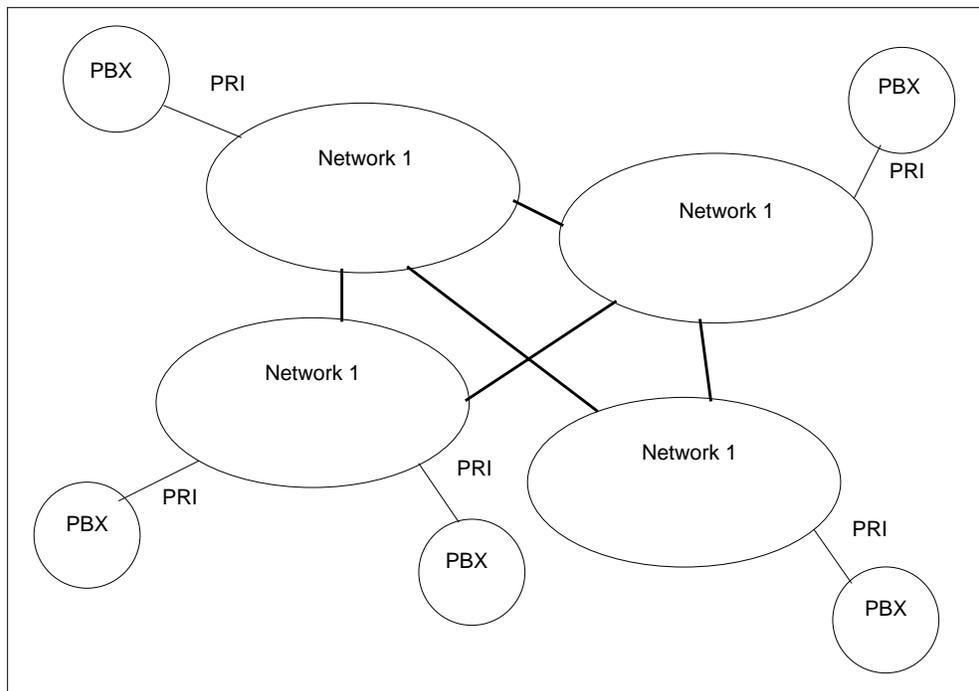
Figure 3 PRI distributes services in a private network
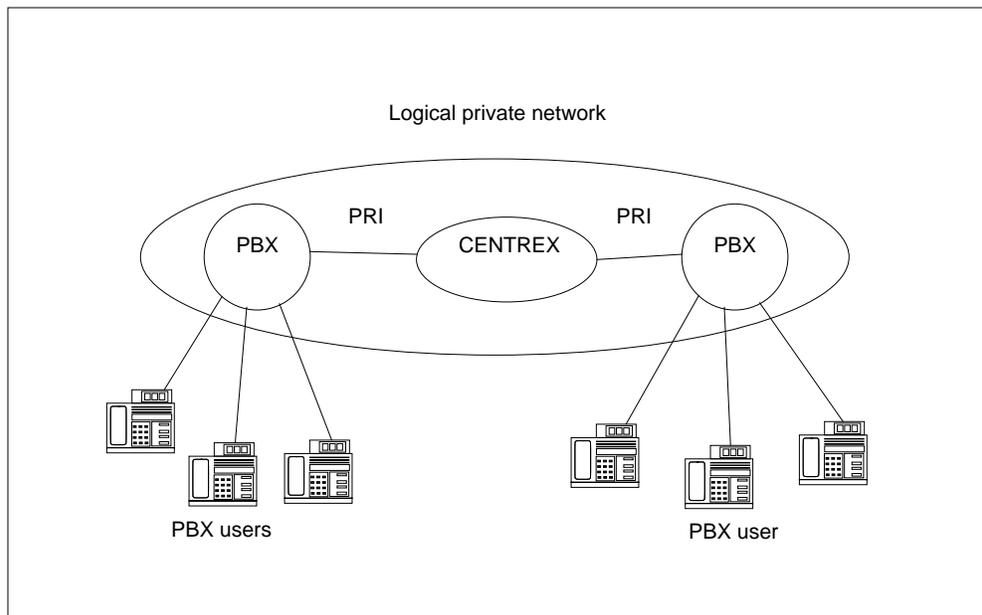
1.3 Description of basic connection service

The objective of the basic connection service is to connect voice or data terminals similar to current networks. This requires interworking between

- T1 analog and digital trunks with conventional A/B signaling

- CCS7 trunks

- ISDN PRI trunks

1.3.1 Voice terminal connectivity

Figure 4 shows the end-to-end connection of voice terminals in a typical ISDN network.

Figure 4 Basic connection service: voice terminal connectivity
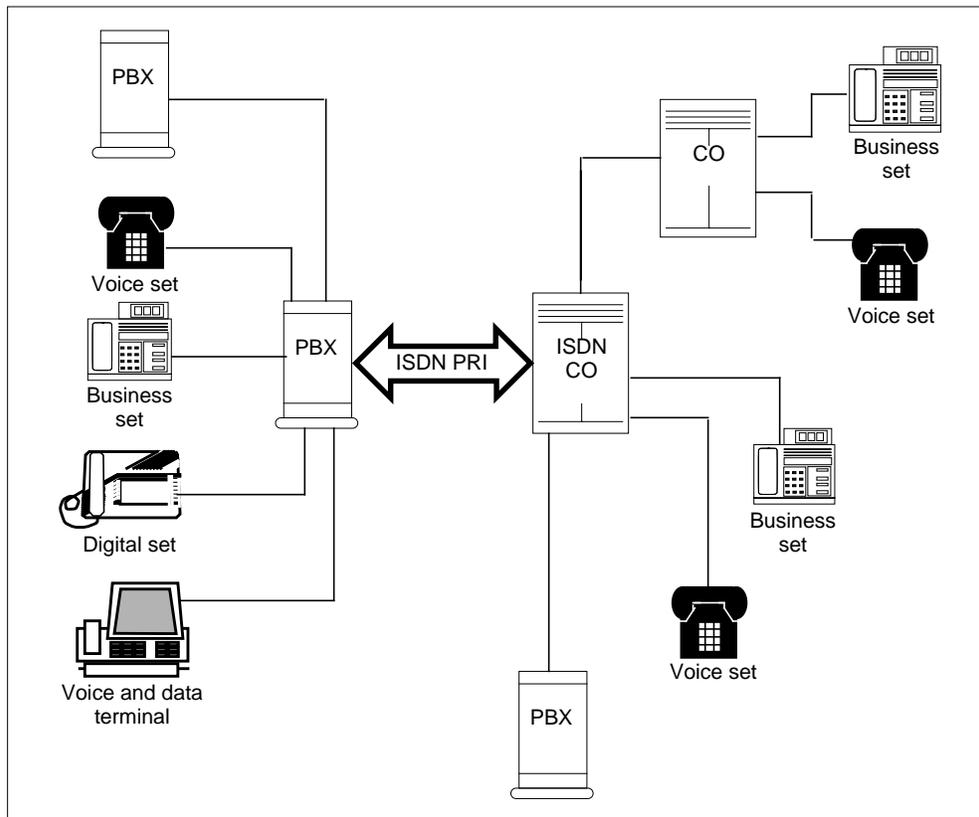
In an ISDN network, end-to-end voice communication circuits need to have a specific bearer service.The default bearer service that is used for interworking with a switched telephone network is the speech bearer service. A 3.1 kHz audio bearer service may also be used.

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
  This is the transfer rate of raw information.

- information transfer capability of 3.1 kHz audio

- user information layer 1 protocol of μ-law speech
  This specifies that the voice encoding is in accordance with the CCITT
  recommendation G.711 for μ-law speech.

The 3.1 kHz audio bearer service can also be used to support voice band
(analog) data.

1.3.2 Digital data terminal connectivity

Figure 5 shows the end-to-end connection of digital data terminals in a typical
ISDN network.

Figure 5 Basic connection service: data terminal connectivity

In an ISDN network, end-to-end digital data terminal circuits need to have a specific bearer service. The ISDN bearer service has the following characteristics:

- information transfer rate of 64 kbit/s

- information transfer capability (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 entered in the information transfer capability field, 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 a CCITT standard (CCITT recommendations I.463) which sets every 8th bit to "1".

  The advantage of setting the 8th bit to "1" is that it meets the current ZCS "1"'s density requirements, and allows transmission of the user's data over trunks still using in-band A/B bit signaling (which robs bit 8).

1.3.3 Numbering plans

PBX users are allocated numbers conforming to a private numbering plan. Any PBX may support multiple customers and multiple private networks, as shown by the example in Figure 6.

Figure 6 Multiple private networks on a PBX and Centrex
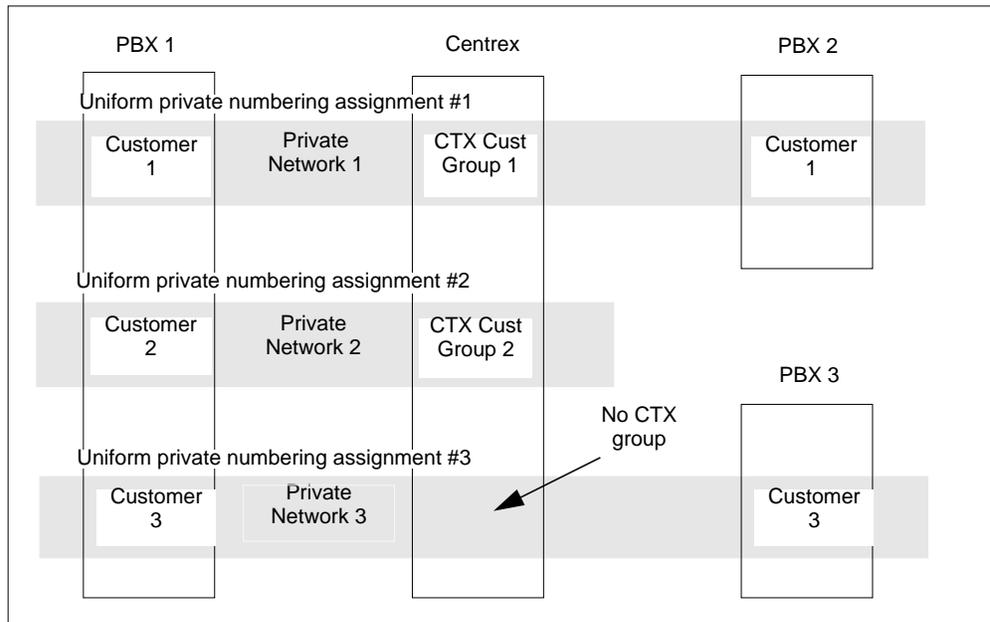
Note: Until standards have been agreed, all customers sharing a PBX must have their own PRIs. In the future, ISDN PRI will require a customer to indicate the customers unique private network number assignment set. This would allow two customers to have the same number assignments without causing a conflict. In the future, sharing of the PRI may be done through Business Group service, which is currently being defined in standards bodies.

1.3.4 Comparison between dialing plan and numbering plan

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

Dialing plan

A dialing plan defines the digits that a terminal user should dial or press to establish a connection or to access a service on a line interface. Dialing plans may include prefix digits and special numbers. Private dialing plans, which may be used by PBX and Centrex users, are not subject to standardization.

Numbering plan

A numbering plan defines the network address of a user and is used for routing within the network (refer to Figure 7). Numbering plans are internationally standardized (for instance, CCITT Recommendation E.164).

Figure 7   Comparison of dialing plan and numbering plan

On a typical terminal connected to a PBX, the user dials the digits,
55095.

The PBX recognizes the customer as a member of Group 1. The Group 1 translation table indicates that the initial 5 in the number should be replaced with the following digits:
613-763

Thus the complete dialing number that is used to route the call is:
613-763-5095

In ISDN, dialing plan digits are carried within information elements. These digits request the functions implied by the digits dialed which are not 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 that are not part of the numbering plan.

1.3.5 Connection types

The basic connection service provides two types of connections: permanent and switched.

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 a PRI). The capability of the permanent connection to carry the different bearer services is dependent on the information transfer capability of the connections.

In essence, a permanent B-channel may be described by the same characteristics as a switched B-channel, except they are provisioned by service order.

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). No ISDN D-channel signaling is required to set up these circuits as they are provisioned by the service order process.

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

Switched connections

Switched connections are set up under control of the user. The user provides the appropriate call establishment information in a connection request (that is, the user specifies a destination address, the bearer service, and the B-channel for each call).

1.3.6 Progress reporting and cut-through

The user interface to terminals is placed as close as possible to the user. For example, ISDN terminals receive out-of-band signals and generate the appropriate displays, audible tones, and announcements.

For other terminals, the user interface is generated from the local switch. This allows the local user interfaces to be consistent. 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. For example, Japanese announcements and Japanese displays would be generated for the called user in Japan, no matter where the call originated.

Some exceptions to the rule above have been made to permit interworking with non-ISDN network trunks 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. Cut-through at the terminating switch to the terminating access interface occurs when the called terminal indicates it is connected to (accepts) the call. This introduces a short clipping delay as there is a race condition between the connected indication arriving and being acted upon in the D-channel and the user talking on the B-channel.

  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.

1.3.7 Conversion of a dialing plan into a network numbering plan

PBX 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 switch (PBX or CO) supporting the non-ISDN user access interface.

The following fields are data filled in the PBX 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 or a private numbering plan. Currently, only private numbering plan digits are acceptable.

- Numbering plan identification: determines whether the numbering plan used is a private or a standardized numbering plan Currently, only a private numbering plan is acceptable.

- Type of number: determines whether the number is the subscriber number, a number represented in a standard numbering plan, or an unknown number. Currently, only unknown numbers are acceptable.

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. Customer-specific dialing plans to access private facilities must be arranged with the network by subscription.

Digit strings are encoded in the number digits field of the *Called party number* information element. Details of the encoding of the referenced information elements can be found in the Call Control Signaling section of this specification.

1.3.8 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 PBX usually allocates channels on calls from the PBX to the CO, and the CO allocates channels on calls from the CO to the PBX. The DMS-100 supports channel negotiation and, hence, the outgoing channel selected by the DMS-100 CO may be changed by the PBX. If this channel is unacceptable to the DMS-100—due, for instance, to the channel being busy—the call is dropped.

In the event of "glare" (that is, 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, the "master" should allocate channels in ascending order and the "slave" in descending order. In this specification, the CO is always the "master".

Part II: Physical layer specification— Layer 1

Chapter 2: Layer 1 introduction

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. There are a number of DS-1 options which have to be specified for this application. Various annotations and additions are included which reflect Northern Telecom's interpretation of the applicable standards (see section 2.2 on page 50).

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

2.1 Technical conformance

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

- bipolar coding with 8-zero suppression (B8ZS)

- current 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 must also be supported as the existing DS-1 transmission facilities may 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 the existing ZCS scheme.

2.2 Standards compatibility

The network interface is based on

- *ANS T1.403, Carrier to customer installation —DS-1 metallic interface specification, 1989*

- *ANS T1.408, ISDN primary rate—customer installation metallic interfaces Layer 1 specification (T1E1/89-46R6)*

- *NTT INS NET 1500 Service Interface Volume 2, part 2 Primary rate user-network interface Layer 1 specification (Rev 1 1989)*

- *CCITT Recommendation I.431, Primary rate user-network interface-Layer 1 specification*

The interface does not support the following features (for further discussion, see later in this specification):

- 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 3: General information

3.1 Architecture

This specification defines the physical DS-1 interface including the DS-0 pipes used by the ISDN B-channels, D-channel, and conventional bit-robbing trunks to transmit information. Figure 8 shows the ISDN PRI functional architecture.

Figure 8 ISDN PRI architecture
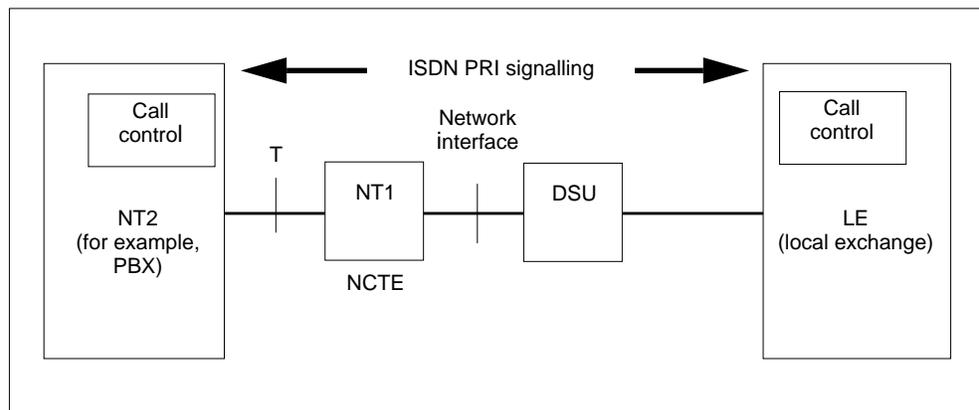
3.2 Services offered by the physical layer

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 *ANS T1.408, ISDN primary rate—customer installation metallic interfaces Layer 1 specification (T1E1/89-46R6)*. 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 current 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.

3.3 Layer 1 signaling

This section of the specification establishes the requirements at the network interface necessary for compatible operation between the carrier and the customer installation.

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.

Chapter 4: Electrical specification

4.1 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 9. 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 9   Network interface
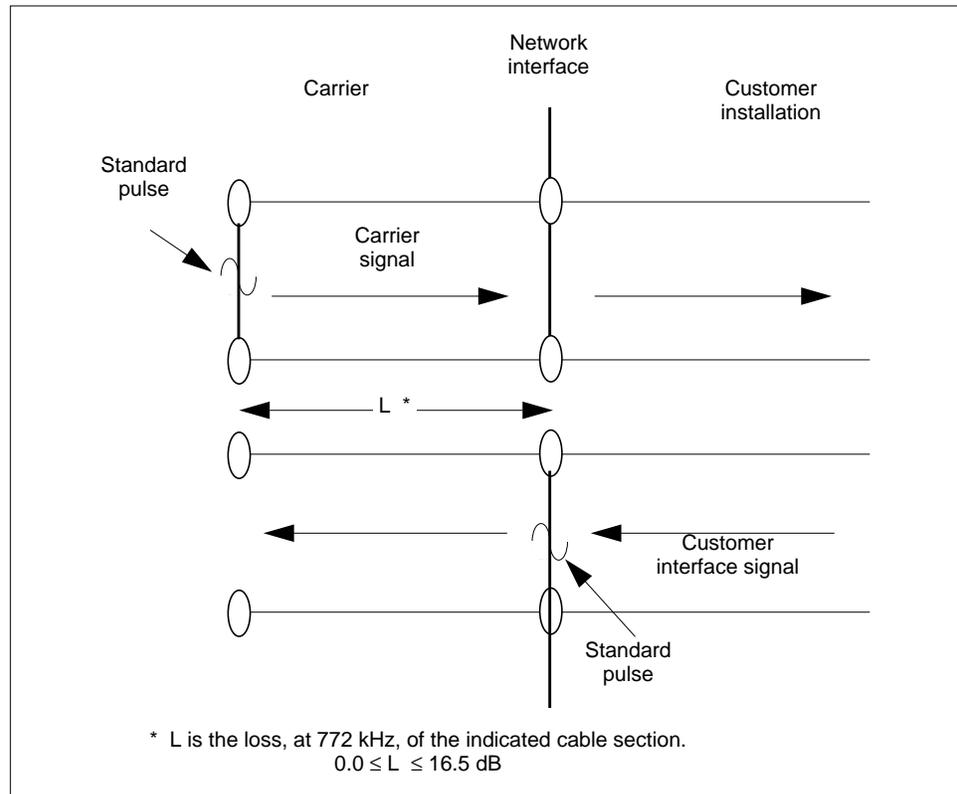
4.2 Impedance matching

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.

Note: 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.

4.3 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 section 4.4 on page 57 and section 4.5 on page 57.

4.3.1 Transmission rate

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

4.3.2 Line codes

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

4.3.3 Test load

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

4.3.4 Standard pulse characteristics

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 10 when scaled by a constant factor. The corner points of the pulse template for maximum and minimum curves are defined, respectively, in Table 1 and Table 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.

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.

Figure 10 Isolated pulse template
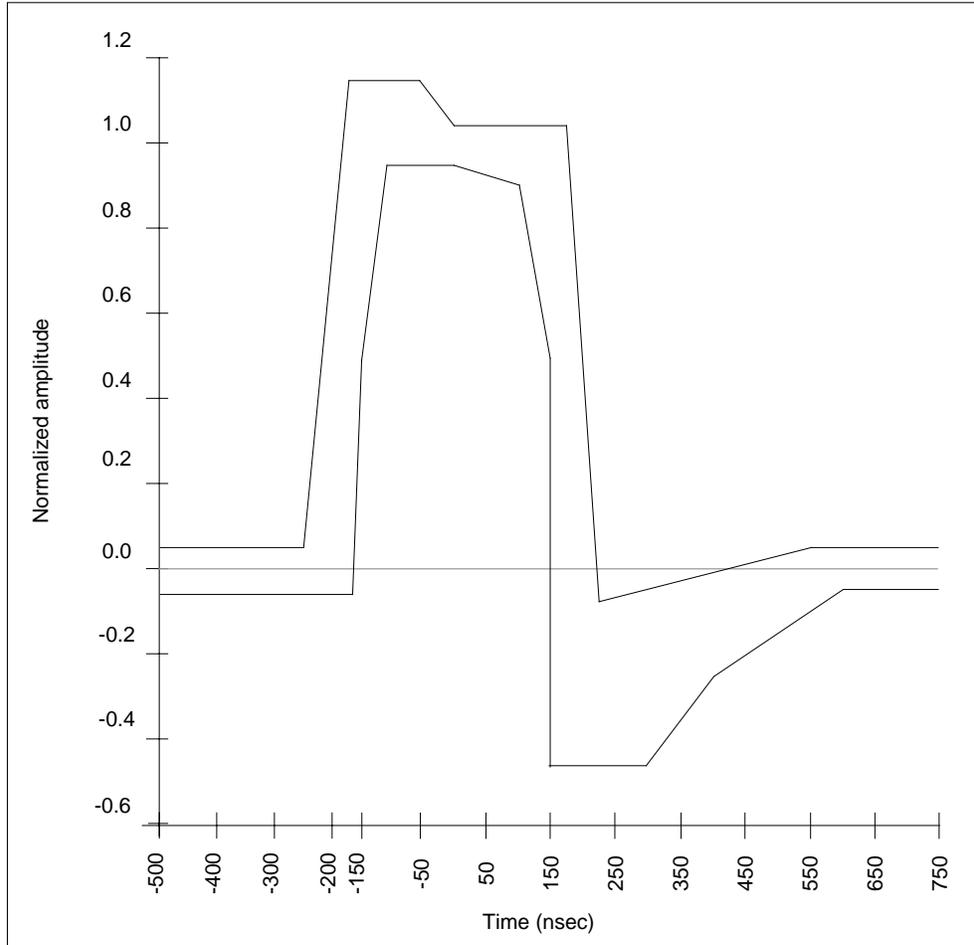
Table 1 Pulse template corner points: maximum curve

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		.05	.05	.80	1.15	1.15	1.05	1.05	-0.07	0.05	0.05

Table 2 Pulse template corner points: minimum curve

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

4.3.5 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 11. 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 11 Pulse amplitude envelope

Envelope of pulse amplitudes lies within the shaded areas
* Reference (100 percent) point may be in the range   2.4 V ≤ Ref ≤ 3.45 V
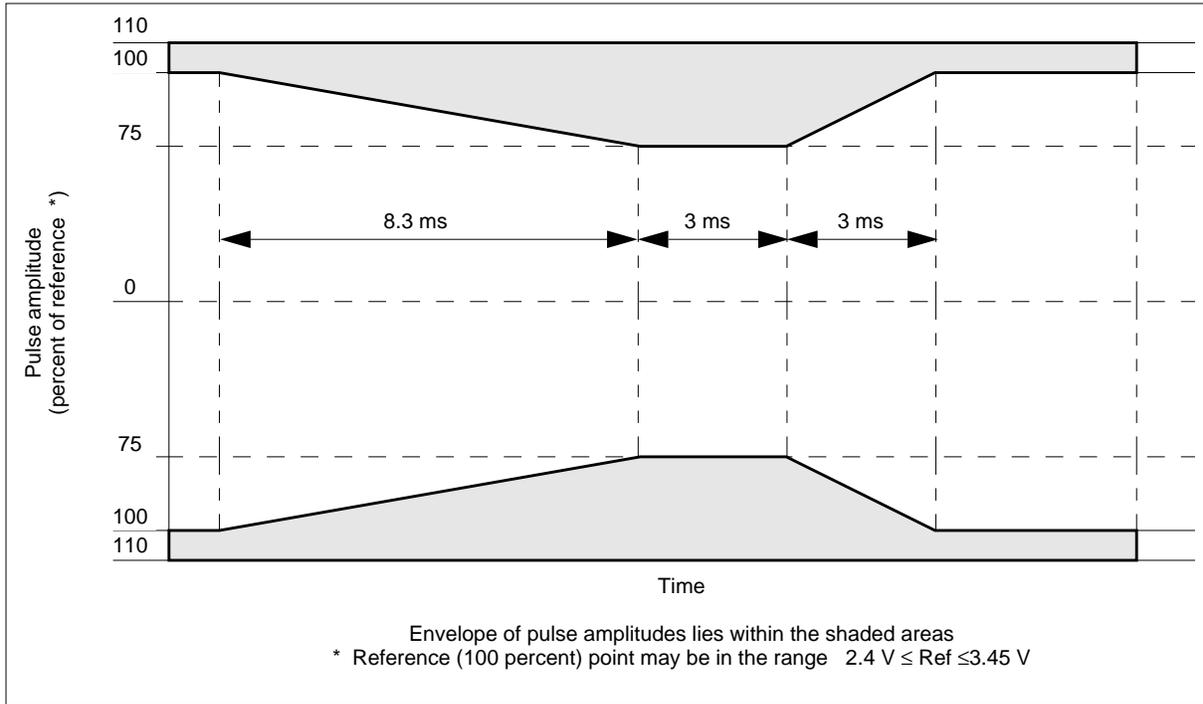
4.4 Signal from the carrier (carrier signal)

The carrier signal at the network interface meets the signal specifications identified in section 4.3 on page 54, except that

- the pulse characteristics are those of a standard pulse (see section 4.3.4 on page 54) 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 10). 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.

4.5 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 4.3 on page 54.

4.6 Pulse density

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

4.7 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 ns (one pulse period).

4.7.1 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 12.

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

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 12   Frequency weighting function for jitter
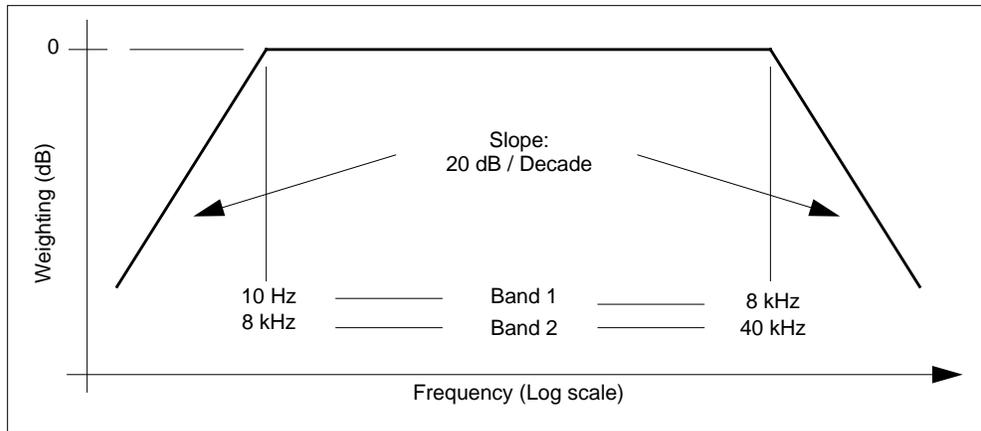
4.7.2 Wander

Wander is specified in frequency band 3. The characteristics of the weighting function which define this band are shown in Figure 13.

Carrier signal

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

CI Signal

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

Figure 13   Frequency weighting function for wander
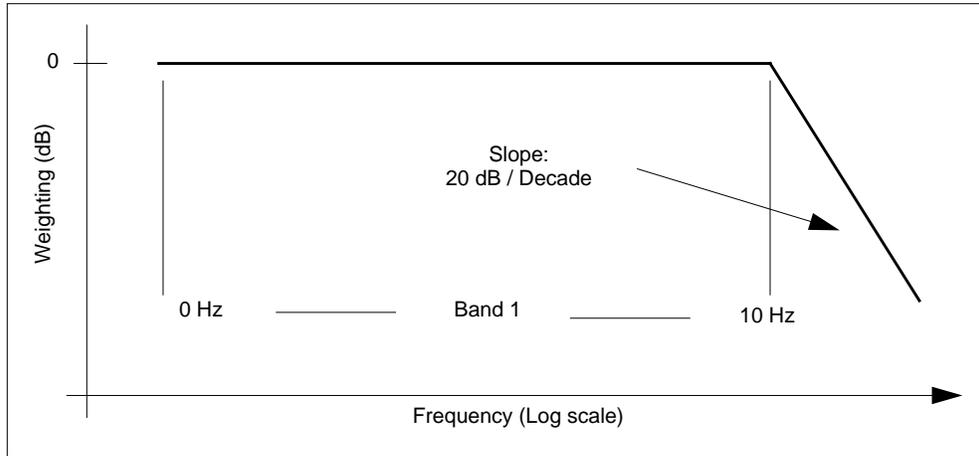
4.8 Powering arrangements

Direct-current power is not delivered to the NI.

Chapter 5: Frame formats

5.1 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.

5.2 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 14.

Figure 14 DS-1 frame bit assignment
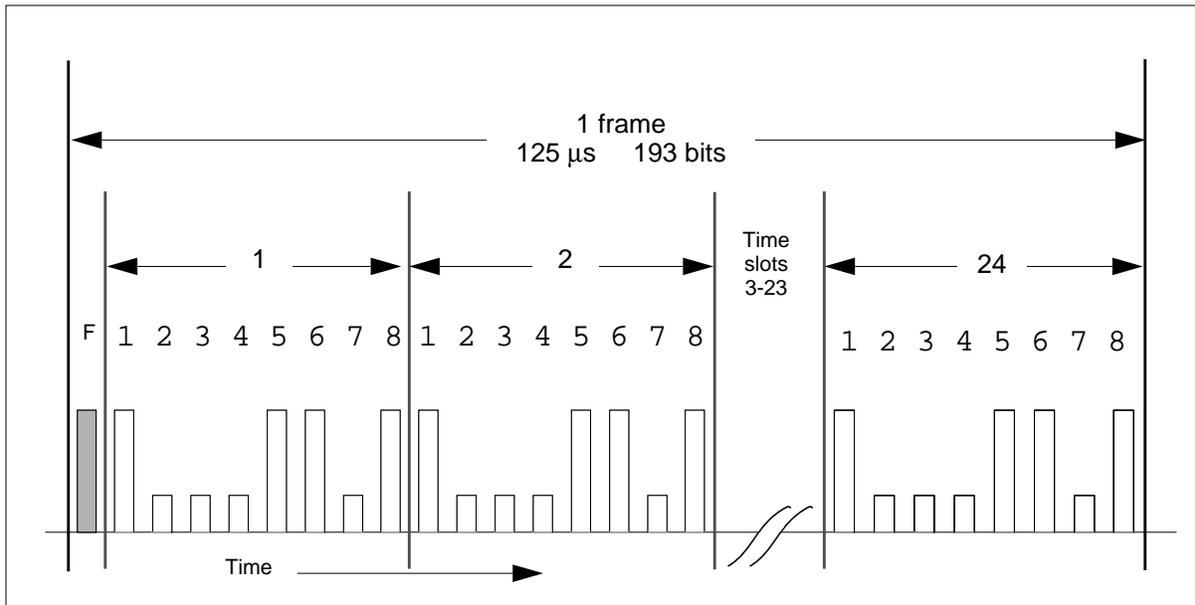
5.3 Superframe format definition

A superframe consists of twelve consecutive frames as shown in Table 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 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).

5.4 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 in Table 4 and the following list:

- 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 4631 of ESF(N) is the coefficient of the term x^0 and bit 0 of ESF(N) is the coefficient of the term x^{4631}.

    — 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 4 Extended superframe format

Frame no.	F bits				Bit use in each time slot		Signaling bit use options	
	Bit no.	FPS	DL	CRC	Traffic	Signaling	T	Signaling channel
1	0	-	m	-	1-8	-		
2	193	-	-	C1	1-8	-		
3	386	-	m	-	1-8	-		

Table 4 Extended superframe format (continued)

Frame no.	F bits				Bit use in each time slot		Signaling bit use options	
	Bit no.	FPS	DL	CRC	Traffic	Signaling	T	Signaling channel
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 - C6).

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

5.5 Idle codes

5.5.1 Codes for idle channels and idle slots

A keep-alive signal is applied to idle channels to ensure that no more than 80 consecutive "0"s are transmitted. The keep alive signal is removed when the pulse density returns to the requirements detailed in 4.6, "Pulse density", 57.

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

5.5.2 Interframe (layer 2) timefill

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

Chapter 6: Clear channel capability

6.1 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 4.6, "Pulse density", on page 57. 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 7: Maintenance

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

7.1 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.

7.2 Alarm indication signal (AIS)

The alarm indication signal (AIS) is not supported in INS 1500.

7.3 Loopback

The line and payload loopbacks that are described in *ANS T1.408, ISDN primary rate—customer installation metallic interfaces Layer 1 specification (T1E1/89-46R6)*are not supported by the network in INS1500.

7.4 ESF maintenance

7.4.1 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 paragraphs 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 bi-polar violations)

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

The presence of all or some of these errors can indicate the location of a problem. 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 paragraphs. 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.

7.4.2 Transmission measurement parameters

During periods of ideal transmission, no error events occur. If the CI detects any error, it sends an RAI—a yellow alarm.

The one-second timing intervals may be derived from the DS-1 signal, or from a separate, equally accurate ($\pm$ 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.

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:

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.

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.

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

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.

Controlled slip event
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.

7.4.3 ESF data link
There are two categories of bit-oriented messages—priority messages, and command and response messages. Only priority messages are currently supported.

Message-oriented codewords are used to carry performance monitoring information (see *ANS T1.408, ISDN primary rate—customer installation metallic interfaces Layer 1 specification (T1E1/89-46R6)*). Message-oriented codewords based on LAPD protocol are not supported by the network.

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 or for at least 1 second as in section 7.1 on page 69.

Command and response messages

Command and response messages are not currently supported by the network, although it is recommended that user equipment support these for future compatibility.

Table 5 lists all the messages, and their associated code words, that have been defined.

Table 5 Bit-oriented data-link messages

Priority Messages	Code word
RAI (Yellow alarm)	000 0000 0111 11111

Note: Only RAI is supported by the current network. All other values are reserved.

Chapter 8: Connector arrangements

8.1 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 15, Figure 16, and Figure 17.

Figure 15 Connector pin assignment (RJ48C)
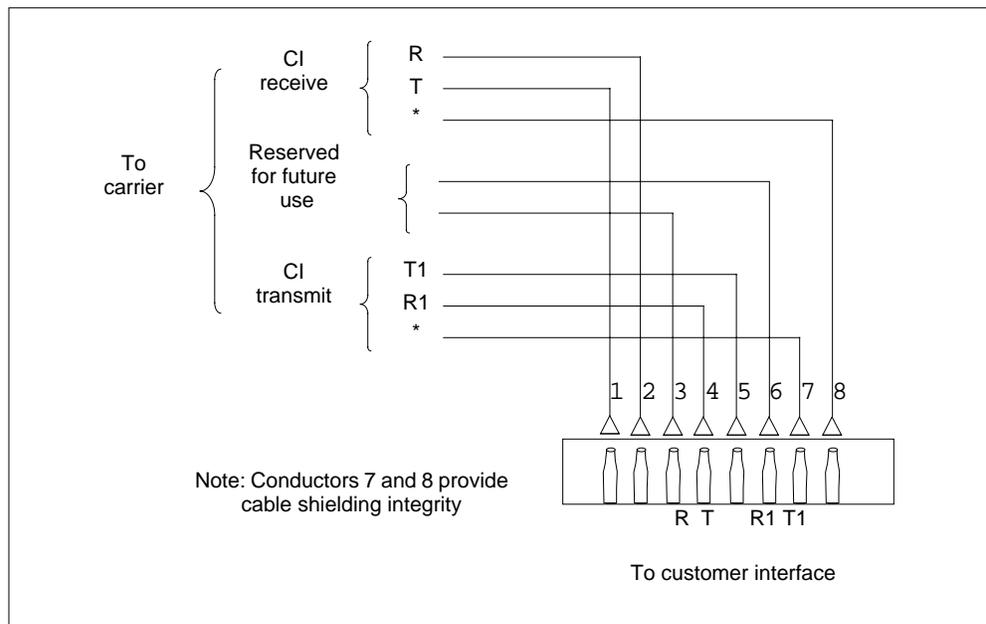
Figure 16 Connector pin assignment (RJ48X)
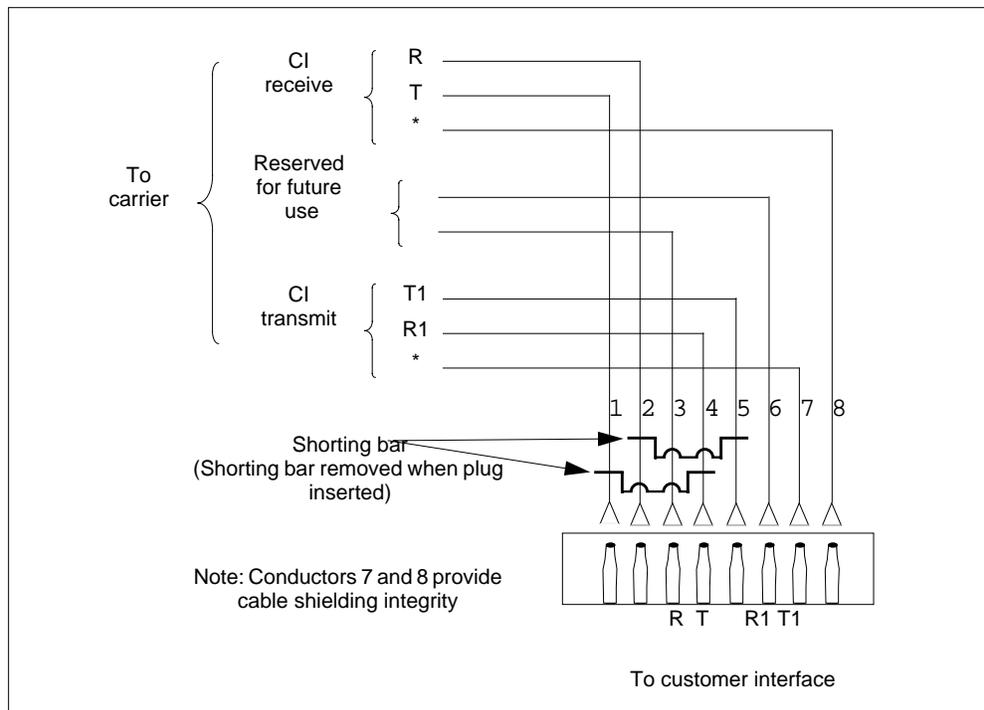
Figure 17 Connector pin assignment (RJ48M)

Connector pin number					
Line	**T**	**R**	**T1**	**R1**	*****	*****
1	26	1	27	2	28	3
2	29	4	30	5	31	6
3	32	7	33	8	34	9
4	35	10	36	11	37	12
5	38	13	39	14	40	15
6	41	16	42	17	43	18
7	44	19	45	20	46	21
8	47	22	48	23	49	24
* Conductors reserved for future use						

Note: Conductors 25 and 50 provide cable shielding integrity
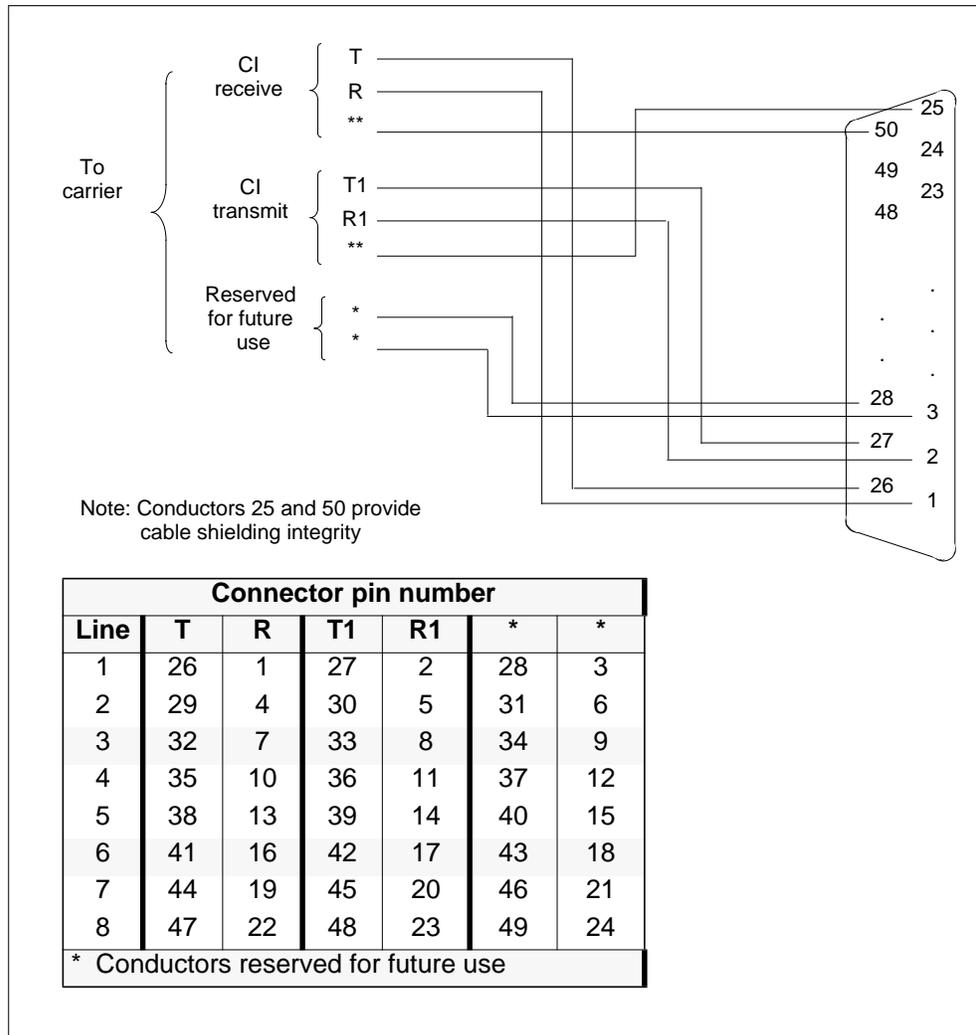
Part III: Data-link layer specification—Layer 2

Chapter 9: Layer 2 introduction

9.1 Scope

This section defines the link access protocol for the D-channel (LAPD) of the ISDN primary rate interface (PRI). It specifies the frame structure, elements of procedure, format of fields, and procedures for the proper operation of the Link Access Procedure (LAP) on the D-channel.

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 (see Note) and Layer 3, and between the data link layer and the physical layer (Layer 1)

   Note: 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

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]).

9.2 Feature summary

The LAPD features that are supported are

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

- Service access point identifier (SAPI) = 0, and terminal endpoint identifier (TEI) = 0 (fixed TEI)

- TEI administration procedures 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 used

The features 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 or user cannot 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

9.3 Standards compatibility

This data link layer specification is based on the *ANS 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*.

9.4 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 controlling

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.

9.5 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.

9.5.1 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*, an*d -Confirm*—for terminating multiple-frame operation

9.5.2 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 10: Frame structure

10.1 Introduction

All peer-to-peer exchanges at the data link layer conform to one of the formats shown in Figure 18. 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 18 Frame formats

Note:
Acknowledged operation
(modulo 128)

—2 octets for frames with sequence numbers

—1 octet for frames without sequence numbers
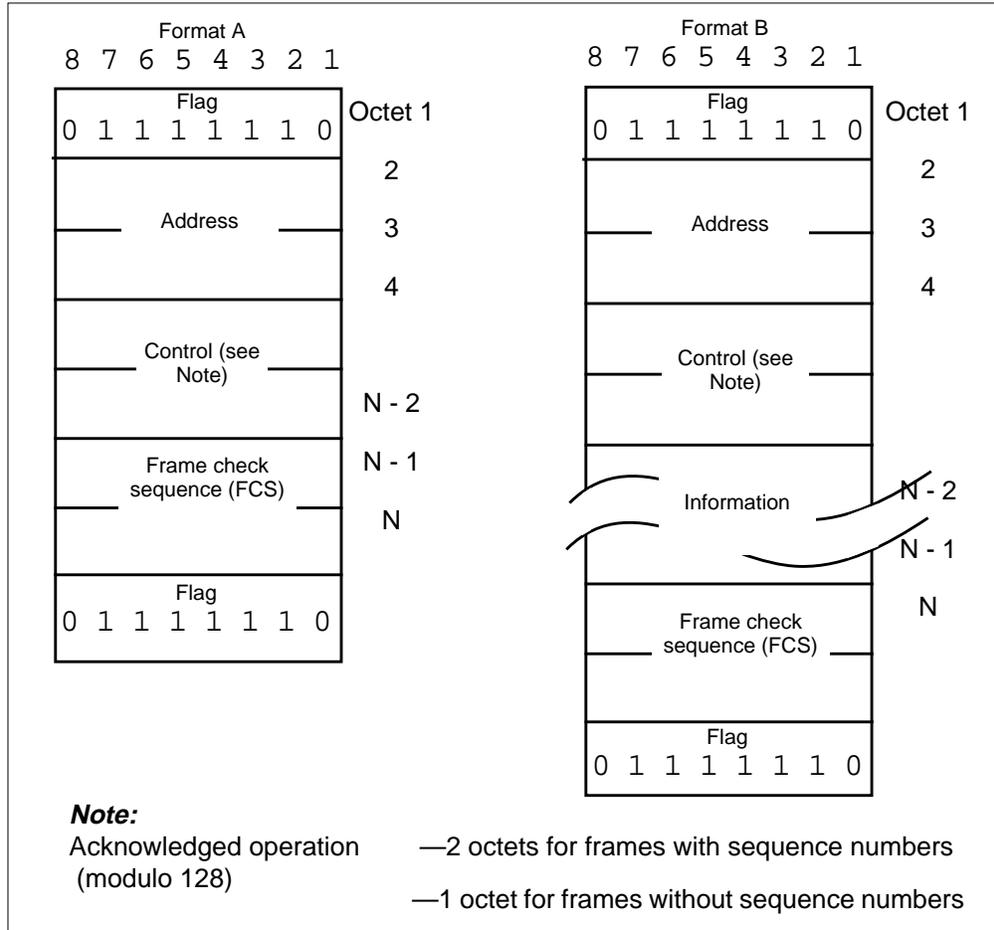
10.2 Flag sequence

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 as 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).

10.3 Address field

The address field consists of 2 octets as shown in Figure 18. 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 11.2 on page 89.

10.4 Control field

Depending on the type of operation, the control field consists of 1 or 2 octets as shown in Figure 18. This field is used to identify the type of command and response. The format of the control field is defined in section 11.4 on page 91.

10.5 Information field

The information field of a frame, when present, follows the control field and precedes the frame check sequence as shown in Figure 18. 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, refer to section 13.9.3 on page 130.

10.6 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.

10.7 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 the 16-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.

10.8 Format convention

10.8.1 Numbering convention

The basic frame numbering convention used is shown in Figure 19. The bits are grouped into octets.

Figure 19 Format convention
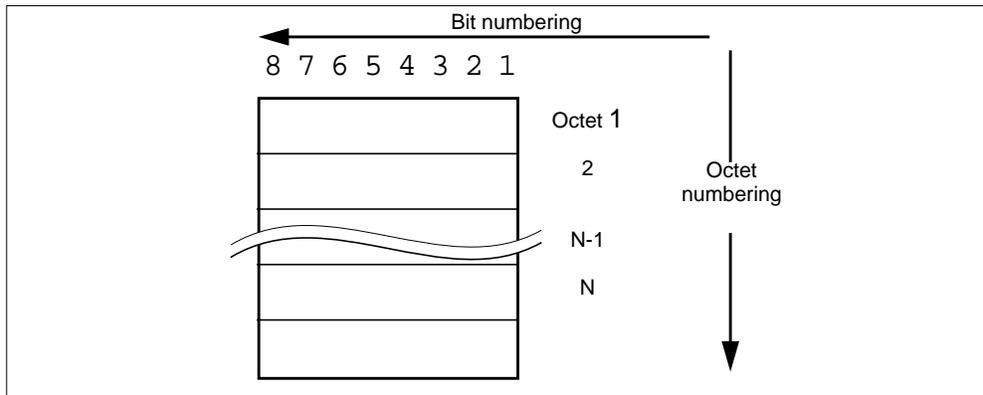
10.8.2 Order of bit transmission

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

10.8.3 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 19 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 20 Format mapping convention (1 of 2)
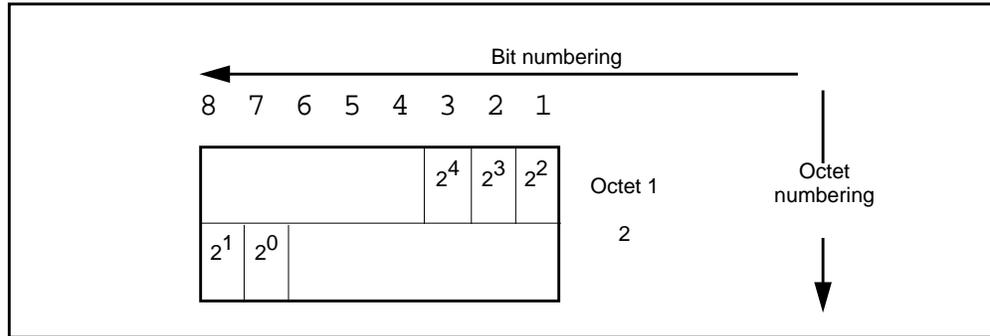
An exception to the preceding field mapping convention is the data-link layer frame check sequence (FCS) field, which spans two octets. In this case, bit 1 of the first octet is the high order bit and bit 8 of the second octet is the low order bit (Figure 21).

Figure 21 Format mapping convention (2 of 2)—frame check sequence
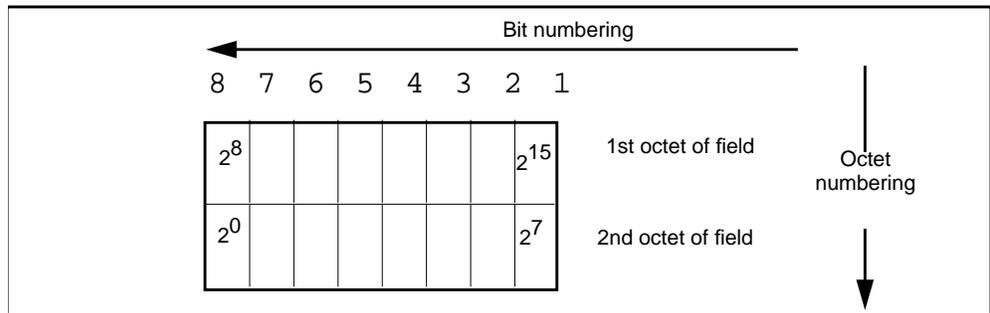
10.9 Invalid frames

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.

10.10 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 11: Elements of procedures

11.1 Introduction

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

Procedures are derived from these elements and are described in Chapter 13: "Definition of peer-to-peer procedures", on page 111.

11.2 Address field format

The address field format shown in Figure 22 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 22 Format mapping convention

EA = Address field extension bit
C/R = Command and response indication bit
SAPI = Service access point identifier
TEI = Terminal endpoint identifier
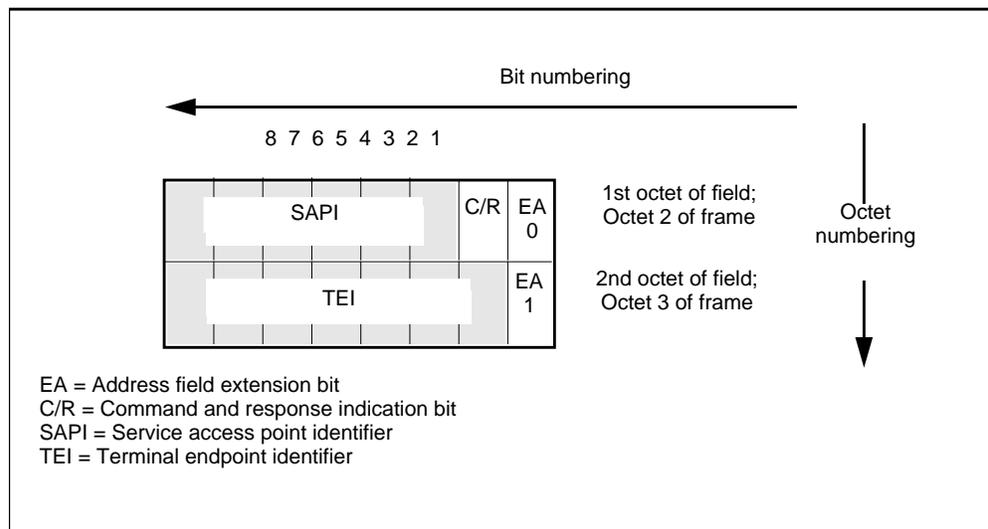
11.3 Address field variables

11.3.1 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 a "0"and bit 1 of the second address octet set to "1".

11.3.2 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 C/R set to "1", and responses are sent with C/R set to "0". The combinations for the network side and user side are shown in Figure 23.

Figure 23 C/R field bit usage
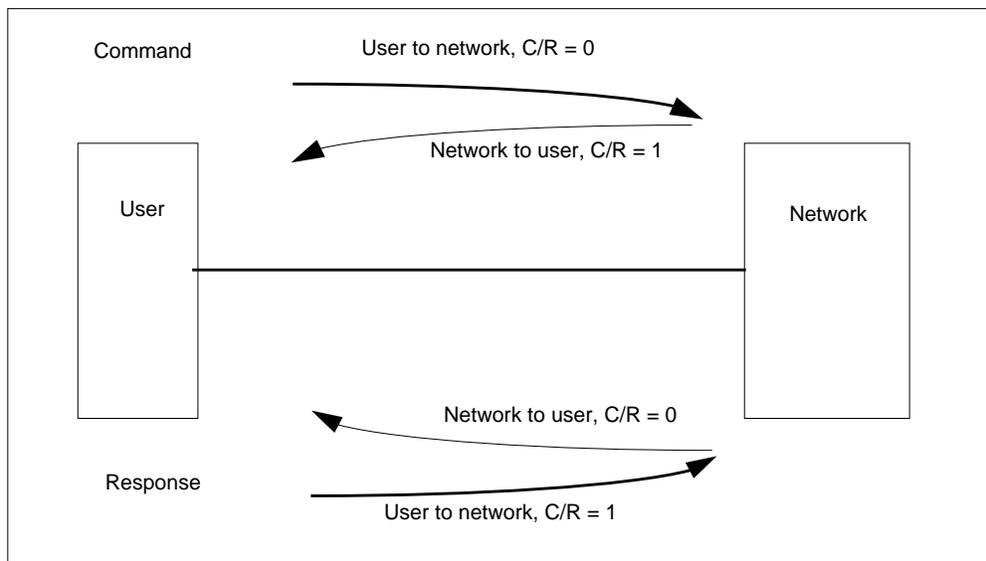
11.3.3 Service access point identifier (SAPI)

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 24.

Figure 24 Allocation of SAPI values

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

11.3.4 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 TE, for example, by the user or manufacturer.

11.4 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 25.

Figure 25 Control field formats

Control field bits (modulo 128)	8	7	6	5	4	3	2	1	
I Frame				N(S)				O	Octet 4
				N(R)				P	Octet 5
S Frame	X	X	X	X	S	S	0	1	Octet 4
				N(R)				P/F	Octet 5
U Frame	M	M	M	P/F	M	M	1	1	Octet 4

N(S)	Transmitter send sequence number		M	Modifier function bit
N(R)	Transmitter receive sequence number		P/F	Poll bit when issued as a command, final bit when issued as a response
S	Supervisory function bit		X	Reserved and set to "0"
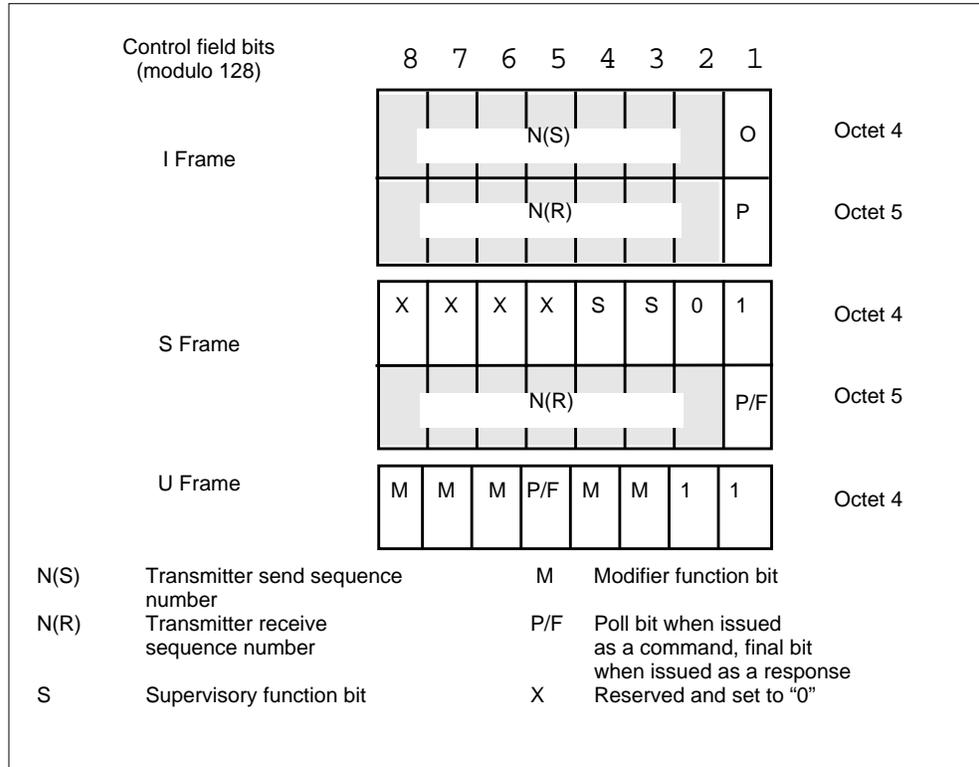
11.4.1 Information transfer format—I frame

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 11.5 on page 93) 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. The P bit that may be set to "0" or "1".

The use of N(S), N(R), and P bits are defined in Chapter 13: "Definition of peer-to-peer procedures", on page 111.

11.4.2 Supervisory format—S frame

The S format is used for frames that 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. The P/F bit that may be set to "0" or "1".

The use of N(S), N(R) and P bits are defined in Chapter 13: "Definition of peer-to-peer procedures", on page 111.

11.4.3 Unnumbered format—U frame

The U format is used for frames that provide additional data link control functions (refer to Figure 26). This format does not contain any sequence numbers. It does include a P/F bit that may be set to "0" or "1". Unnumbered frames have a one-octet-sized control field.

The use of the P bit is defined in Chapter 13: "Definition of peer-to-peer procedures", on page 111.

11.5 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.

11.5.1 Poll/final (P/F) bit

All frames contain a poll/final (P/F) bit (see Figure 26). 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.

When the P bit set to "1", this indicates that the data-link-layer entity is requesting a response frame (polling) from the data-link-layer entity to which the frame is addressed.

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 13: "Definition of peer-to-peer procedures", on page 111.

Figure 26 Example of P/F bit for U-format frames
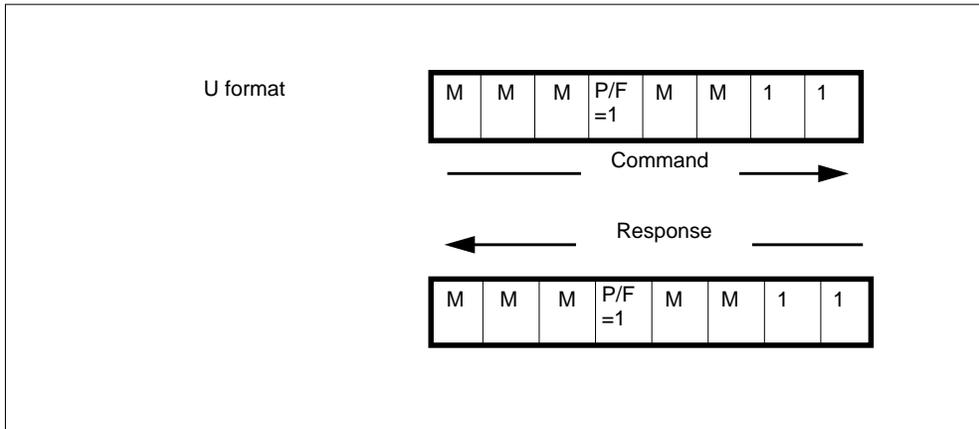
11.5.2 Multiple frame operation—variables and sequence numbers

This section describes all the variables and sequence numbers that are used when frames are transmitted. Figure 27 shows how these numbers progress as different frames are sent.

Modulus

Each I frame is sequentially numbered. The modulus is 128, and the sequence numbers cycle through the entire range, 0 through 127.

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 has a value in the range 0 through 127. 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.

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 has a value in the range 0 through 127. 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 $V(A) \leq N(R) \leq V(S)$.

Figure 27 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] $\geq$ k [=2]

When 1st acknowledge frame
returned:
V(S) = 2
V(A) = 2
V(R) = 1

When 2nd acknowledge frame
returned for both frames sent:
V(S) = 2
V(A) = 3
V(R) = 1
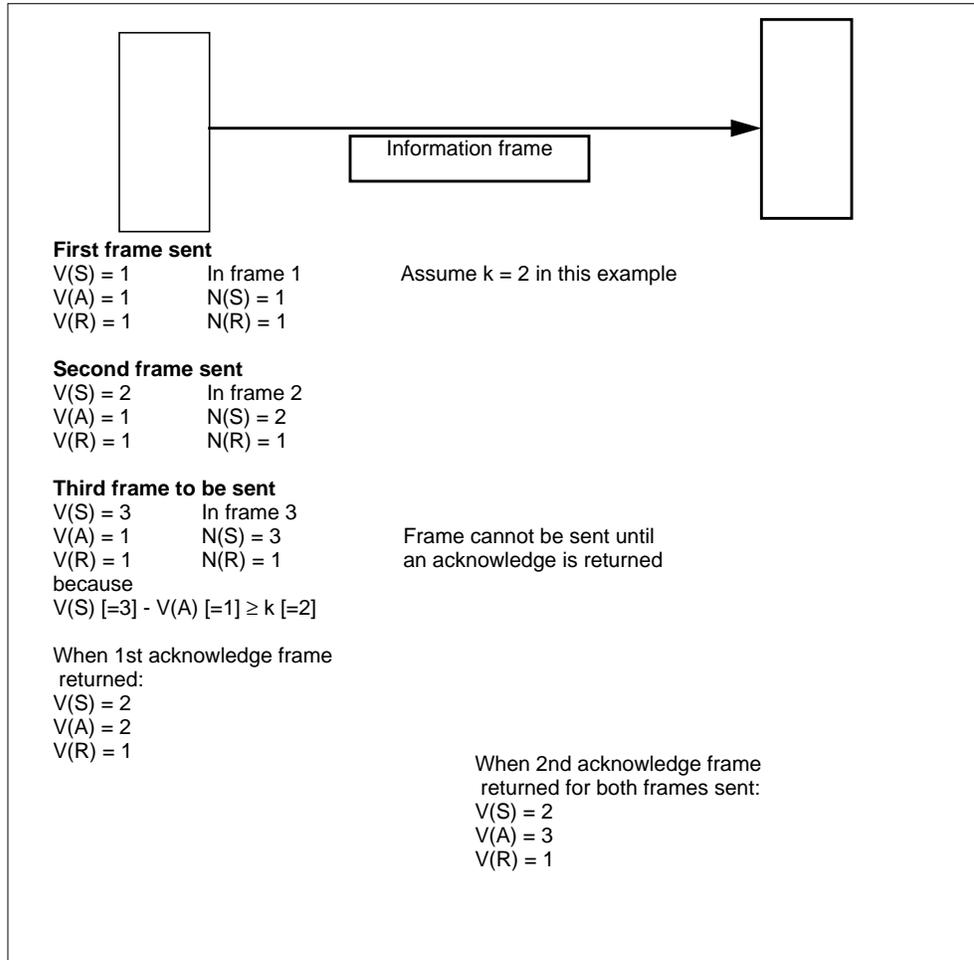
Send sequence number, N(S)

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)].

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 has a
value in the range 0 through 127. 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 28 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 balance mode extended

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.

11.6 Frame types

11.6.1 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 in the following subsections.

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.

All commands and responses that are transmitted in a Supervisory frame—with its supervisory function bits set to "11"—are ignored. Similarly those commands and responses sent in an unnumbered frame that has its modifier bits set to any other value than those identified in Figure 28 are also ignored.

11.6.2 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.

11.6.3 Set asynchronous balanced mode extended (SABME) command

The SABME command is used to place the addressed user side or network side into a multiple-frame, acknowledged, information transfer operating mode with modulo 128 sequence numbering. The SABME frame is not numbered.

No information field can be present in the SABME command frame. A data-link-layer entity confirms acceptance of a SABME command by transmitting a UA response at the first opportunity.

When the UA is received, the sending side data-link-layer entity's variables are reset as follows. The send state variable V(S), acknowledge state variable V(A), and receive state variable V(R) are set to zero. The transmission of an SABME command indicates that all exception conditions have been cleared.

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.

11.6.4 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

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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 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.

11.6.5 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.

11.6.6 Receive not ready (RNR) command and response

The RNR supervisory frame is used by a data-link-layer entity to indicate to the other end of the link that it is in a busy condition. That is, for a short time, it cannot accept additional incoming I frames. The value of N(R) in the RNR frame acknowledges I frames numbered up to and including N(R) - 1 have been received.

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 ask for the status of its peer data-link-layer entity.

11.6.7 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.

11.6.8 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.

11.6.9 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.

11.6.10 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. This frame is not numbered. The DM response frame does not contain an information field.

11.6.11 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 28.

• 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 It consists of five octets with this response and provides the reason for the FRMR response. This information field format is shown in Figure 29.

Figure 29 FRMR information field format for extended (modulo 128) operation)
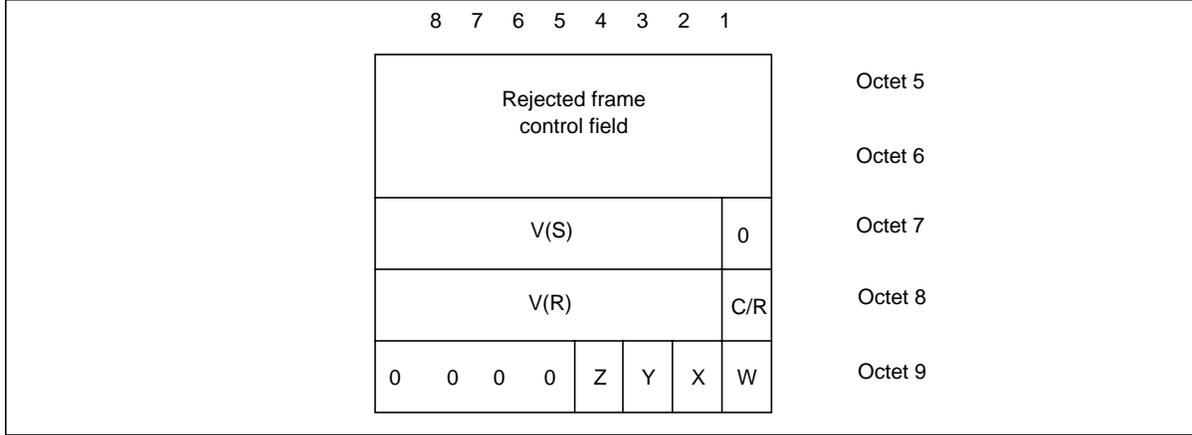
Note 1: The rejected frame control field is the control field of the received frame which causes rejection. When the rejected frame is not numbered, the control field of the rejected frame is positioned in octet 5, with octet 6 set to "0000 0000".

Note 2: V(S) is the value of the current send state variable (on the user side or network side) that is reporting the rejection condition.

Note 3: If C/R set to "1", it indicates that the rejected frame was a response. If C/R is set to "0", it indicates that the rejected frame was a command.

Note 4: V(R) is the value of the current receive state variable (on the user side or network side) that is reporting the rejection condition.

Note 5: W set to "1" indicates that the control field received and returned in octets 5 and 6 was undefined or not implemented.

Note 6: X set to "1" indicates that the control field received and returned in octets 5 and 6 was 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 must be set to "1" in conjunction with this bit.

Note 7: Y set to "1" indicates that the information field received exceeded the maximum established information field length (N201) of the user side or network side reporting the rejection condition.

Note 8: Z is set to "1" indicates that the control field received and returned in octets 5 and 6 contained an invalid N(R).

Octet 7, bit 1 and octet 9, bits 5 through 8, are always set to "0" as indicated.

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

Chapter 12: Elements for layer-to-layer communication

12.1 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

12.2 Interface

The interface part of the primitive determines the interface across which the primitive flows. For ISDN PRI, the following primitives have been 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

12.3 Generic names

The generic name specifies the activity that should be performed by the primitive. This section 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 are shown in Table 6.

Table 6 Primitives associated with the data-link layer

Generic name	Type				Parameters		Message unit contents
	Request	**Indi- cation**	**Res- ponse**	**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

12.3.1 DL-Establish

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

12.3.2 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.

12.3.3 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 Chapter 13: "Definition of peer-to-peer procedures" on page 111).

12.3.4 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.

12.3.5 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.

12.3.6 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.

12.3.7 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

The management entity may respond with an *MDL-Error* primitive if the management entity cannot obtain a TEI value.

12.3.8 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.

12.4 Primitive types

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

12.4.1 Request

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

12.4.2 Indication

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

12.4.3 Response

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

12.4.4 Confirm

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

12.5 Parameter definition

12.5.1 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.

12.5.2 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.

12.6 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.

In this section, the interactions between Layer 3 and the data link layer are specified.

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 30). 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 while the *Awaiting establish* and *Awaiting release* states are transition states.

Figure 30 State transition diagram for sequences of primitives at a point-to-point data link connection endpoint as seen by Layer 3
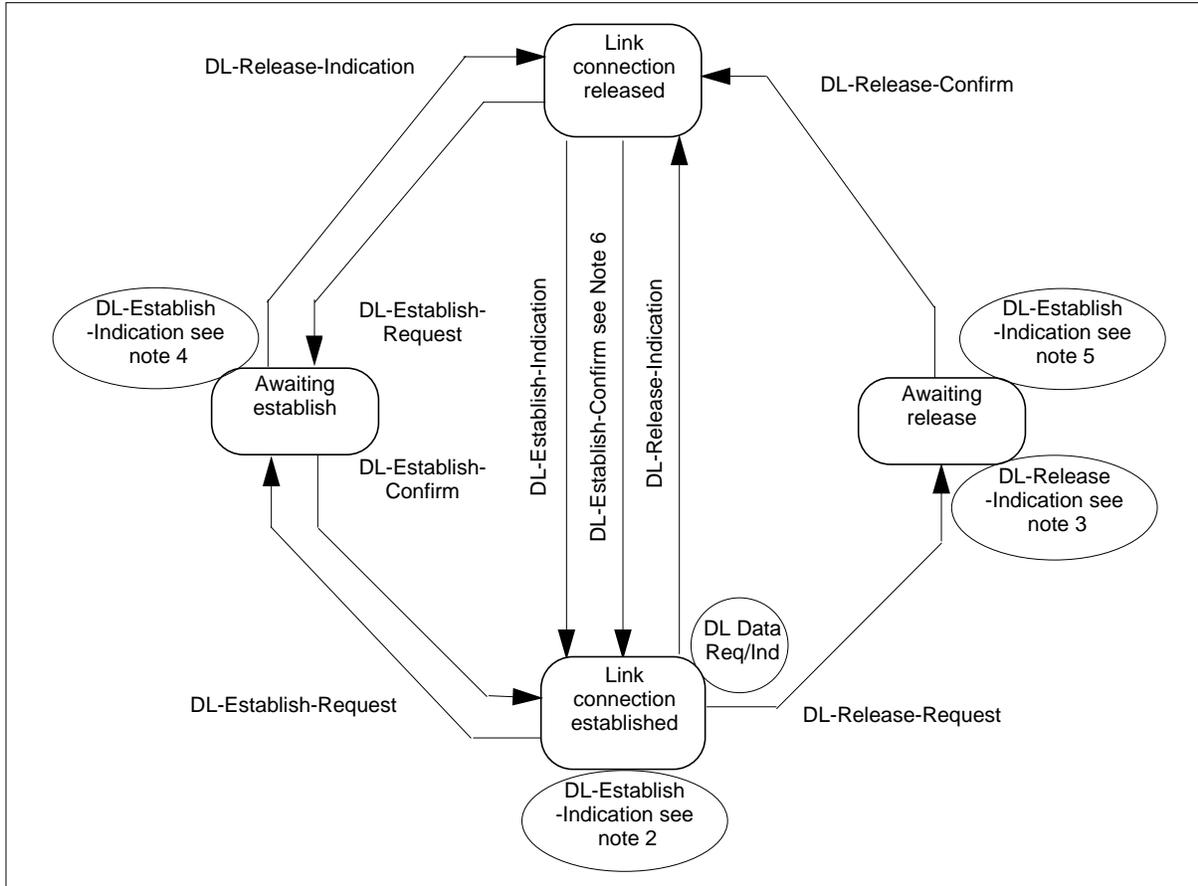
Note 1: If the data link layer entity issues a *DL-Establish-Indication* primitive, (for instance, if the data link layer is initiated or the peer system initiated re-establishment), a *DL-Release-Confirm* primitive, or a *DL-Release-Indication* primitive, all the data link service data units representing *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 call) 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 13: Definition of peer-to-peer procedures

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

13.1 Procedure for use of the P/F bit

13.1.1 Unacknowledged information transfer

Unacknowledged information transfer is not supported for PRI.

13.1.2 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 7.

Table 7 Immediate response operation of 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, FRMR, DM

13.2 Procedures for unacknowledged information transfer

Unacknowledged information transfer is not supported for PRI.

13.3 Terminal end-point 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.

13.4 Automatic negotiation of data-link-layer parameters

Automatic negotiation of data-link-layer parameters is not supported in this specification.

13.5 Procedures for establishment and release of multiple frame operation

13.5.1 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 13.7 on page 125. All frames (other than unnumbered frames) received during the establishment procedures are ignored.

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 13.9.1 on page 129. 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

  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 13.9.8 on page 130.

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 is received—by the originator of the SABME command—with the F bit set to "1", 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 is received (by the originator of the SABME command) with the F bit set to "1", the originator of the SABME command

- 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 is received (by the originator of the SABME command) with the F bit set to '"0", the originator of the SABME command ignores the response.

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

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 N) 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 N is set using the retransmission counter, N200. This counter is defined in section 13.9.2 on page 130.

13.5.2 Information transfer
 I-frames and supervisory frames are transmitted and received (according to the procedures described in section 13.6 on page 117) if

- UA is transmitted in response to a received SABME command

- UA response is received in response to a transmitted SABME command

If an 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 13.7 on page 125.

13.5.3 Termination of multiple frame operation
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 queue, are discarded.

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

- discards all I queues

- AND, delivers a *DL-Release-Confirm* primitive to Layer 3, if a *DL-Release-Request* primitive is outstanding

- OR delivers a *DL-Release-Indication* primitive to Layer 3

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, N200 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 using the *DL-Release-Confirm* primitive. The conditions relating to the TEI-assigned state are defined in section 13.5.4 on page 116.

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, N200 by one

This is procedure is repeated N times. The value of N is set using the retransmission counter, N200. This counter is defined in section 13.9.2 on page 130.

If the data-link-layer entity does not receive the correct response after N attempts to recover, the data-link-layer entity indicates this to the management entity using the *MDL-Error-Indication* primitive. The data-link-layer entity enters the TEI-assigned state, and notifies Layer 3 using the *DL-Release-Confirm* primitive.

13.5.4 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 13.5.1 on page 112.

- 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 13.5.1 on page 112, 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.

13.5.5 Collision of unnumbered commands and responses
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.

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.

13.5.6 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 a SABME or DISC command with the P bit set to "1".

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

13.6 Procedures for information transfer in multiple frame operation

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

13.6.1 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 13.6.7 on page 124 are carried out.

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 13.6.4 on page 120 and section 13.6.7 on page 124.

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

> *Note 1:* The term own- or peer-receiver busy refers to the peer-to-peer flow control state in the data-link-layer entities.

> *Note 2:* Any *DL-Data-Request* primitives received while in the timer recovery condition are queued.

13.6.2 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 done depending on the state of the P bit

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").

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 13.6.6 on page 124.

13.6.3 Sending and receiving acknowledgments
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 $V(R)$.

Receiving acknowledgment
On receipt of a valid I-frame or supervisory frame (RR, RNR, or REJ)—even in an 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 the acknowledgment 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, acknowledgment timer, T200 is not reset.

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

If the acknowledgment 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 acknowledgment timer, T200. If the timer then expires, the data-link-layer entity attempts to recover as defined in section 13.6.7 on page 124.

If the acknowledgment 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 13.6.4 on page 120.

13.6.4 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 the acknowledgment timer, T200

  — starts the timer recovery timer, T203

  — if it was a REJ command frame with the P-bit set to "1", it transmits an appropriate supervisory response frame (see section 13.6.4.1 on page 121) with the F-bit set to "1"

  — transmits the corresponding I-frame as soon as possible, as defined in section 13.6.1 on page 117 taking into account the conditions 1 through 3 in section 13.6.4.2 on page 121

  — notifies the management entity that a protocol violation has occurred

    Use 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 the acknowledgment timer, T200

  — starts timer recovery timer (T203)

  — enters the multiple-frame-established state

  — transmits the corresponding I-frame as soon as possible, as defined in section 13.6.1 on page 117 taking into account the conditions 1 through 3 section 13.6.4.2 on page 121

- 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"

The definitions of the appropriate supervisory response frame are given in section 13.6.4.1 on page 121.

13.6.4.1 Supervisory responses

The appropriate supervisory response frames are the following:

- 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.

13.6.4.2 Conditions for I-frames transmission

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

1. 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.

2. If the data-link-layer entity is transmitting an SABME command, a DISC command, a UA response, or a DM response when it receives the REJ frame, it ignores the request for retransmission.

3. 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.

13.6.5 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 the acknowledgment 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 counter, N200

- OR, if it is already in a timer recovery condition, adds one to its retransmission counter, N200

The data-link-layer entity then

- if the value of the retransmission counter, N200 is less than its trip value:

  — transmits an appropriate supervisory command (with a P bit set to "1")

    See section 13.6.4.1 on page 121 for a definition of the appropriate supervisory frame.

  — restarts the acknowledgment timer, T200

- If the value of the retransmission counter, N200 is equal to its trip value, the data-link-layer entity

— initiates a re-establishment procedure as described in section 13.7 on page 125.

— 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 section 13.6.4.1 on page 121 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 the acknowledgment 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 the acknowledgment 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 section 13.6.4.1 on page 121 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 the acknowledgment 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 section 13.6.4.1 on page 121 for a definition of the appropriate supervisory frame.

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

13.6.6 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.

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

13.6.7 Waiting acknowledgment

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

If the acknowledgment 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 counter, N200

- if it *is* in the timer recovery condition, adds one to its retransmission counter, N200

The data-link-layer entity then

- if the value of the retransmission counter, N200, is less than its trip value

  — restarts timer T200 and either one of the following

    – transmits an appropriate supervisory command (with the P bit set to "1") (see section 13.6.4.1 on page 121 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 counter, N200, is equal to its trip value

  — initiates a re-establishment procedure as defined in section 13.7 on page 125

  — 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 $N(R)$.

The acknowledgment 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.

The acknowledgment timer, T200 is reset and restarted if the received supervisory response is an RNR response. This allows the enquiry process—described in section 13.6.5 on page 121—to proceed.

13.7 Re-establishment of multiple frame operation
13.7.1 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, an SABME command is received

- a *DL-Establish-Request* primitive is received from Layer 3

- while in the multiple-frame mode of operation, the retransmission counter, N200 must have reached its limit and the acknowledgment timer, T200 must have timed out

- 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") (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

13.7.2 Procedures

In all re-establishment situations, the data-link-layer entity follows the procedures defined in section 13.5.1 on page 112. Any locally generated condition that causes re-establishment procedures to be started, starts the re-establishment procedure by transmitting a SABME command.

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)], issue a *DL-Establish-Indication* primitive to Layer 3, and discard 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.

13.8 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 paragraphs.

13.8.1 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

Send sequence number N(S) value ≠ Receive state variable V(R) at the receiver.

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 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 an SABME or DISC command is received.

13.8.2 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:

$$V(A) \leq N(R) \leq V(S)$$

That is, Acknowledge state variable $\leq$ Receive sequence number $\leq$ Send state variable

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 13.7 on page 125.

13.8.3 Acknowledgment timer, T200 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 the acknowledgment timer, T200, takes the recovery action defined in section 13.6.7 on page 124 to determine which I-frame(s) must be re-transmitted.

13.8.4 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 Chapter 10: "Frame structure", section 10.9, "Invalid frames", on page 87 and Chapter 11: "Elements of procedures", section 11.6, "Frame types", on page 97.

13.8.5 Frame rejection condition

A frame rejection condition occurs when undefined commands or response frames are received. See section 11.6.11 on page 99 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 13.7 on page 125

13.8.6 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 13.7 on page 125

13.8.7 Unsolicited response frames

The action taken on the receipt of an unsolicited response frame is defined in Table 8.

13.8.8 Multiple assignment of a TEI value

Not supported in this release.

13.9 List of system parameters

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

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

Table 8 Action on receipt of an unsolicited response frame

Unsolicited response frame	TEI assigned	Awaiting estab-lishment	Awaiting release	Multiple frames 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					

13.9.1 Acknowledgment timer (T200)

The acknowledgment timer, T200 is used to verify that an acknowledgment for any frame is received within a set time. If the acknowledgment is not received before the timer times out, the frame is resent. This is repeated until the retransmission counter, N200 indicates that the frame is not being received.

This timer has a default value of 1 second. This assumes that there is no satellite link in the transmission path.

Note: The proper operation of the procedure requires that the time-out for the acknowledgment timer be set greater than the maximum time between

transmission of command frames and the reception of their corresponding response or acknowledgment frames.

13.9.2 Retransmission counter (N200)

The maximum number of retransmissions of a frame is a system parameter. It is set using the retransmission counter, N200. The default trip value of N200 is 3.

13.9.3 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.

13.9.4 Maximum number of transmissions of an identity request message (N202)

Not supported for PRI.

13.9.5 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 is in the range 1 through 127.

The default value is 7.

13.9.6 TEI identity check timer, T201

Not supported for PRI.

13.9.7 Timer, T202

Not supported for PRI.

13.9.8 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 up without frames being exchanged. The default value of timer T203 is 10 seconds.

13.10 Data-link-layer monitor function

13.10.1 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.

13.10.2 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 a 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 a P bit set to "1") is transmitted.

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

13.10.3 Connection verification procedures
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 the acknowledgment 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.

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)

- 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.

Expiry of timer T203

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

- sets the retransmission counter, N200 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 14: Occurrence of MDL-Error-Indication

14.1 Introduction

The *MDL-Error-Indication* primitive is used to notify the management entity of the data link layer of almost any error situation. The error situations for which this primitive is generated are shown in Table 9.

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 from the network and the user side, for the various types of error reported.

The following paragraphs provide a key to the information contained in Table 9.

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.

14.2 Preferred management actions

The preferred management actions on an error situation is to issue an error log. This suggests that the network side management entity has the preferred action of logging the event into an error counter. The length and the operation of the counter mechanisms for the error situations are implementation dependent.

In all error situations, the action to be taken by the user side is implementation dependent.This means that it is optional whether the user side has incorporated any form of error counter to log or store the reported event.

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

Table 9 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 transmission (after N200 tries) (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

Table 9 Management entity actions for MDL-Error-Indications (continued)

Error code	Error condition	Affected states *	Network management action	User management action
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 15: Layer 2 SDL diagrams

To assist in the understanding of the data link layer, this chapter provides an example of a detailed specification and description language (SDL) diagram of the point-to-point procedures.

This representation does not describe all of the possible actions of the data-link-layer entity. A non-partitioned representation is used to minimize complexity. This representation does not show all possible interactions and shows just one of many sequences of events.

The representation is a peer-to-peer model of the point-to-point procedures of the data-link layer and is applicable to the data-link-layer entities at both the user and network sides for all ranges of TEI values.

15.1 Use of queues

To enable a satisfactory representation of the data-link-layer entity, conceptual queues for the I-frame transmission has been explicitly brought out. These conceptual queues are finite but unbounded and should in no way restrict the implementation of the point-to-point procedures. An additional signal has been provided to initiate the servicing of these queues.

Figure 31 shows the symbols and abbreviations used in the SDL representations, and Figure 32 through Figure 54 show the SDL states. Full descriptions of their meanings and application can be found in the CCITT Z series of recommendations.

Figure 31 SDL symbol key

State

Signal reception

Signal generation

Save a signal (until completion of a transition to a new state

Process description

Test

Procedure call

Implementation option

Procedure definition

***   To mark an event or signal required as a result of the representation approach adopted, which is local to the data link layer entity

RC   Retransmission counter

A-O   Used to represent the *MDL-Error-Indication* signals as defined in Chapter 6. Where multiple codes are shown, only one applies

Figure 32 SDL states 1

Figure 33 SDL states II

Figure 34 SDL states III

Figure 35 SDL states IV

Note:
Only possible when Layer 2 initiates
establishment
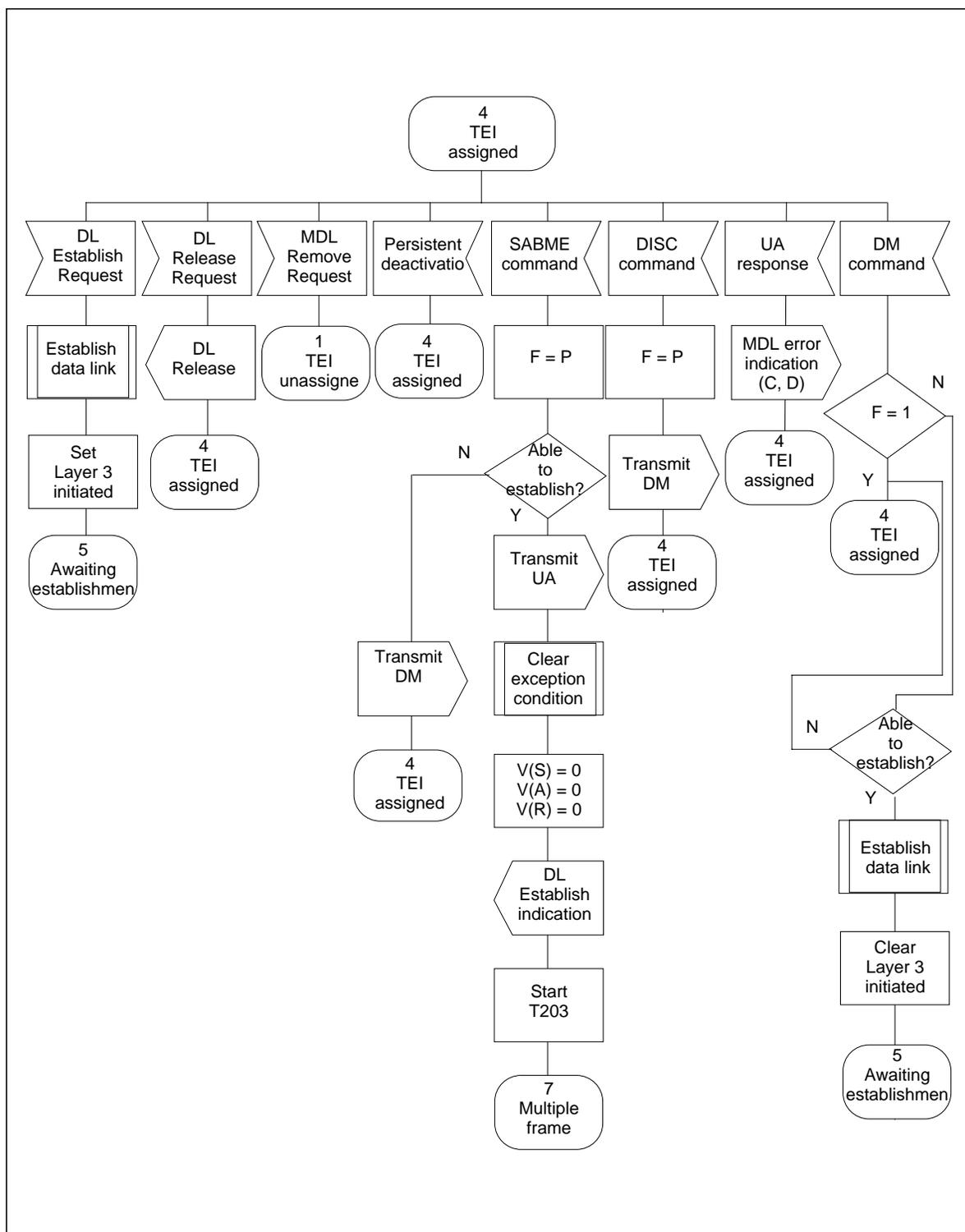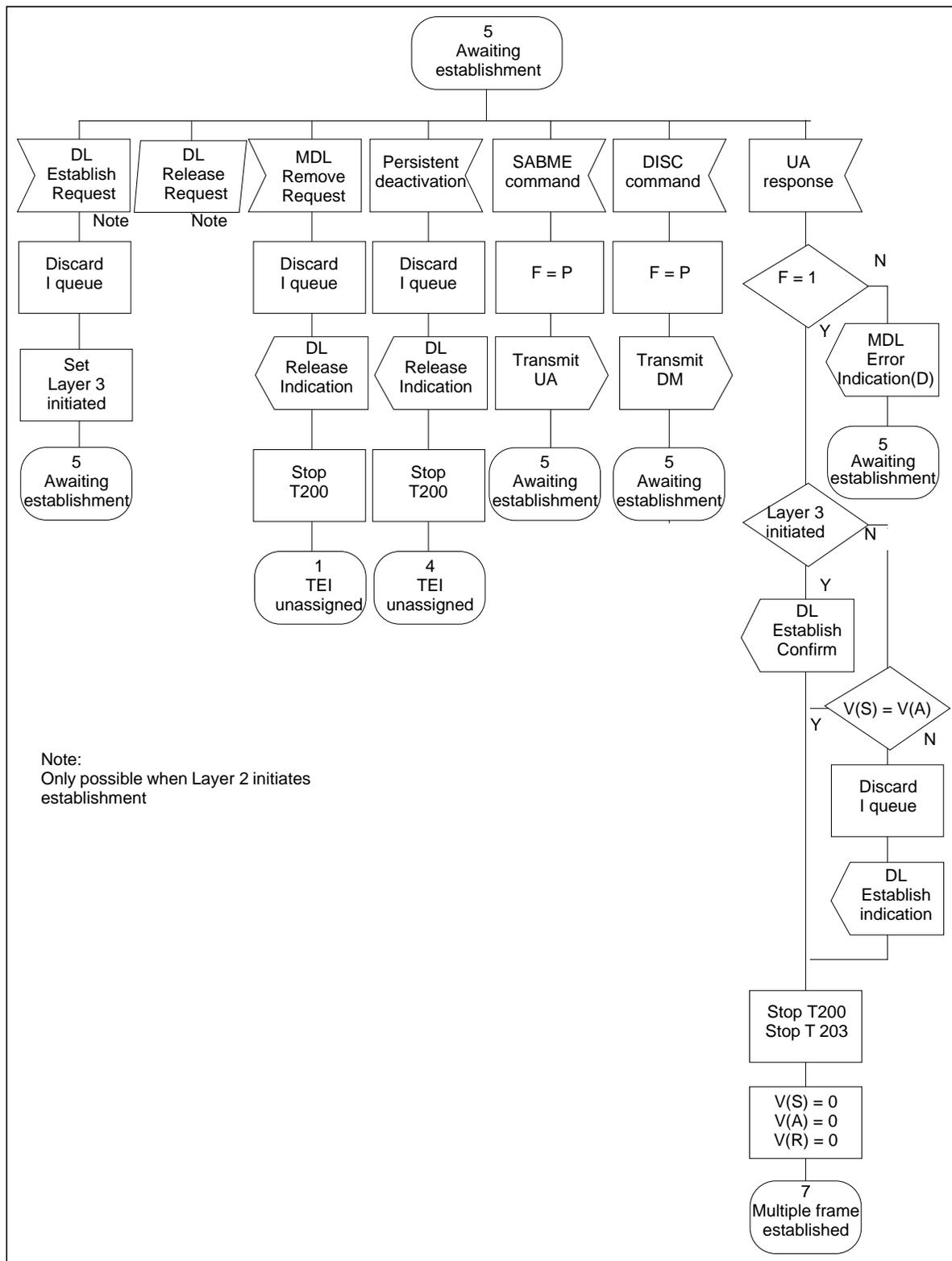
Figure 36 SDL states V
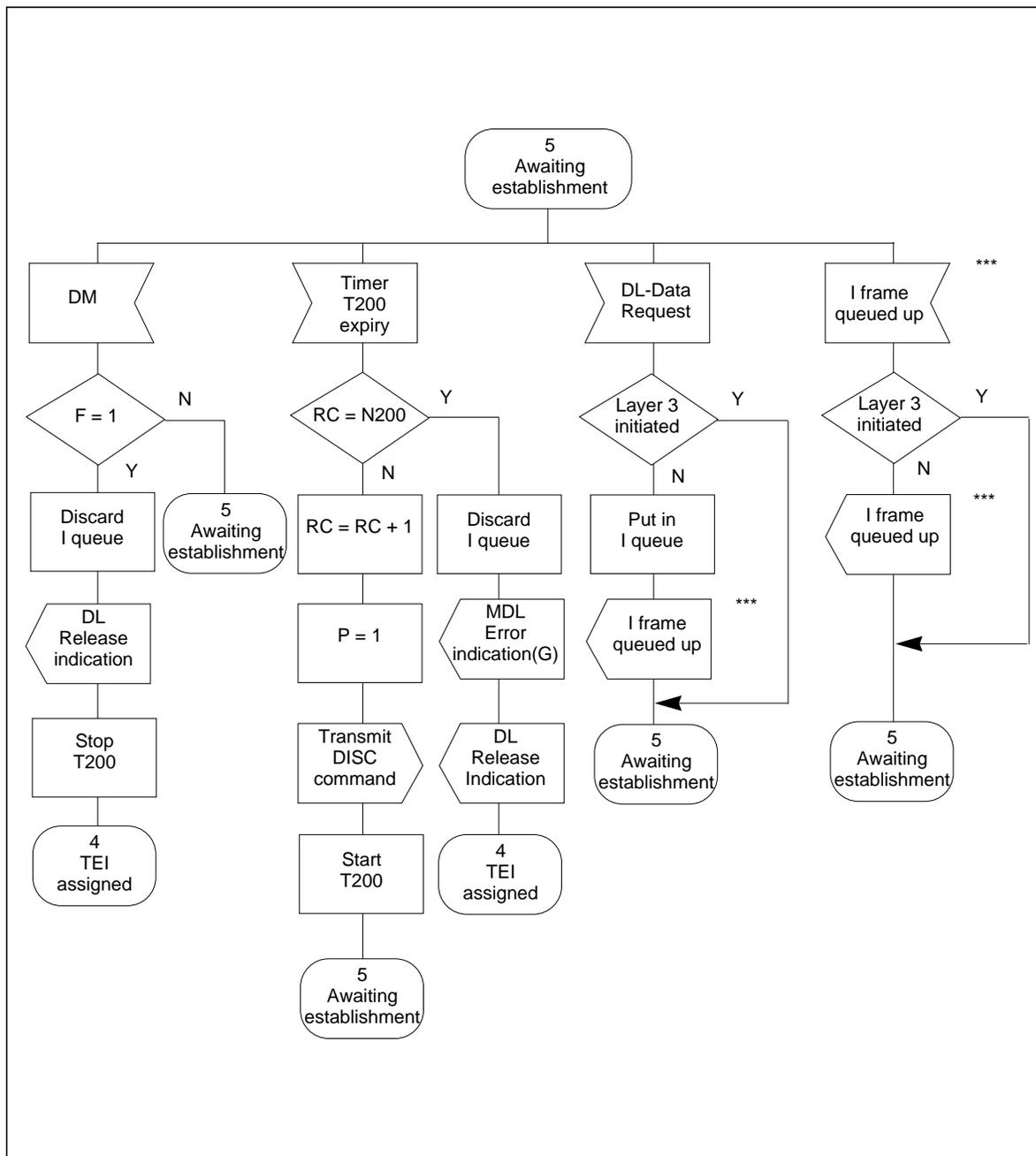
Figure 37 SDL states VI
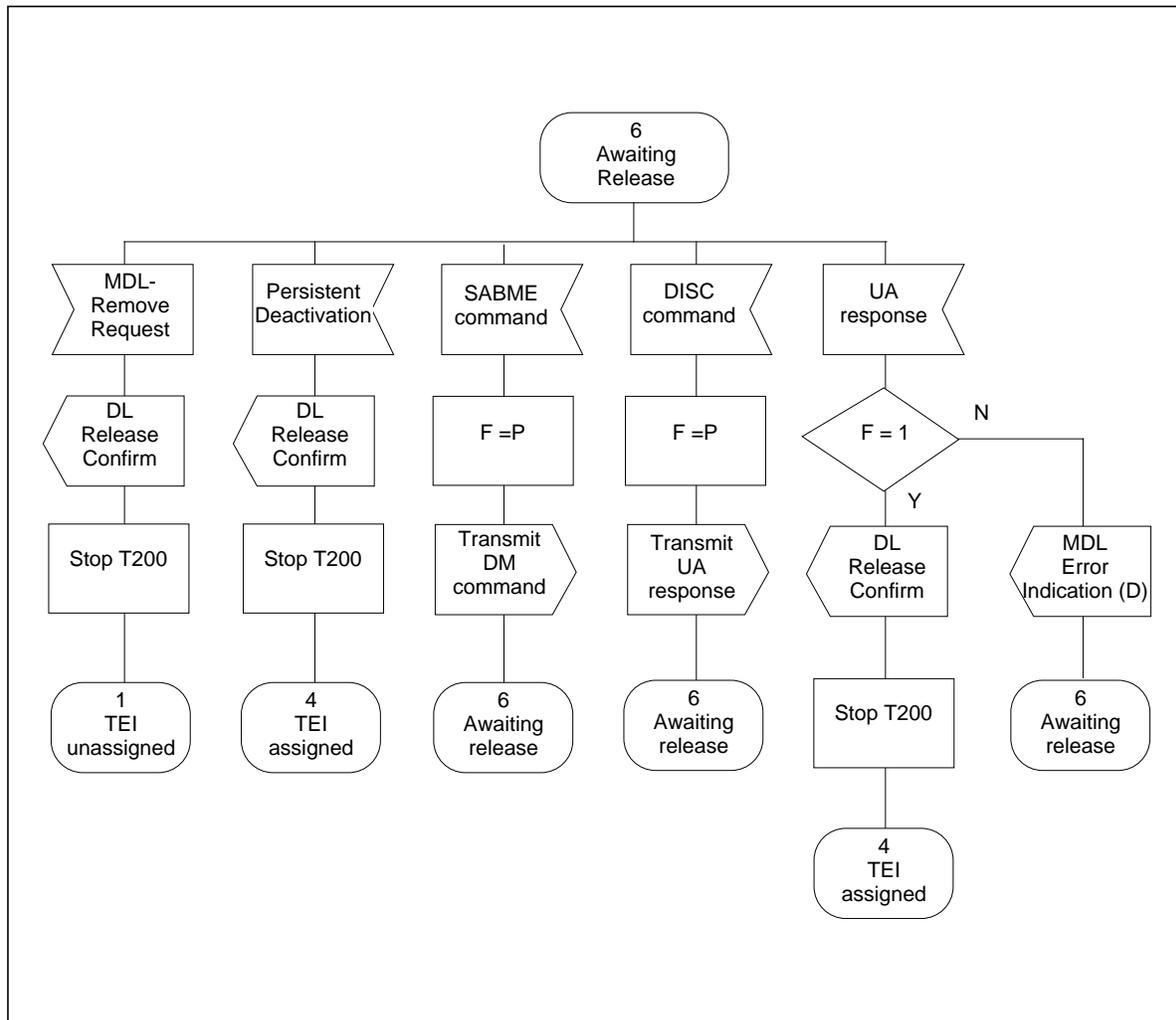
Figure 38 SDL states VII
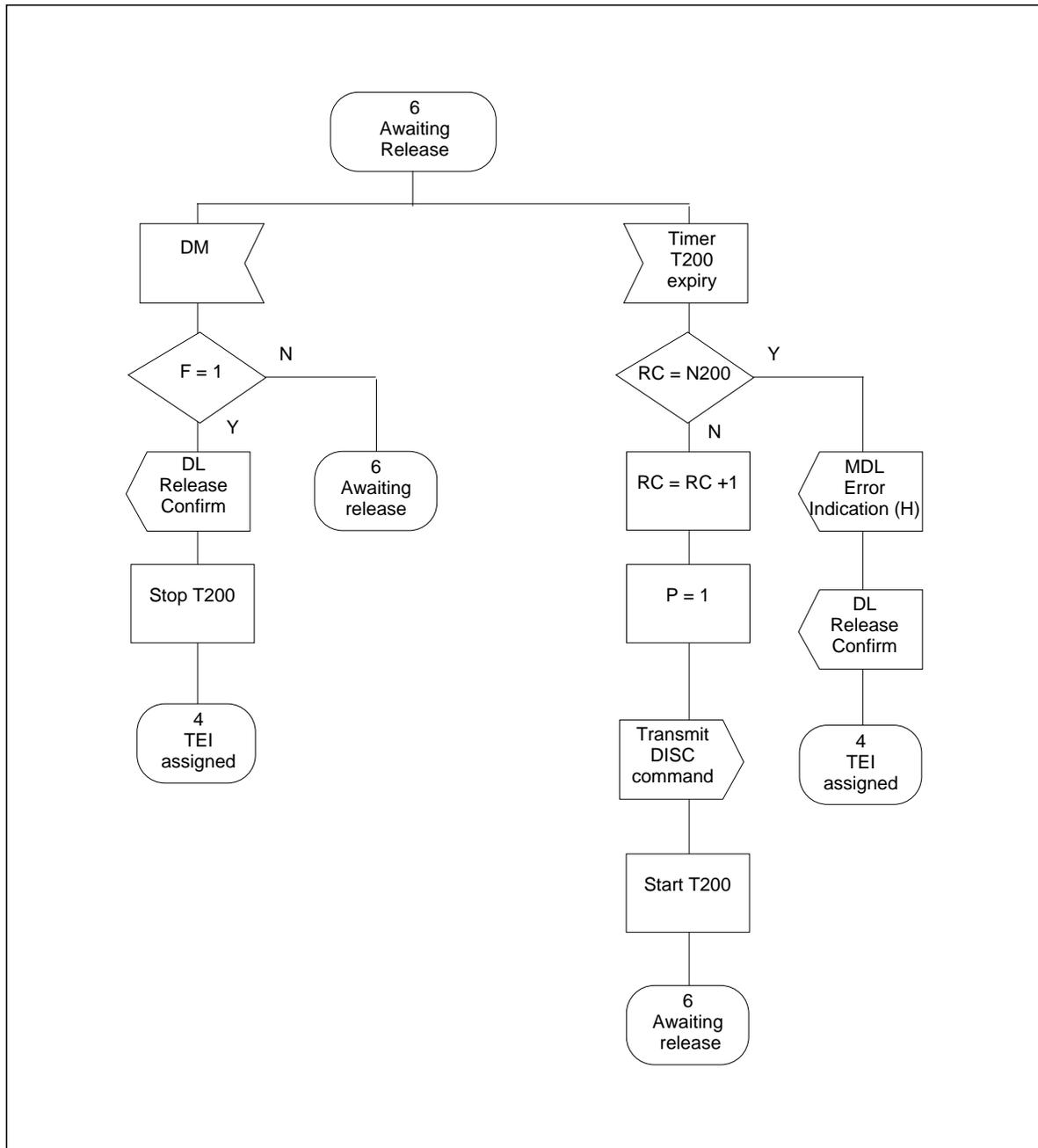
Figure 39 SDL states VIII
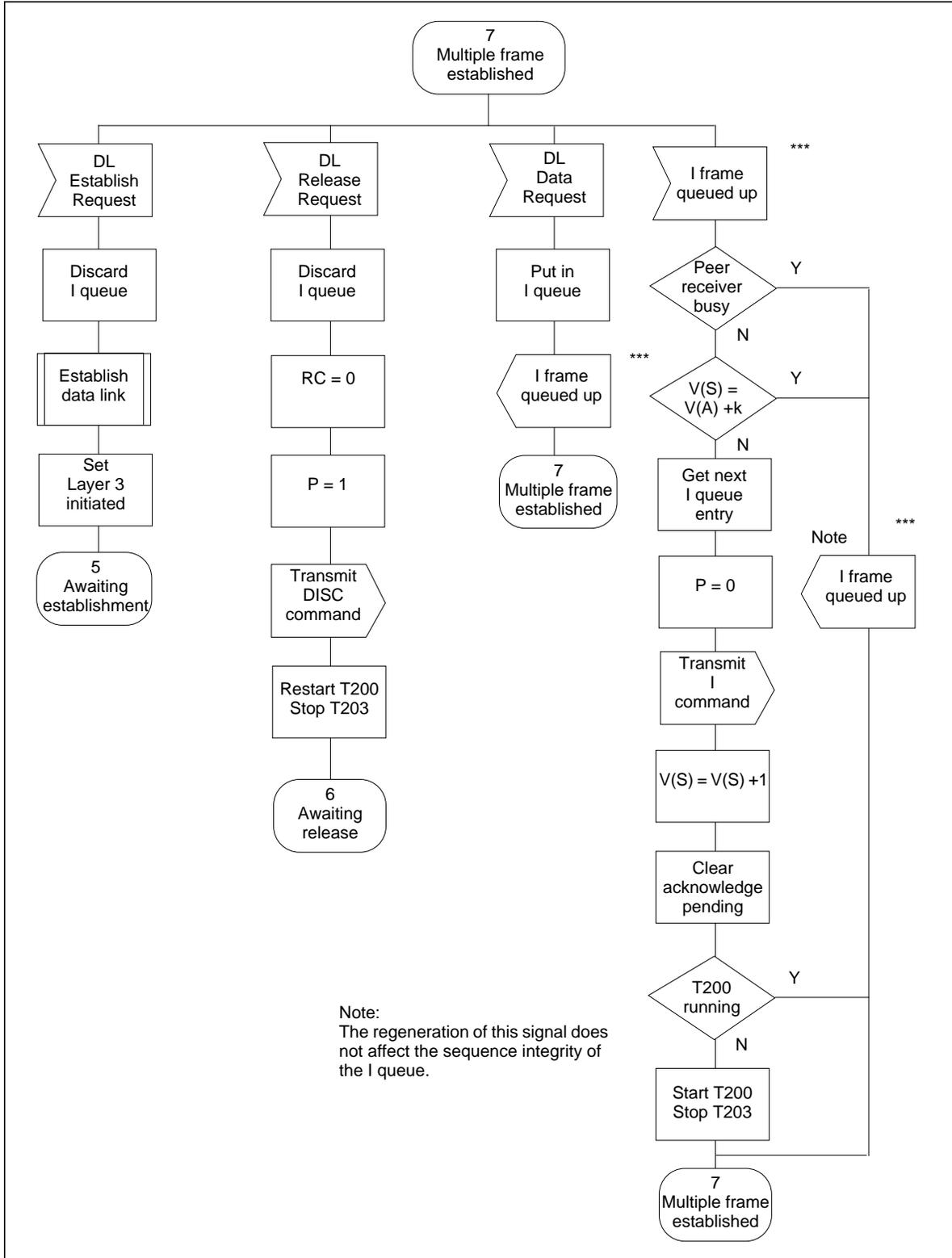
Figure 40 SDL state IX
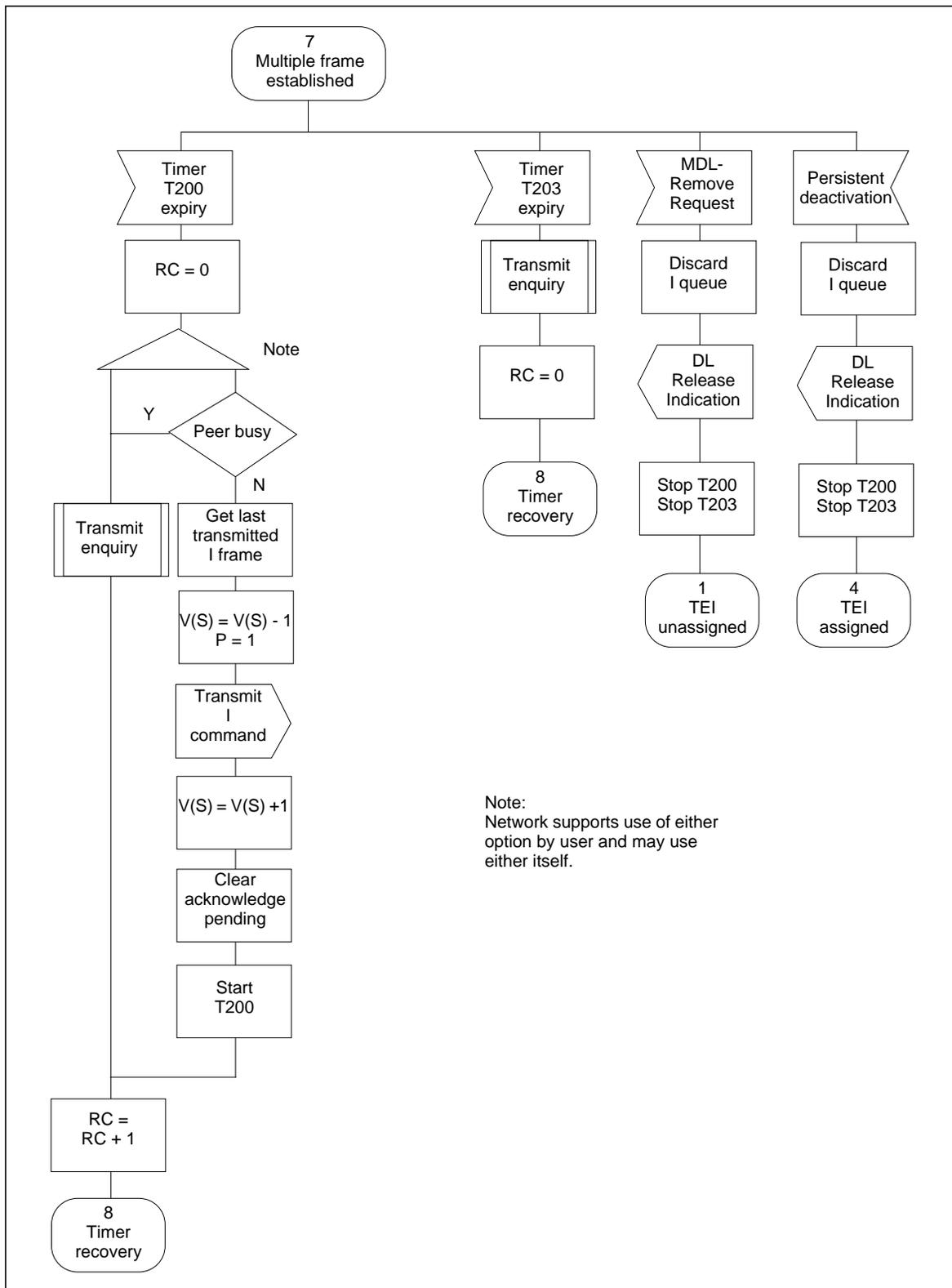
Figure 41 SDL state X
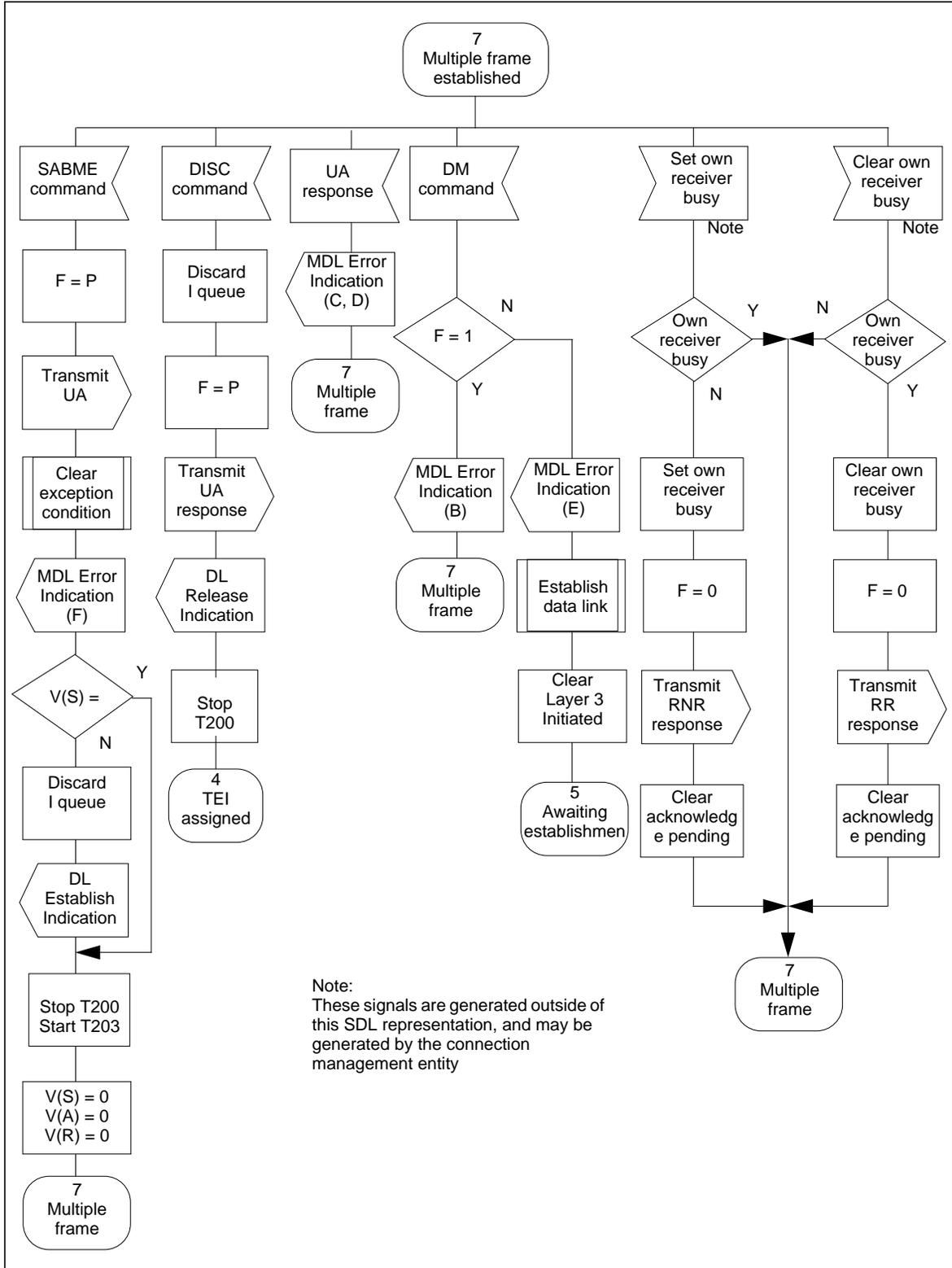
Figure 42 SDL state XI
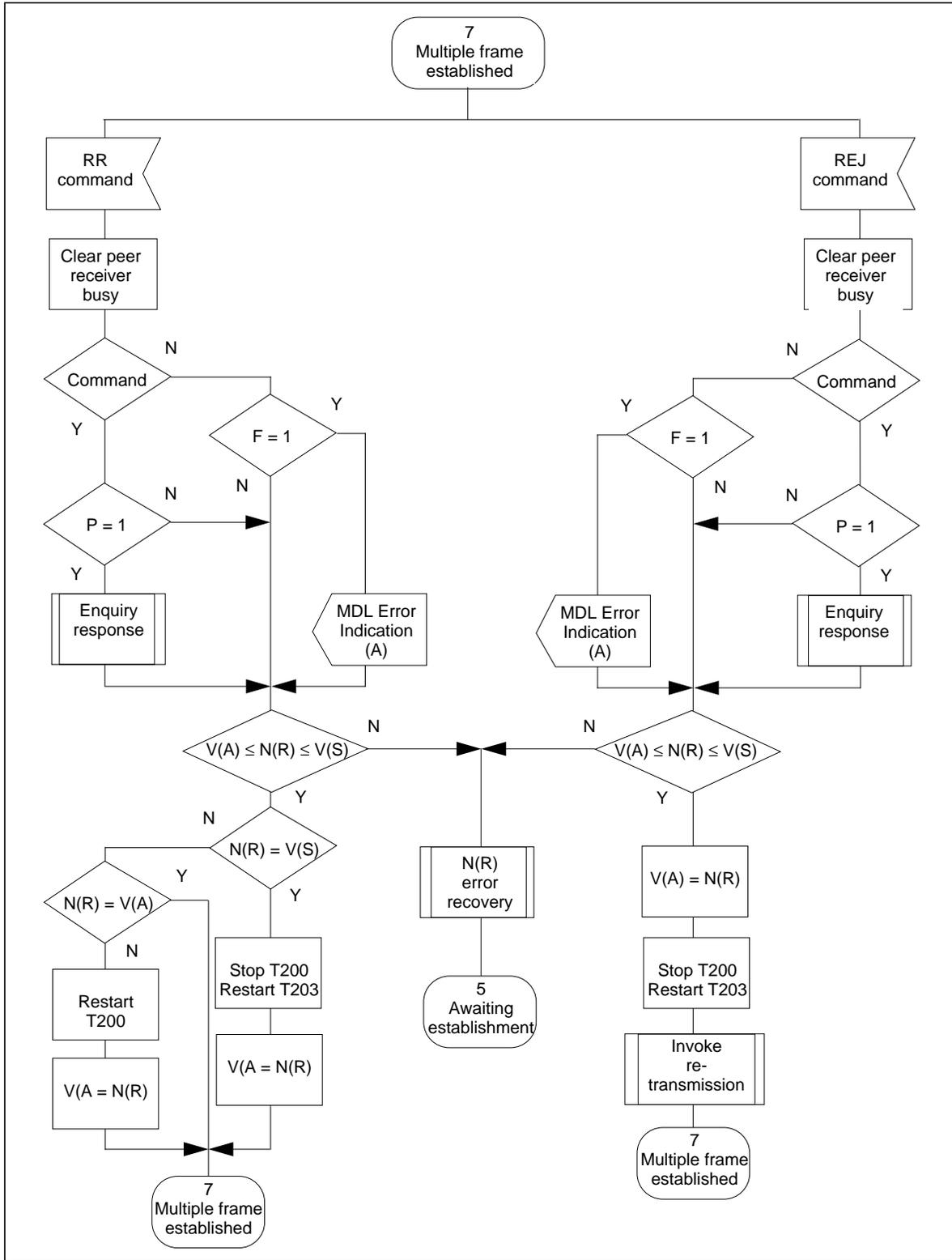
Figure 43 SDL state XII

Figure 44 SDL state XIII
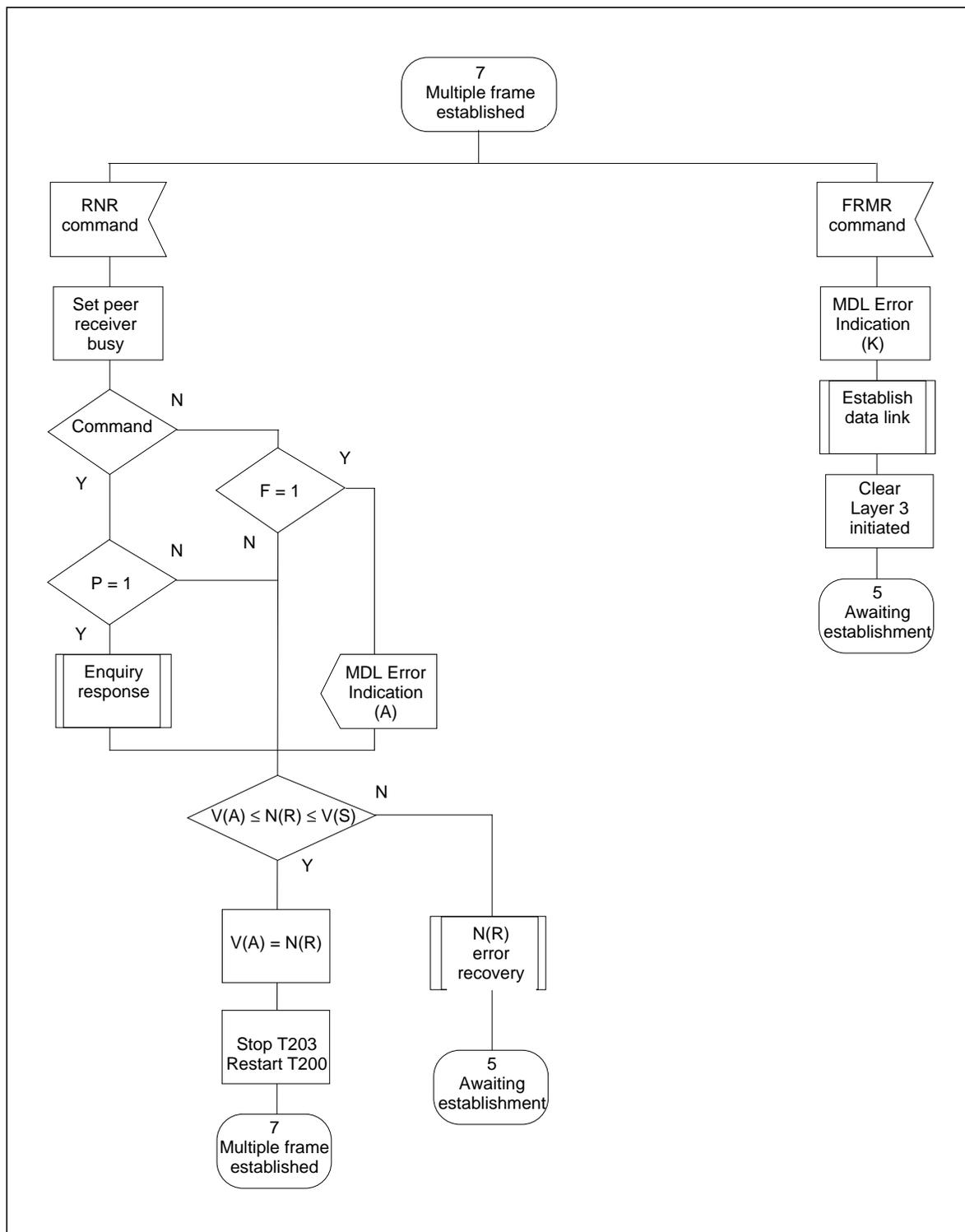
Figure 45 SDL state XIV
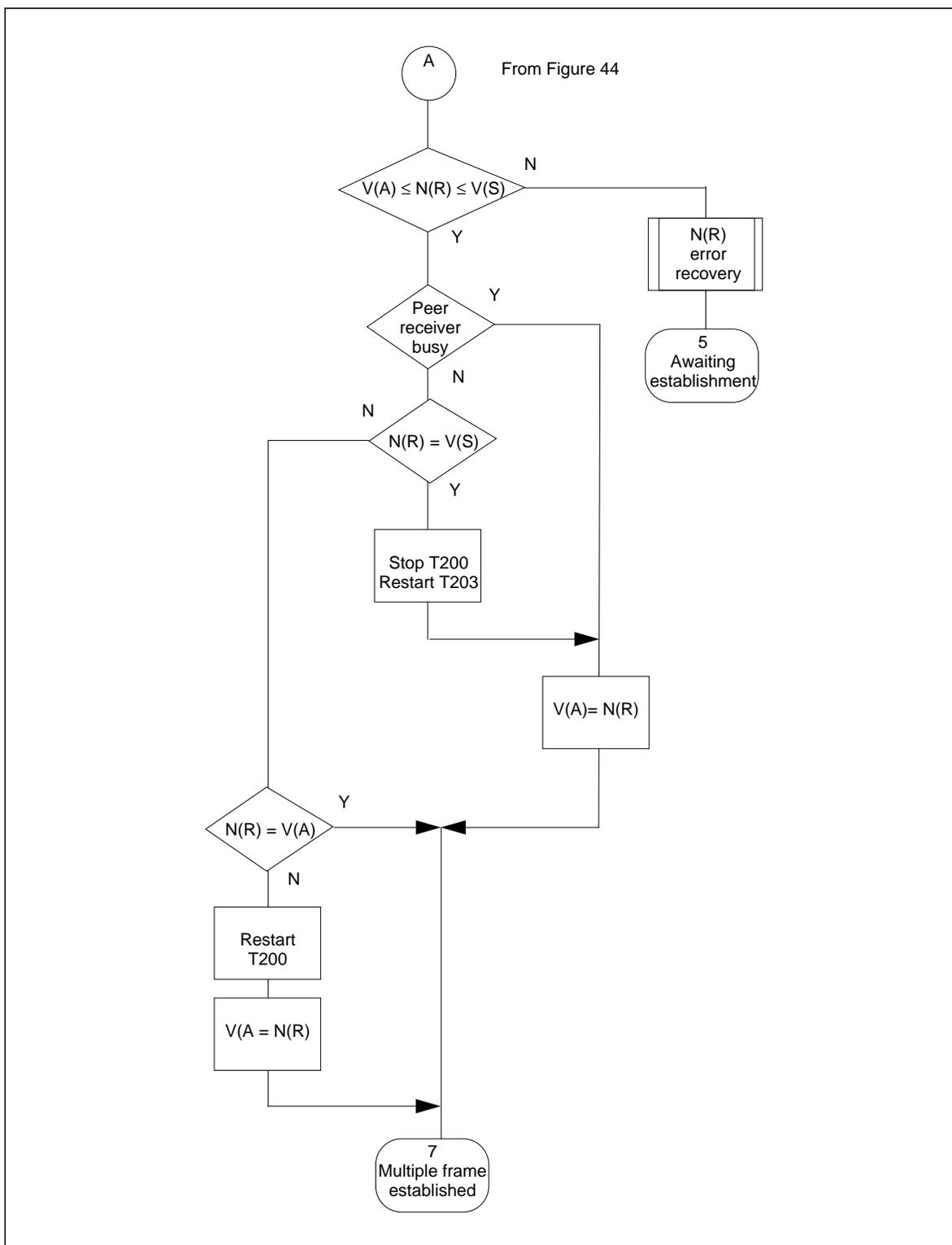
Figure 46 SDL state XV
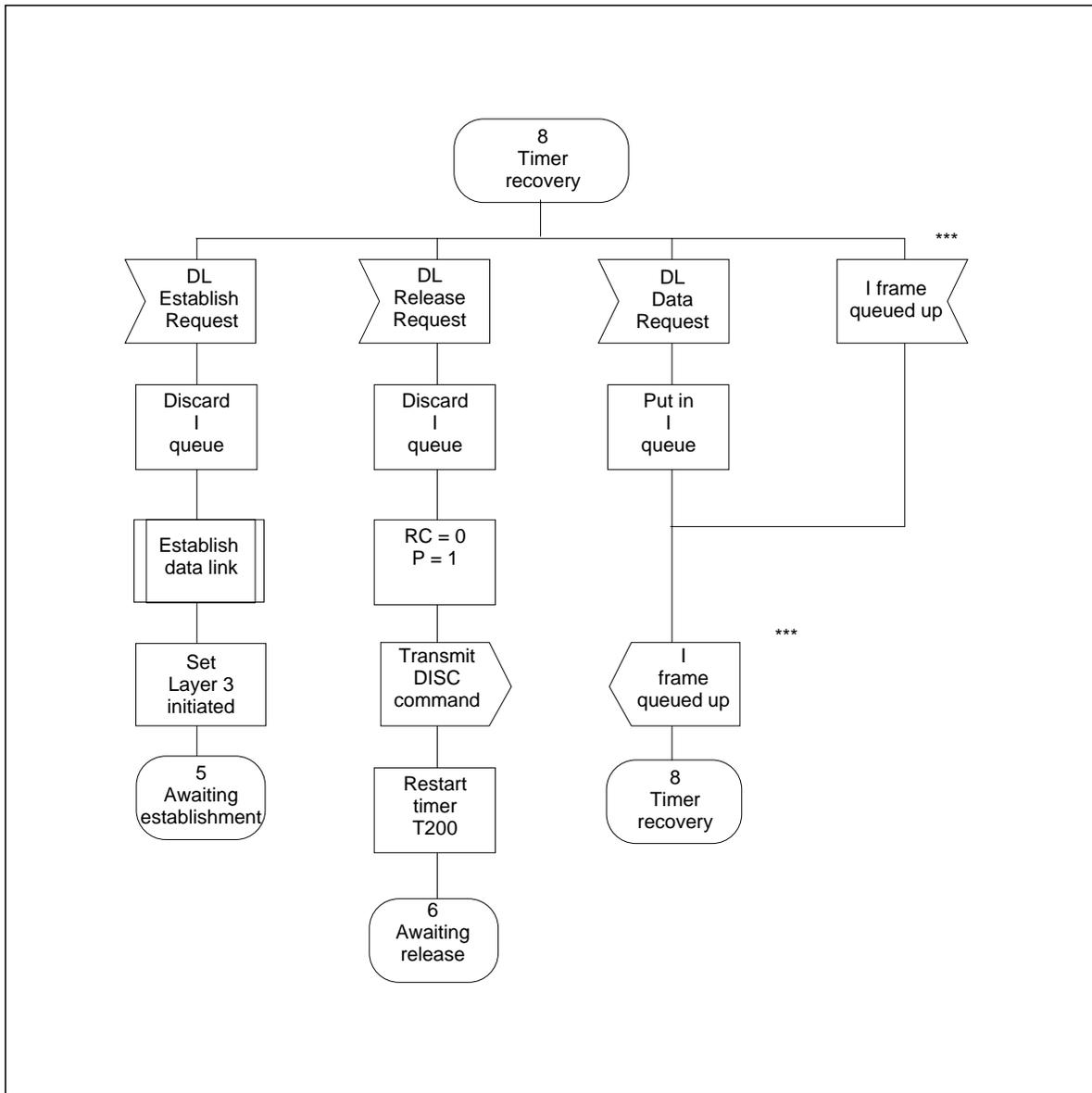
Figure 47 SDL state XVI
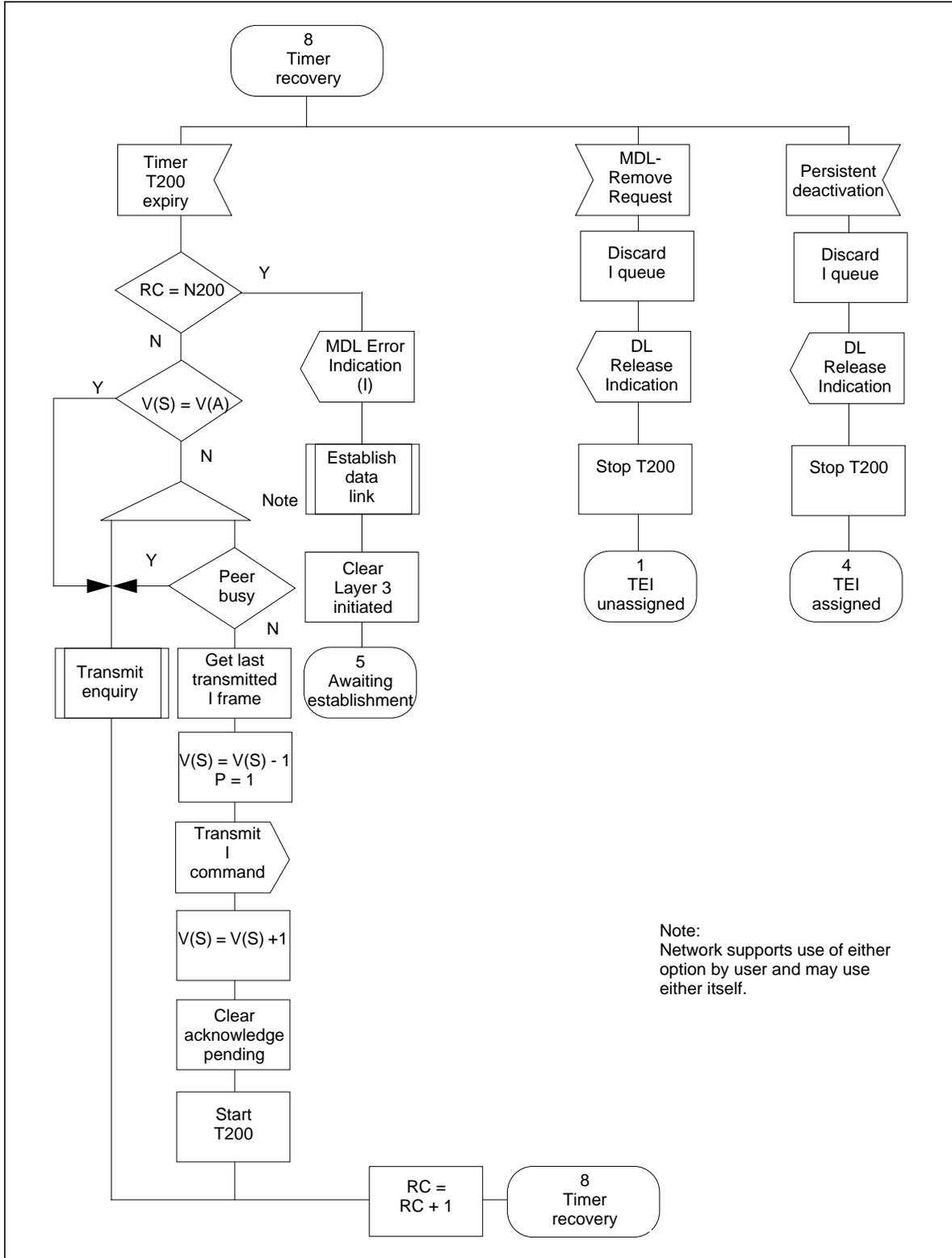
Figure 48 SDL state XVII
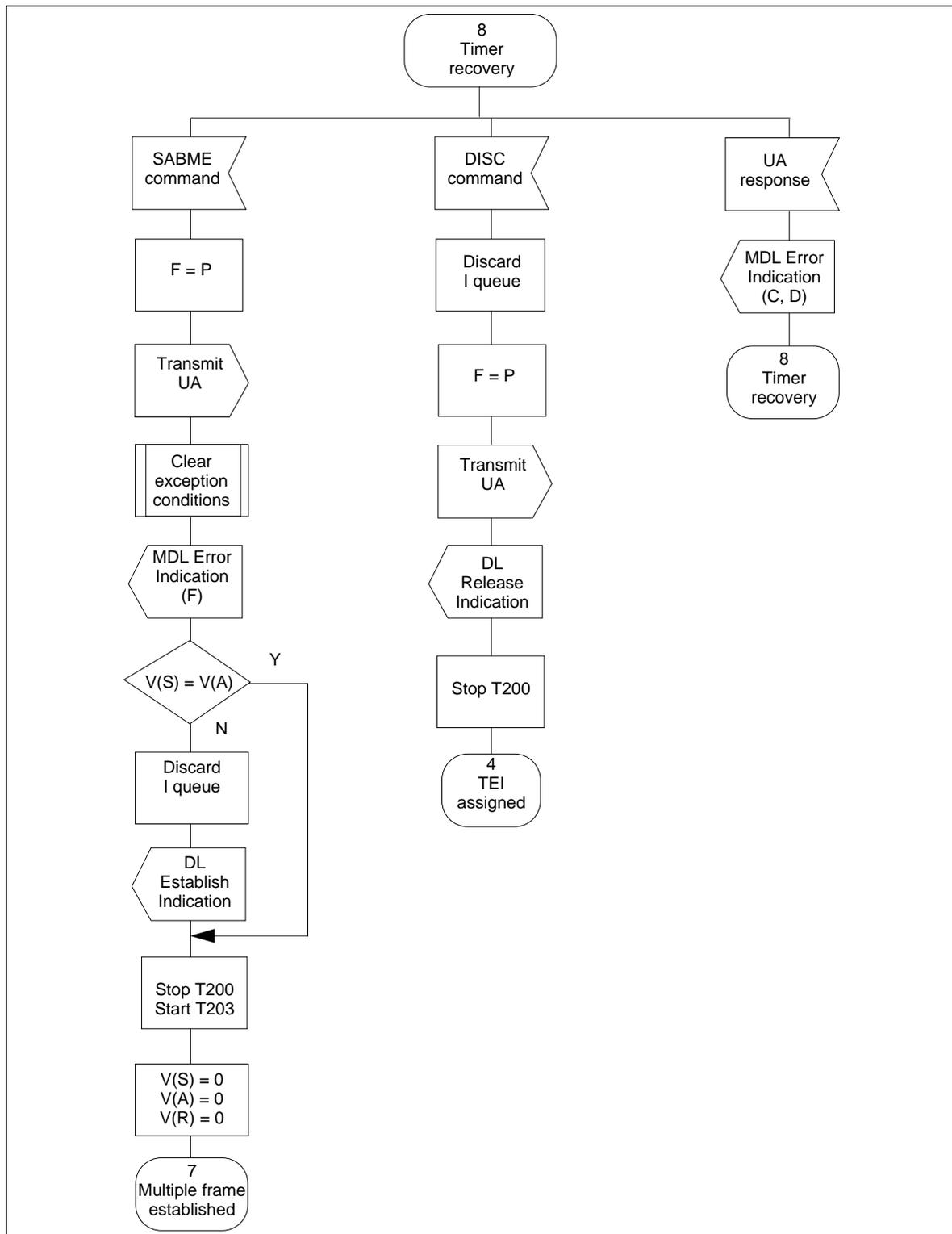
Figure 49 SDL state XVIII
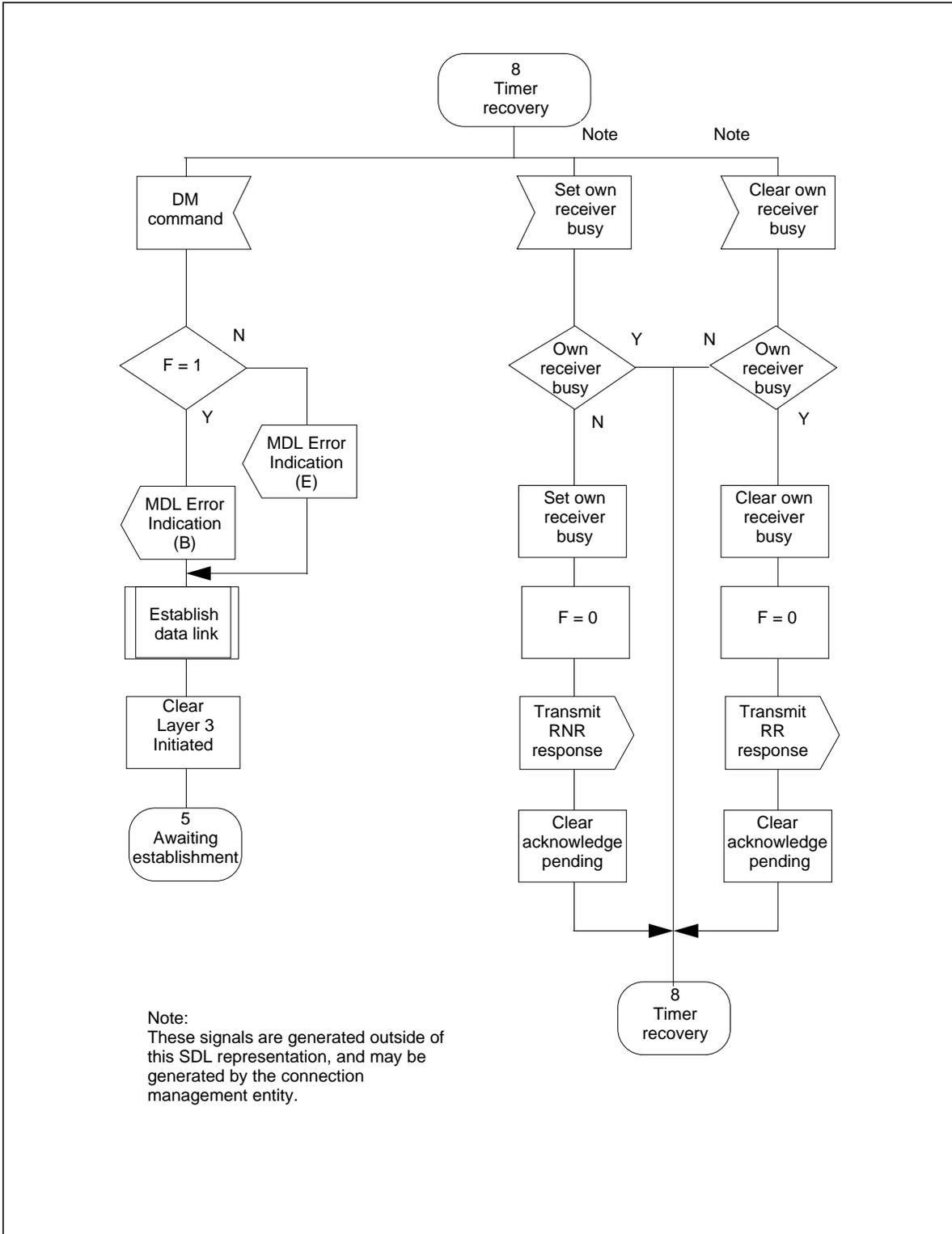
Figure 50 SDL state XIX
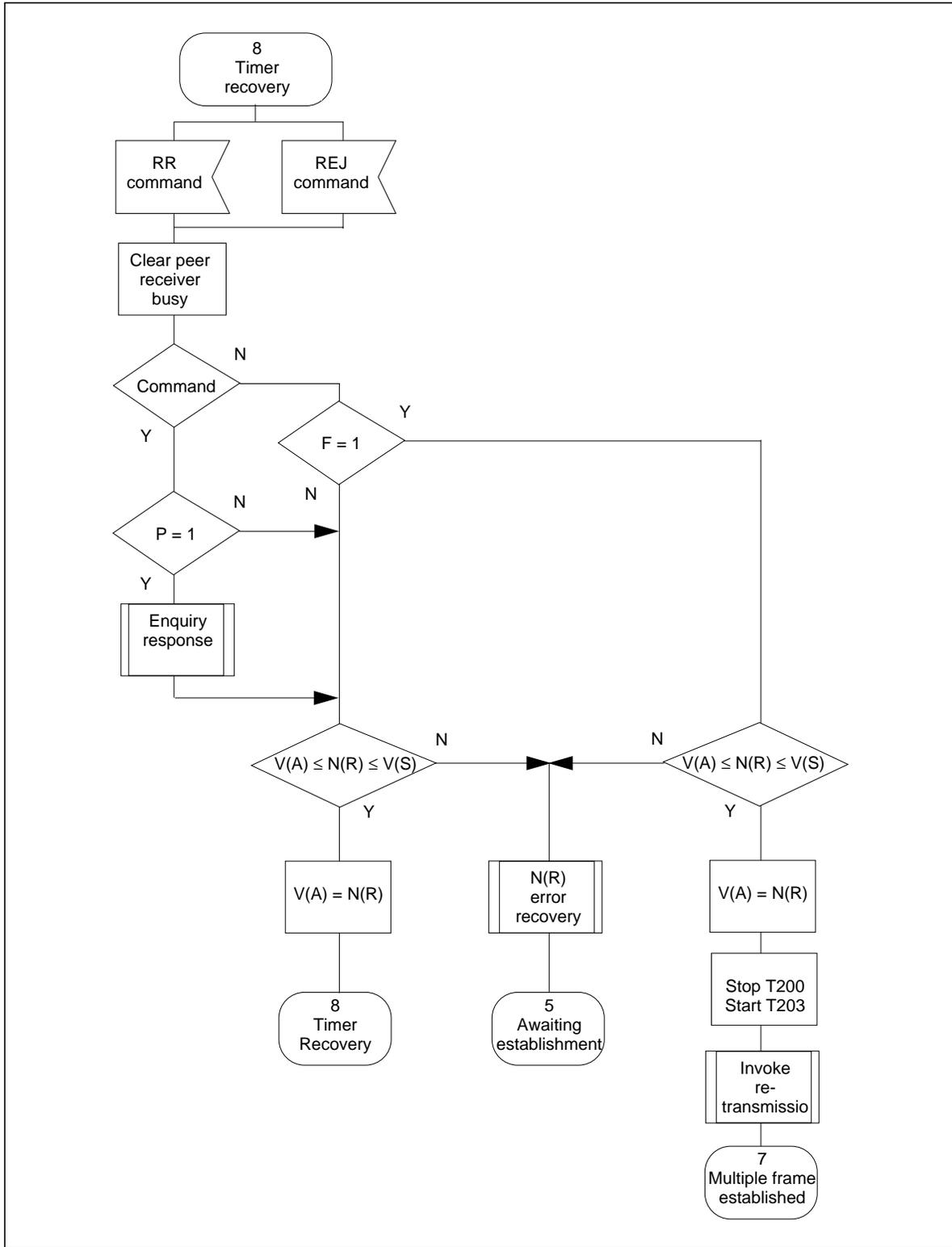
Figure 51 SDL state XX

Figure 52 SDL state XXI
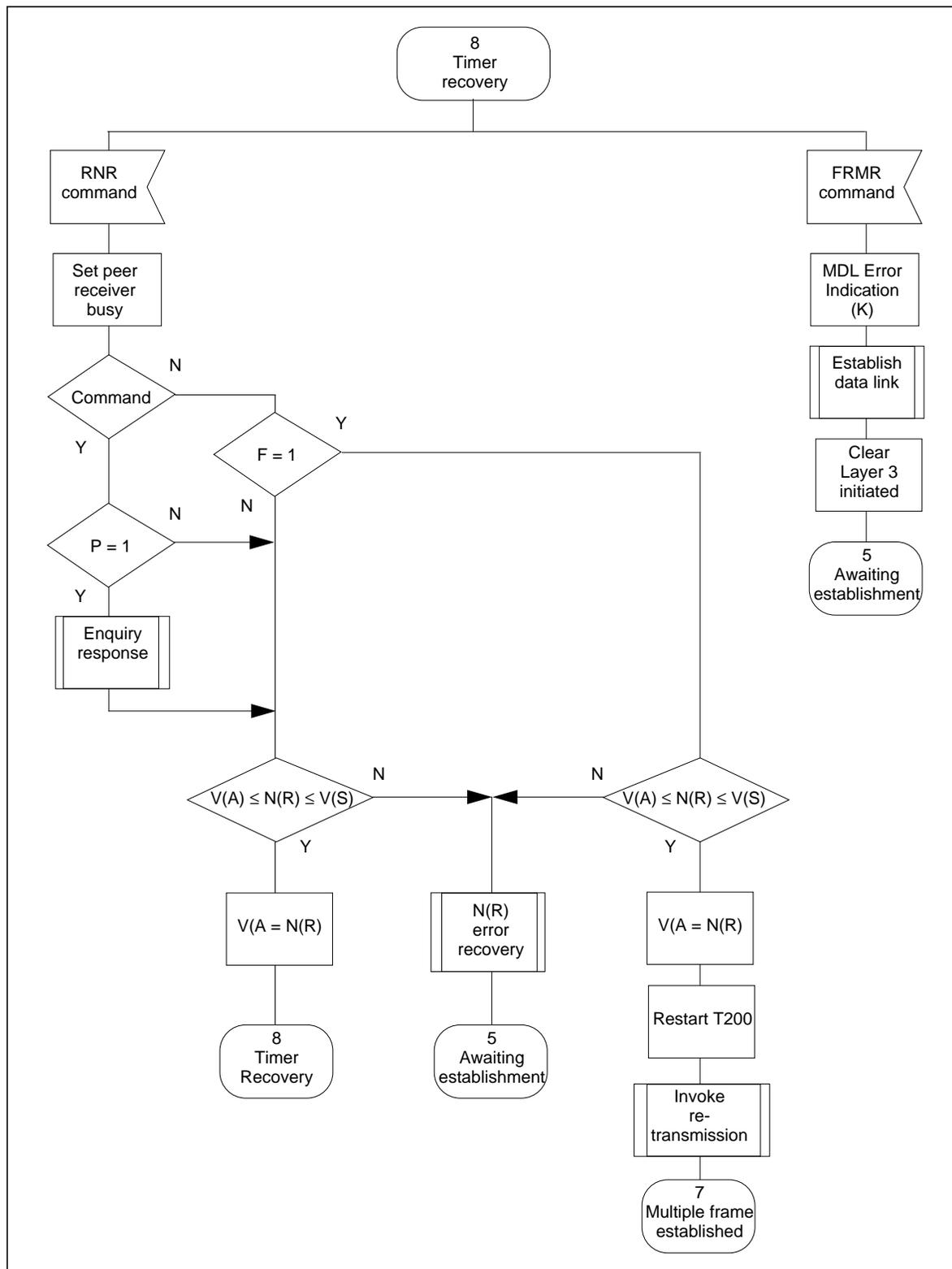
Figure 53 SDL state XXII
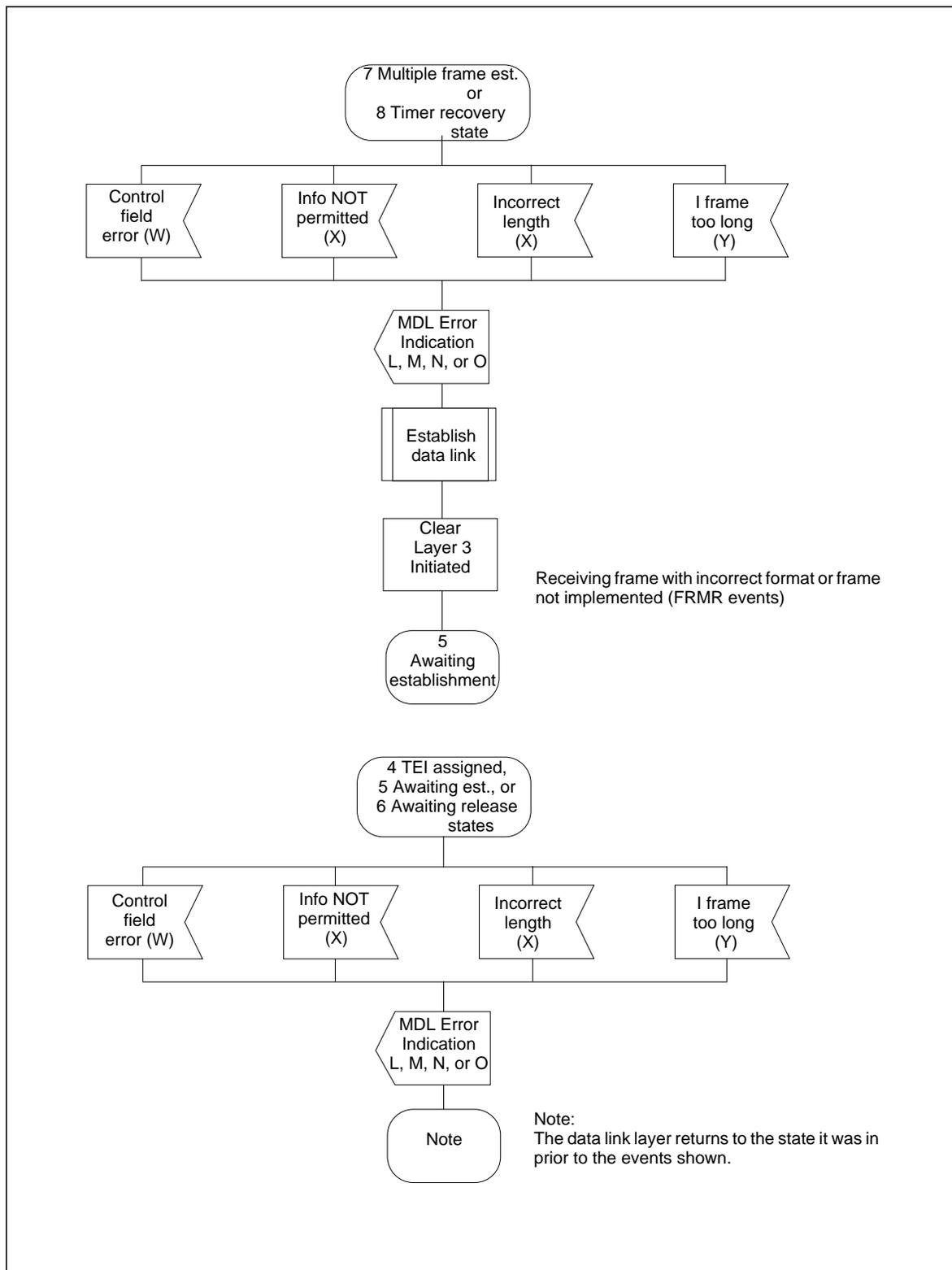
Figure 54 SDL state XXIII
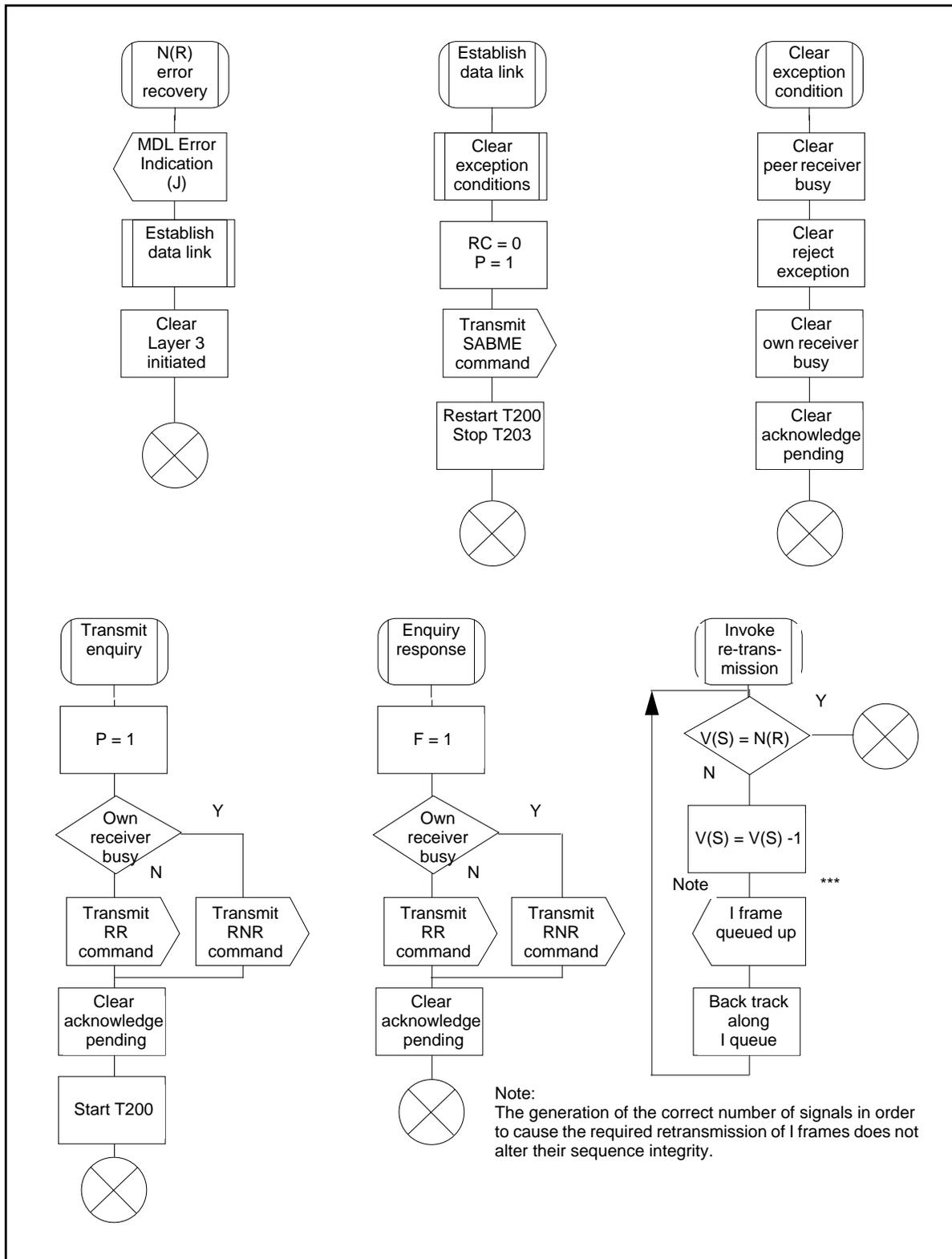
Part IV: Call control signaling—Layer 3

Chapter 16: Layer 3 introduction

16.1 Scope

This section defines the call signaling protocol for DMS-100-to-PBX applications using an Integrated Services Digital Network (ISDN) Primary Rate Interface (PRI).

The format of this section is similar to the standards to enable comparison between the standard and the implementation of this interface. Additional messages, procedures, and parameter encodings have been provided in order to satisfy the signaling requirements of the interface.

This section 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 section also describes the protocol structure on which supplementary services are based. Procedures for the operation of supplementary services are defined in Part V.

References in the text to "network side" equipment are to be understood as relating to a DMS-100 Central Office (CO). Similarly, the terms "incoming" and "outgoing" are used to describe the call as viewed by the user side of the interface.

16.2 Conformance

Products conforming to this specification support all mandatory procedures and information elements outlined in chapters 17 through 22 inclusive of this section of the specification.

It is intended that the call signaling protocol be fully symmetric to enable direct user-to-user communication.

16.3 Standards compatibility

This call control signaling specification is based on the general format and procedures found in the *CCITT Recommendation Q.931(I.451), ISDN user-*

network interface Layer 3—specification and *ANS T1.607, Layer 3 signaling specification for circuit switched bearer service* recommendations.

Chapter 17: Overview of call control

In this chapter, call states are defined for circuit switched calls in section 17.1 on page 167 and for the interface in section 17.2 on page 170.

Section 17.1 defines the basic call control states that individual calls may have. 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 20: "Call control procedures" in terms of

- The messages (defined in Chapter 18: "Message function definitions") which are transferred across the user-network interface.

- 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 Chapter 22: "Layer 3 SDL diagrams".

17.1 Circuit switched calls

This section defines the basic call control states for circuit switched calls. These states are also applicable for circuit switched data on a B-channel.

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

The states which may exist on the user side or on the network side of the user-network interface are defined in Table 10.

Table 10 Call states

State no.	State name	User side	Network side	Definition
0	Null	X	X	No call exists.
1	Call initiated	X	X	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.
2				Not used.
3	Outgoing call proceeding	X	X	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	X	X	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.
5				Not used.
6	Call present	X	X	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 received a satisfactory response.
7	Call received	X	X	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	X	X	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 10 Call states (continued)

State no.	State name	User side	Network side	Definition
9	Incoming call proceeding	X	X	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	X	X	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	X	X	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	X	X	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.
13				Not used
14				Not used
15				Not used
16				Not used
17				Not used
18				Not used
19	Release request	X	X	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

17.2 States associated with the global call reference

This paragraph 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 Chapter 20: "Call control procedures".

There is only one global call reference per interface.

The states which may exist on the user side and the network side of the user-network interface are defined in Table 11.

Table 11 Call states associated with global call reference

State no.	State name	User side	Network side	Definition
0	Null	X	X	No transaction exists.
1	Restart request	X	X	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 received an acknowledgement response from the user.
2	Restart	X	X	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 been received from all locally active call references.

Chapter 18: Message function definitions

This chapter provides an overview of the message structure, providing the function 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 55.

Figure 55 Message significance within the network
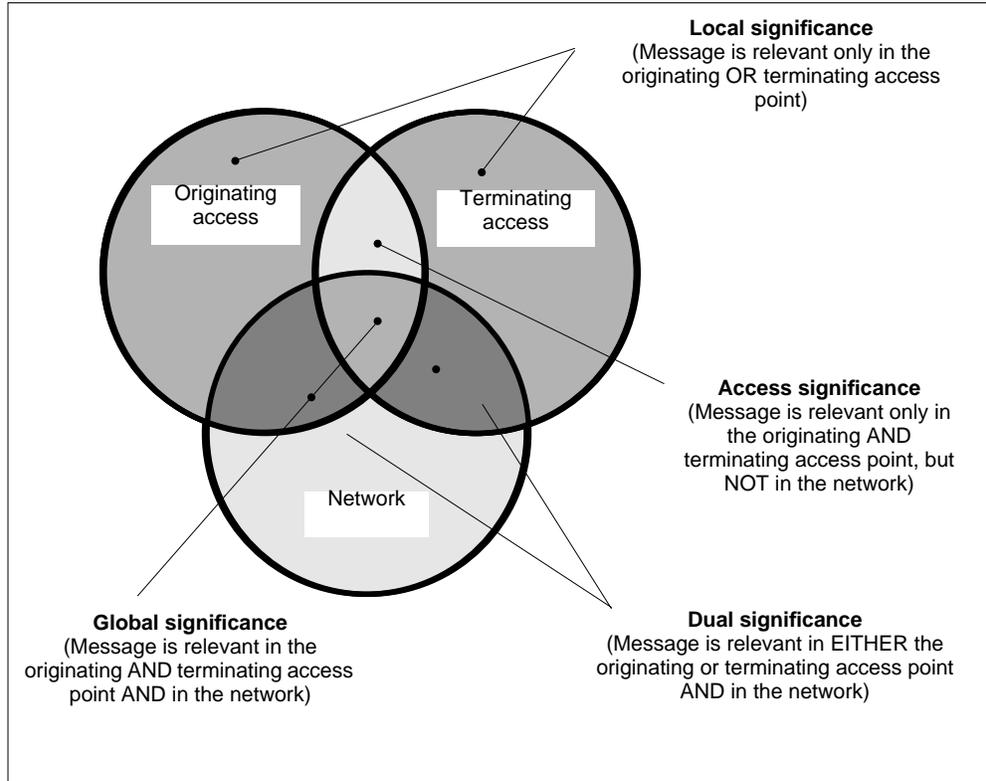
- A table listing the information elements in the order of their appearance in the message. The relative order of information elements is the same for all message types). For each information element the table indicates

    — the direction in which the message 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. Note that the *Channel identification* information element may contain a repeated field and its length is therefore marked as "*" (unknown)

- Further explanatory notes, as necessary

18.1 Messages for circuit-mode connection control

Table 12 summarizes the messages for circuit-mode connection control.

Table 12 Messages for circuit-mode connection control

Call establishment messages	Reference
Alerting	Table 13
Call proceeding	Table 14
Connect	Table 15
Connect acknowledge	Table 16
Progress	Table 19
Setup	Table 22
Call clearing messages	
Disconnect	Table 17
Release	Table 20
Release complete	Table 21
Miscellaneous messages	
Notify	Table 18
Status	Table 23
Status enquiry	Table 24

18.1.1 Alerting

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

The contents of the alerting message are shown in Table 13.

Table 13 Alerting message content

Message type: Alerting				
Significance: Global				
Direction: Both				
Information element	**Reference**	**Direction**	**Type**	**Length**
Protocol discriminator	See "Protocol discriminator" on page 188.	Both	M	1
Call reference	See "Call reference" on page 188.	Both	M	2 - 3
Message type	See "Message type" on page 191.	Both	M	1

Table 13 Alerting message content (continued)

Message type: Alerting				
Significance: Global				
Direction: Both				
Channel identification	See "Channel identification" on page 217.	Both (see Note 1)	M/O (see Note 2)	2 - *
Progress indicator	See "Progress indicator" on page 227.	Both	O (see Note 3)	2 - 4
Note 1: Included in the network-to-user direction for support of symmetric call control procedures. *Note 2:* Mandatory in the network-to-user direction if this message is the first message in response to Setup message. Mandatory in the user-to-network direction if this message is the first message in response to Setup message, unless the user accepts the B-channel indicated in the Setup message. *Note 3:* Included for interworking. Included in the network-to-user direction in connection with the provision of in-band information and patterns				

18.1.2 Call proceeding

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

The contents of the call proceeding message are shown in Table 14.

Table 14 Call proceeding message content

Message type: Call proceeding				
Significance: Local				
Direction: Both				
Information element	**Reference**	**Direction**	**Type**	**Length**
Protocol discriminator	See "Protocol discriminator" on page 188.	Both	M	1
Call reference	See "Call reference" on page 188.	Both	M	2 - 3
Message type	See "Message type" on page 191.	Both	M	1

Table 14 Call proceeding message content (continued)

Message type: Call proceeding				
Significance: Local				
Direction: Both				
Channel identification	See "Channel identification" on page 217.	Both	M/O (see Note)	2 - *
Progress indicator	See "Progress indicator" on page 227.	Both	O	2 - 4
Note: Mandatory in the network-to-user direction if this message is the first message in response to *Setup* message. Mandatory in the user-to-network direction if this message is the first message in response to *Setup* message, unless the user accepts the B-channel indicated in the *Setup* message.				

18.1.3 Connect

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

The contents of the connect message are shown in Table 15.

Table 15 Connect message content

Message type: Connect				
Significance: Global				
Direction: Both				
Information element	**Reference**	**Direction**	**Type**	**Length**
Protocol discriminator	See "Protocol discriminator" on page 188.	Both	M	1
Call reference	See "Call reference" on page 188.	Both	M	2 - 3
Message type	See "Message type" on page 191.	Both	M	1
Channel identification	See "Channel identification" on page 217.	Both (see Note 1)	M/O (see Note 2)	2 - *
Progress indicator	See "Progress indicator" on page 227.	Both	O	2 - 4

Table 15 Connect message content (continued)

Message type: Connect				
Significance: Global				
Direction: Both				
Information element	**Reference**	**Direction**	**Type**	**Length**
Low layer compatibility	See "Low-layer compatibility" on page 225.	Both	O	2 - 16
Note 1: Included in the network-to-user direction for support of symmetric call procedures.				
Note 2: Mandatory in the network-to-user direction if this message is the first message in response to *Setup* message. Mandatory in the user-to-network direction if this message is the first message in response to *Setup* message, unless the user accepts the B-channel indicated in the *Setup* message.				

18.1.4 Connect acknowledge

This message is sent by the network to the called user to indicate the user has been awarded the call. It may also be sent by the calling user to the network to allow symmetrical call control procedures.

The contents of the connect acknowledge message are shown in Table 16.

Table 16 Connect acknowledge message content

Message type: Connect acknpwledge				
Significance: Local				
Direction: Both				
Information element	**Reference**	**Direction**	**Type**	**Length**
Protocol discriminator	See "Protocol discriminator" on page 188.	Both	M	1
Call reference	See "Call reference" on page 188.	Both	M	2 - 3
Message type	See "Message type" on page 191.	Both	M	1

18.1.5 Disconnect

This message is sent by the user to request the network to clear an end-to-end connection or is sent by the network to indicate that the end-to-end connection is cleared.

The contents of the disconnect message are shown in Table 17.

Table 17 Disconnect message content

Message type: Disconnect

Significance: Global

Direction: Both

Information element	Reference	Direction	Type	Length
Protocol discriminator	See "Protocol discriminator" on page 188.	Both	M	1
Call reference	See "Call reference" on page 188.	Both	M	2 - 3
Message type	See "Message type" on page 191.	Both	M	1
Cause	See "Cause" on page 209.	Both	M	2 - 32
Progress Indicator	See "Progress indicator" on page 227.	See Note 1	O	2 - 4

Note 1: Included in the network-to-user direction if the network provides in-band tones.

18.1.6 Notify

This message is sent by the user to indicate information pertaining to a call. The DMS-100 may receive this message but ignores it if the call state is NOT N10 (active state).

The contents of the notify message are shown in Table 18.

Table 18 Notify message content

Message type: Notify

Significance: Access

Direction: User- to-network

Information element	Reference	Direction	Type	Length
Protocol discriminator	See "Protocol discriminator" on page 188.	u - n	M	1
Call reference	See "Call reference" on page 188.	u - n	M	2 - 3

Table 18 Notify message content (continued)

Message type: Notify				
Significance: Access				
Direction: User- to-network				
Information element	**Reference**	**Direction**	**Type**	**Length**
Message type	See "Message type" on page 191.	u - n	M	1
Notification indicator	See "Notification indicator" on page 226.	u -n	M	3

18.1.7 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 and patterns.

The contents of the progress message are shown in Table 19.

Table 19 Progress message content

Message type: Progress				
Significance: Global				
Direction: Network-to-user				
Information element	**Reference**	**Direction**	**Type**	**Length**
Protocol discriminator	See "Protocol discriminator" on page 188.	n - u	M	1
Call reference	See "Call reference" on page 188.	n - u	M	2 - 3
Message type	See "Message type" on page 191.	n - u	M	1
Progress indicator	See "Progress indicator" on page 227.	n - u	M	2 - 4

18.1.8 Release

This message is sent by the user or the network 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 *Release complete* message.

The contents of the release message are shown in Table 20.

Table 20 Release message content

Message type: Release				
Significance: Local (see Note 1				
Direction: Both				
Information elemen	**Reference**	**Direction**	**Type**	**Length**
Protocol discriminator	See "Protocol discriminator" on page 188.	Both	M	1
Call reference	See "Call reference" on page 188.	Both	M	2 - 3
Message type	See "Message type" on page 191.	Both	M	1
Cause	See "Cause" on page 209.	Both	O (see Note 2)	2 - 32

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.

18.1.9 Release complete

This message is sent by the user or the network 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.

The contents of the release complete message are shown in Table 21.

Table 21 Release complete message contents

Message type: Release Complete				
Significance: Local (see Note 1)				
Direction: Both				
Information element	**Reference**	**Direction**	**Type**	**Length**
Protocol discriminator	See "Protocol discriminator" on page 188.	Both	M	1
Call reference	See "Call reference" on page 188.	Both	M	2 - 3
Message type	See "Message type" on page 191.	Both	M	1
Cause	See "Cause" on page 209.	Both	O (see Note 2)	2 - 32

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.

18.1.10 Setup

This message is sent by the calling user to the network and by the network to the called user to initiate call establishment.

The contents of the setup message are shown in Table 22.

Table 22 Setup message content

Message type: Setup				
Significance: Globa**l**				
Direction: Both				
Information element	**Reference**	**Direction**	**Type**	**Length**
Protocol discriminator	See "Protocol discriminator" on page 188.	Both	M	1
Call reference	See "Call reference" on page 188.	Both	M	2 - 3
Message type	See "Message type" on page 191.	Both	M	1

Table 22 Setup message content (continued)

Message type: Setup				
Significance: Global				
Direction: Both				
Information element	**Reference**	**Direction**	**Type**	**Length**
Bearer capability	See "Bearer capability" on page 197.	Both	M	4 - 10
Channel identification	See "Channel identification" on page 217.	Both	M/O (see Note 1)	2 - *
Progress indicator	See "Progress indicator" on page 227.	Both	O (see Note 2)	2 - 4
Keypad facility	See "Keypad facility" on page 224.	u - n	O (see Note 4)	2 - 34
Calling party number	See "Calling party number" on page 206.	Both	O (see Note 3)	2 - 36
Calling party subaddress	See "Calling party sub-address" on page 208.	Both	O (see Note 5)	2 - 23
Called party number	See "Called party number" on page 203.	Both	O (see Note 4)	2 - 35
Called party subaddress	See "Called party sub-address" on page 205.	Both	O (see Note 5)	2 - 23
Low layer compatibility	See "Low-layer compatibility" on page 225.	Both	O (see Note 5)	2 - 16
High layer compatibility	See "High-layer compatibility" on page 220.	Both	O (see Note 5)	2 - 4

Table 22 Setup message content (continued)

Message type: Setup
Significance: Globa**l**
Direction: Both

Information element	Reference	Direction	Type	Length

Note 1: Mandatory in the network-to-user direction. Included in the user-to-network direction when the user wants to indicate a channel. If not included, any channel is considered acceptable. If multiple channels are indicated, the first is used.

Note 2: Included in the event of interworking or in connection with the provision of in-band information and patterns. Only one *Progress indicator* information element is allowed with this message. All further *Progress indicator* information elements are ignored

Note 3: May be included by the calling user or the network to identify the calling user.

Note 4: One or both of the *Keypad facility* or the *Called party number* information elements must be included in the *Setup* message in the user-to-network direction. If both are included, the *Called party number* information element takes precedence and the *Keypad facility* is ignored. If only the *Keypad facility* information element is present, the *Type of Number* and *Numbering Plan Indicator* are assumed to be *Unknown*. If neither information element is included, the DMS-100 treats this case as a mandatory information element missing. In the network-to-user direction, the *Called party number* information elements are optional.

Note 5: The *Called party subaddress, Calling party subaddress, Low layer compatibility,* and *High layer compatibility* information elements are transparently transported across the network.

18.1.11 Status

This message is sent by the user or the network in response to a *Status enquiry* message or at any time during a call to report error conditions as described in Chapter 20: "Call control procedures", section 20.8, "Handling of error conditions", on page 253.

The contents of the ststus message are shown in Table 23.

Table 23 Status message content

Message type: Status
Significance: Local
Direction: Both

Information element	Reference	Direction	Type	Length
Protocol discriminator	See "Protocol discriminator" on page 188.	Both	M	1

Table 23 Status message content (continued)

Message type: Status				
Significance: Local				
Direction: Both				
Information element	**Reference**	**Direction**	**Type**	**Length**
Call reference	See "Call reference" on page 188.	Both	M	2 - 3
Message type	See "Message type" on page 191.	Both	M	1
Cause	See "Cause" on page 209.	Both	M	2 - 32
Call state	See "Call state" on page 201.	Both	M	3

18.1.12 Status enquiry

This message is sent by the user or the network 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.

The contents of the status enquiry message are shown in Table 24.

Table 24 Status enquiry message content

Message type: Status enquiry				
Significance: Local				
Direction: Both				
Information element	**Reference**	**Direction**	**Type**	**Length**
Protocol discriminator	See "Protocol discriminator" on page 188.	Both	M	1
Call reference	See "Call reference" on page 188.	Both	M	2 - 3
Message type	See "Message type" on page 191.	Both	M	1

18.2 Messages used with the global call reference

Table 25 summarizes the messages which may use the global call reference as defined in section 19.3, "Call reference", on page 188.

Table 25 Messages using the global call reference

Messages:	Reference
Restart	Table 26
Restart acknowledge	Table 27
Status	Table 28

18.2.1 Restart

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

The contents of the restart message are shown in Table 26.

Table 26 Restart message content

Message type: Restart				
Significance: Local				
Direction: Both				
Information element	**Reference**	**Direction**	**Type**	**Length**
Protocol discriminator	See "Protocol discriminator" on page 188.	Both	M	1
Call reference	See "Call reference" on page 188.	Both	M (see Note 1)	2 - 3
Message type	See "Message type" on page 191.	Both	M	1
Channel identification	See "Channel identification" on page 217.	Both	O (see Note 2)	2 - *
Restart indicator	See "Restart indicator" on page 229.	Both	M	3
Note 1: This message is sent with the global call reference as defined in section 19.3, "Call reference", on page 188.				
Note 2: Included when necessary to indicate the particular channel(s) which are to be restarted.				

18.2.2 Restart acknowledge

This message is sent to acknowledge the receipt of the *Restart* message and to indicate that the requested restart is complete.

The contents of the restart acknowledge message are shown in Table 27.

Table 27 Restart acknowledge message content

Message type: Restart acknowledge				
Significance: Local				
Direction: Both				
Information element	**Reference**	**Direction**	**Type**	**Length**
Protocol discriminator	See "Protocol discriminator" on page 188.	Both	M	1
Call reference	See "Call reference" on page 188.	Both	M (see Note 1)	2 - 3
Message type	See "Message type" on page 191.	Both	M	1
Channel identification	See "Channel identification" on page 217.	Both	O (see Note 2)	2 - *
Restart indicator	See "Restart indicator" on page 229.	Both	M	3

Note 1: This message is sent with the global call reference as defined in section 19.3, "Call reference", on page 188.

Note 2: Included when necessary to indicate the particular channel(s) which are to be restarted.

18.2.3 Status

This message may be sent from either the user or the network at any time when an unexpected message with a global call reference is received, or when it is required to report other conditions of the call.

The contents of the status message are shown in Table 28.

Table 28 Status message content

Message type: Status				
Significance: Local				
Direction: Both				
Information element	**Reference**	**Direction**	**Type**	**Length**
Protocol discriminator	See "Protocol discriminator" on page 188.	Both	M	1
Call reference	See "Call reference" on page 188.	Both	M (see Note 1)	2 - 3
Message type	See "Message type" on page 191.	Both	M	1
Cause	See "Cause" on page 209.	Both	M	2 -32
Call state	See "Call state" on page 201.	Both	M	3
Note : This message is sent with the global call reference as defined in section 19.3, "Call reference", on page 188.				

Chapter 19: Message formats

19.1 Overview

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

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

The first three information elements are common to all messages and are always present, while the last information element is specific to each message type. This organization is illustrated in Figure 56.

Figure 56 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							…
Other information elements as required								n

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.

19.2 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 Table 29.

The *Protocol discriminator* information element is the first part of every message and is one complete octet.

Table 29 Q.931 protocol discriminator coding

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

All other values are reserved.

19.3 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 across ISDN networks.

The *Call reference* information element is the second part of every message. 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 three octets. See Figure 57. The *Call reference* information element includes the length of the call reference value, the call reference value and the call reference flag.

Figure 57 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 numerical value of the *Call reference* information element and are independent of the length of the *Call reference* information element.

The *Call reference* information element value is two octets long for primary rate interface. The INS 1500 network always uses two octets for the *Call reference* information element.

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 the opposite end 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, Octet 2) can be set to one of the following:

- "0", indicating that the message is sent from the side that originates the call reference

- "1", indicating that the message is sent to the side that originates 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).

A *Call reference* information element containing a dummy (null) call reference is one octet long and is coded "0000 0000", see Figure 58.

Figure 58 Dummy (null) call reference

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
				0	0	0	0	

The numerical value of the global call reference is zero, see Figure 59. The equipment receiving a message containing the global call reference should interpret the message as pertaining to all call references associated with the appropriate data link connection identifier. The messages which can use the global call reference value are defined in Chapter 18: "Message function definitions" in section 18.2 on page 184.

Figure 59 Examples of the encoding for the global call reference

Global call reference (1 octet value)

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
				0	0	0	0	
Flag (0/1)	0	0	0	0	0	0	0	2

Global call reference (2 octet value)

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
				0	0	0	0	
Flag (0/1)	0	0	0	0	0	0	0	2
0	0	0	0	0	0	0	0	3

19.4 Message type

The purpose of the message type information element is to identify the function of the message being sent.

The message type is the third part of every message. The message type is coded as shown in Figure 60.

Figure 60 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**
0	1 1 1 0	Notify
1	1 1 0 1	Status
1	0 1 0 1	Status Enquiry

19.5 Other information elements

19.5.1 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 (see Figure 61):

- single octet information elements
- variable length information elements

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 code set (see section 19.5.2 on page 194).

Figure 61 Information element formats

Single octet information element

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**

Variable length information element

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 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 spare and reserved bits are set to "1" (see Figure 62).

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 paragraphs in 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.

  Additional octets may be defined in future implementations (that is, "1 Ext" may be changed to "0/1 Ext"). All equipment should be prepared to receive these additional octets although it need not interpret or act upon the contents of these octets.

- 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.

Figure 62 Code set 0 information element identifier encoding

8 7 6 5	4 3 2 1	
Information element identifier		
1 : :	: : : :	**Single octet information element**
0 0 1	0 - - -	Locking shift
0 0 1	1 - - -	Non-locking shift (see Note 1)
0 : : :	: : : :	**Variable length information element**
0 0 0	0 1 0 0	Bearer capability
0 0 0	1 0 0 0	Cause
0 0 1	0 1 0 0	Call state
0 0 1	1 0 0 0	Channel identification
0 0 1	1 1 1 0	Progress indicator
0 1 0	0 1 1 1	Notification indicator
0 1 0	1 1 0 0	Keypad facility
1 1 0	1 1 0 0	Calling party number
1 1 0	1 1 0 1	Calling party sub-address
1 1 1	0 0 0 0	Called party number
1 1 1	0 0 0 1	Called party sub-address
1 1 1	1 0 0 1	Restart indicator
1 1 1	1 1 0 0	Low layer compatibility
1 1 1	1 1 0 1	High layer compatibility

Note: Not supported by DMS-100 in BCS 34

19.5.2 Extension of code sets

In BCS 34, DMS-100 does not support code sets other than code set 0. In the future, the DMS-100 will support extensions of the code set, and this section is included to indicate the possible implementations of these extensions.

There are a number of possible information element identifier values using the formatting rules described in the previous paragraph. 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 code sets with at least 133 information element identifier values each. One common value in the single octet format is employed in each code set to allow shifting from one code set to another. The content of this *Shift* information element identifies the code set to be used for the next information element or elements. The code set in use at any given time is referred to as the "active code set". By convention, code set 0 is the initially active code set.

The coding rules specified in section 19.5.1 on page 192 apply to information elements belonging to any active code set.

Transitions from one active code set to another—by means of the locking shift procedure—may only be made to a code set with a higher numerical value than the original.

User or network equipment should have the capability to recognize a *Shift* information element and can 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.

Code set 6 is reserved for information elements specific to the local network (either public or private). These elements do not have significance across the boundaries between local networks, or across a national or international boundary. Therefore, code set 6 information elements are treated as if they were unrecognized information elements beyond the local network boundary. (See the procedures in paragraph 20.8.7 on page 258.

19.5.3 Locking shift procedure

In BCS 34, DMS-100 does not support the locking shift procedure. In the future, the DMS-100 will support extensions of the code set, and this section is included to indicate the possible implementations of these extensions.

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

For example, code set 0 is active at the start of message content analysis. If a *Locking shift* information element to code set 6 is encountered, the next information elements are interpreted according to the information element identifiers assigned in code set 6. Code set 6 remains active until another *Locking shift* information element is encountered.

The locking shift is valid only within the message which contains the *Locking shift* information element.The *Locking shift* information element uses the single octet information element format as shown in Figure 63.

Figure 63 Locking shift

8 7 6 5	4 3 2 1	
1 0 0 1	0 1 1 0	Code set 6

19.5.4 Non-locking shift procedure

The non-locking shift procedure is not supported in the 1989 version of the INS-1500 specification. If the DMS-100 receives a *Non-locking shift* information element, the *Non-locking shift* information element and the information element immediately following it are treated as not-implemented information elements.

19.5.5 Bearer capability

The *Bearer capability* information element is used to indicate that the network is to provision one of the bearer capabilities as defined in CCITT Recommendation I.211. No default bearer capability is assumed by the absence of this information element. Refer to Figure 64.

Figure 64 Bearer capability information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
	Bearer capability information element identifier							1
0	0	0	0	0	1	0	0	
	Length of information element							2
1	Coding standard		Information transfer capability					3
1	Transfer mode		Information transfer rate					4
Ext. 0/1	Layer 1 identifier 0 1		Layer 1 protocol identification					5 (see Note 1)
1	Spare 0 0		Data access rate					5a (see Note 2)
Ext. 1	Layer 2 identifier 0 1		Layer 2 protocol identification					6 (see Note 1)
Ext. 1	Layer 3 identifier 1 1		Layer 3 protocol identification					7 (see Note 1)

Note 1: This octet may be omitted

Note 2: This octet is present if octet 5 is set to 0010 0001, indicating rate adaption.

Coding standard (octet 3)

7 6	
0 0	CCITT/TTC standardized coding

All other values are reserved.

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	Reserved
1	0	0	0	0	3.1 kHz audio (modem)[a]

a. 3.1 kHz audio receives identical treatment to speech

Transfer mode (octet 4)

7	6	
0	0	Circuit mode

Information transfer rate (octet 4)

5	4	3	2	1	
1	0	0	0	0	64 kbit/s

Layer and protocol identification (Octet 5, 5a)

This field identifies the protocols and data rate adaption used for the user information on the access channel at the user-to-network interface

7	6	
0	1	Layer 1

5	4	3	2	1	
0	0	0	0	1	Rate adaption based on CCITT I, X, and V series. To indicate the data rate, octet 5 bit 8 is set to "0" and the following octet indicates the user information data rate. See encoding of octet 5a
0	0	0	1	0	Recommendation G.711 μ-law speech

Access data rate (octet 5a)

8
1	Last octet of this octet group

7 6
0 0	Spare

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

User information Layer 2 protocol (Octet 6)

5 4 3 2 1
0 0 0 1 0	Recommendation Q.921 (I.441)

User information Layer 3 protocol (Octet 7)

5 4 3 2 1
0 1 1 1 0	Recommendation Q.931 (I.451)

Examples of bearer capability codes

The codes used in this information element for the bearer services supported by DMS-100 are shown in the following chart.

Attribute	Encoding	Octet
(1) Speech		
Transfer capability = speech	1000 0000	3
Transfer mode and rate = circuit-mode, 64 kbit/s	1001 0000	4
Layer 1 protocol identifier = µ- law	1010 0010	5
Octet 5a not present		
(2) 64 kbit/s unrestricted digital, rate adapted to 56 kbit/s		
Transfer capability = unrestricted digital	1000 1000	3
Transfer mode and rate = circuit-mode, 64 kbit/s	1001 0000	4
Layer 1 protocol ID = Rate adaption	0010 0001	5
Data rate = 56 kbit/s	1000 1111	5a
(3) 64 kbit/s clear, unrestricted digital, circuit-mode		
Transfer capability = unrestricted digital	1000 1000	3
Transfer mode and rate = circuit-mode, 64 kbit/s	1001 0000	4
Octets 5 and 5a are not present		
(4) 3.1 kHz audio		
Transfer capability = 3.1 kHz audio	1001 0000	3
Transfer mode and rate = circuit-mode, 64 kbit/s	1001 0000	4
Layer 1 protocol ID = µ- law	1010 0010	5
Octet 5a not present		

19.5.6 Call state

The purpose of the *Call state* information element (Figure 65) is to describe the current status of a call.

Figure 65 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						3

Coding standard (octet 3)

8 7	
0 0	CCITT/TTC standardized coding

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

6 5	4 3 2 1	State no.	User state	Network state
0 0	1 1 0 0	12	Disconnect indication	Disconnect indication
0 1	0 0 1 1	19	Release request	Release request

All other values are reserved. States are defined in Chapter 17: "Overview of call control".

Global interface state value (octet 3)

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

All other values are reserved.

19.5.7 **Called party number**

The purpose of the *Called party number* information element (Figure 66) is to identify the called party of a call.

Figure 66 Called party number information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
Called party number information element identifier								1
0	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 1)							4 ...n

Note: The address (number) digit in octet 4 precedes the digit in octet 5. Similarly, for the digit in octet (n) and octet (n+1). Therefore the digit that is "dialed" first is the one located in octet 4.

Type of number (octet 3)

7 6 5	
0 0 0	Unknown

All other values are reserved

Numbering plan identification (octet 3)

4 3 2 1	
0 0 0 0	Unknown

All other values are reserved

Number digit coding (octet 4 ...n)

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

Note: The maximum number of digits that may be included in the *Called party number* information element is 32. However, the DMS-100 ignores any digits after the 30th. Similarly the DMS-100 does not send more than 30 digits in a *Called party number* information element.

19.5.8 Called party sub-address

The purpose of the *Called party sub-address* information element (Figure 67) is to identify the sub-address of the called party of a call.

Figure 67 Called party sub-address information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
Called party sub-address information element identifier								1
0	1	1	1	0	0	0	1	
Length of information element								2
Ext. 1	Type of sub-address			Odd/even indicator	Spare 0	0	0	3
Sub-address information								4 ...n

Type of sub-address (octet 3)

7 6 5	
0 0 0	NSAP (X.213, ISO 8348 AD2)
0 1 0	User specified sub-address

All other values are reserved

Odd/even indicator (octet 3)

4	
0	Even number of address signals
1	Odd number of address signals

Note: The *Odd/even indicator* information element is used when the type of sub-address is "User specified" and the coding is binary coded decimal.

Sub-address information (octet 4 ...n)

The information in this field is passed with the message by the DMS-100, but is not validated by the DMS-100. The maximum length of this field is 20 octets.

19.5.9 Calling party number

The purpose of the *Calling party number* information element (Figure 68) is to identify the origin of a call.

Figure 68 Calling party number information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
	Calling party number information element identifier							1
0	1	1	0	1	1	0	0	
	Length of information element							2
Ext. 0/1	Type of number			Numbering plan identification				3
Ext. 1	Present indicator	Spare 0	Reserved 0	0		Screening indicator		3a (see Note 1)
Spare 0	Number digits (IA5 characters)							4 … n

Note 1: This octet may be omitted.

Note 2: The contents of this information element, other than octet 3a, are coded as shown for the *Called party number* information element.

Presentation indicator (octet 3a)

7 6	
0 0	Presentation allowed
0 1	Presentation restricted
1 0	Number not available due to interworking
1 1	Reserved

Note: If octet 3a is omitted then

- "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	Reserved
0	1	User provided, verified, and passed
1	0	Reserved
1	1	Network provided

Note 1: If octet 3a is omitted "Network provided" is assumed to be default.

Note 2: The maximum number of digits that may be included in the *Calling party number* information element is 32. However, the DMS-100 ignores any digits after the 20th. Similarly the DMS-100 does not send more than 20 digits in a *Calling party number* information element.

Note 3: Non-numeric digits in the CGN IE are considered invalid and are therefore ignored. Numeric digits that follow invalid digits are accepted as valid.

19.5.10 Calling party sub-address

The purpose of the *Calling party sub-address* information element is (Figure 69) to identify the sub-address of the calling party of a call.

Figure 69 Calling party sub-address information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
	Called party sub-address information element identifier							1
0	1	1	1	0	0	0	1	
Length of information element								2
Ext. 1	Type of sub-address		Odd/ even indicato r	Spare	0	0	0	3
Sub-address information								4...n

Type of sub-address (octet 3)

7 6 5	
0 0 0	NSAP (X.213, ISO 8348 AD2)
0 1 0	User specified sub-address

All other values are reserved

Odd/even indicator (octet 3)

4	
0	Even number of address signals
1	Odd number of address signals

Note: The *Odd/even indicator* information element is used when the type of sub-address is "User specified" and the coding is binary coded decimal.

Sub-address information (octet 4 ...n)

The information in this field is passed with the message by the DMS-100, but is not validated by the DMS-100. The maximum length of this field is 20 octets.

19.5.11 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 *Cause* information element is coded as shown in Figure 70. Diagnostic information is not available on the DMS-100 for every cause.

Figure 70 Cause information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
	Cause information element identifier							1
0	0	0	0	1	0	0	0	
	Length of information element							2
Ext. 0/1	Coding standard		Spare 0	General location				3
Ext. 1	Recommendation							3a (see Note 1)
Ext. 1	Cause value							4
	Class			Value				
	Diagnostics (if any)							5 … n (see Note 1).

Note 1: These octets may be omitted.

Coding standard (octet 3)

7 6	
0 0	CCITT/TTC standardized coding
0 1	Reserved
1 0	Reserved
1 1	Standard specific to the identified location which is indicated by the *General location* field in octet 3. This coding standard should only be used when the desired cause cannot be represented with the CCITT/TTC standardized coding. The DMS-100 treats receipt of this coding standard as an information element content error.

General 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 interworking point

All other values are reserved.

Recommendation (octet 3a)

7 6 5	4 3 2 1	
0 0 0	0 0 0 0	TTC standard JT -Q931

Note 1: If octet 3a is omitted from the *Cause* information element, it is assumed that the TTC standard JT-Q931 is to be used.

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 1through 4). The class indicates the general nature of the event.

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

Diagnostics (octet 5)

Diagnostic information is not available for every cause value (see Table 30). The inclusion of diagnostics is optional. When available, the coding of the diagnostic(s) is the same as for the corresponding information element or message type.

Table 30 Cause value definitions

Cause value		Cause no.	Cause (and definition)	Diagnostics
Class	**Value**			
7 6 5	**4 3 2 1**			
			Normal class	
0 0 0	0 0 0 1	1	"Unassigned number" 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	
0 0 0	0 0 1 0	2	"No route to specified transit network" 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	
0 0 0	0 0 1 1	3	"No route to destination" Indicates that the called user cannot be reached because the network through which the call has been routed does not serve the destination desired.	
0 0 0	0 1 1 0	6	"Channel unacceptable" Indicates the channel most recently identified is not acceptable to the sending entity for use in this call.	Zero in diagnostic field
0 0 0	0 1 1 1	7	"Call awarded and being delivered to an established channel" Indicates the user has been awarded the incoming call, and that the call is being connected to a channel already established to that user for similar calls.	
			Normal class	
0 0 1	0 0 0 0	16	"Normal call clearing" Indicates that the call is being cleared because one of the users involved in the call has requested that the call be cleared.	Zero in diagnostic field
0 0 1	0 0 0 1	17	"User busy" Indicates that the called user is unable to accept another call because another call(s) is occupying the resources required to handle the new call.	

Table 30 Cause value definitions (continued)

Cause value		Cause no.	Cause (and definition)	Diagnostics
Class	**Value**			
7 6 5	**4 3 2 1**			
0 0 1	0 0 1 0	18	"No user responding" Indicates a user is not responding to a call establishment message with either an alerting or connect indication within the prescribed period of time allocated.	Zero in diagnostic field
0 0 1	0 0 1 1	19	"No answer from user (user alerted)" Indicates a user has provided an alerting indication but has not provided a connect indication within a prescribed period of time.	Zero in diagnostic field
0 0 1	0 1 0 1	21	"Call rejected" Indicates 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 or incompatible.	Zero in diagnostic field
0 0 1	0 1 1 0	22	"Number changed address" Indicates the called number, indicated by the calling party number is no longer assigned. This cause is returned to calling user.	
0 0 1	1 0 1 0	26	"Non-selected user clearing the call" Indicates that the user has not been awarded the incoming call.	
0 0 1	1 0 1 1	27	"Destination out of order" Indicates that the destination indicated by the user cannot be reached because the interface to the destination is not functioning correctly. "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, or user equipment off-line	Zero in diagnostic field
0 0 1	1 1 0 0	28	"Incomplete *Number* information element" 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.	
0 0 1	1 1 0 1	29	"Facility rejected" Indicates that a facility requested by the user cannot be provided by the network.	
0 0 1	1 1 1 0	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.	

Table 30 Cause value definitions (continued)

Cause value		Cause no.	Cause (and definition)	Diagnostics
Class	**Value**			
7 6 5	**4 3 2 1**			
0 0 1	1 1 1 1	31	"Normal unspecified" Indicates that a normal event has occurred, but no other cause in the normal class applies.	Zero in diagnostic field
			Network congestion class	
0 1 0	0 0 1 0	34	"No circuit/channel available" Indicates that there is no appropriate circuit or channel, presently available, to handle the call.	Zero in diagnostic field
0 1 0	0 1 1 0	38	"Network out of order" Indicates that the network is not functioning correctly and that the condition is likely to last a relatively long period of time. That is, re-attempting the call is not likely to be successful	
0 1 0	1 0 0 1	41	"Temporary failure" Indicates that the network is not functioning correctly but that the condition is *not* likely to last a long period of time. That is, the user may wish to try another call attempt almost immediately.	Zero in diagnostic field
0 1 0	1 0 1 0	42	"Switch equipment congestion" Indicates that the switching equipment generating this cause is experiencing a period of high traffic.	Zero in diagnostic field
0 1 0	1 0 1 1	43	"User information discarded" Indicates that the network could not deliver access information to the remote user as requested.	Information element identifier
0 1 0	1 1 0 0	44	"Requested circuit or channel not available" Indicates that the channel requested by the user during local channel negotiation is not currently available. (For example, the channel is in use, or out of service for maintenance).	Zero in diagnostic field
0 1 0	1 1 1 1	47	"Resources unavailable" Indicates that the user has requested a resource that is not available, and no other cause in the resource unavailable class applies.	Zero in diagnostic field
			Service or option not available class	
0 1 1	0 0 1 0	50	"Requested facility not subscribed" Indicates that the user has not subscribed to this facility and therefore cannot access the facility at this time.	
0 1 1	1 0 0 1	57	"Bearer capability not authorized" Indicates that the user has requested a bearer capability which is implemented by the equipment which generated this cause but which the user is not authorized to use.	Zero in diagnostic field

Table 30 Cause value definitions (continued)

Cause value		Cause no.	Cause (and definition)	Diagnostics
Class	**Value**			
7 6 5	**4 3 2 1**			
0 1 1	1 0 1 0	58	"Bearer capability not presently available" 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.	
0 1 1	1 1 1 1	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	
1 0 0	0 0 0 1	65	"Bearer capability not implemented" Indicates that the equipment sending this cause does not support the bearer capability requested	Information element identifier
1 0 0	0 0 1 0	66	"Channel type not implemented" Indicates that the equipment sending this cause does not support the channel type requested.	
1 0 0	0 1 0 1	69	"Requested facility not implemented" This cause indicates that the equipment sending this cause does not support the requested supplementary service.	
1 0 0	0 1 1 0	70	"Only restricted digital information bearer capability is available" 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.	
1 0 0	1 1 1 1	79	"Unspecified service or option not implemented" 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 (for example, parameter out of range) class	
1 0 1	0 0 0 1	81	"Invalid call reference value" 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.	Message type

Table 30 Cause value definitions (continued)

Cause value		Cause no.	Cause (and definition)	Diagnostics
Class	**Value**			
7 6 5	**4 3 2 1**			
1 0 1	0 0 1 0	82	"Identified channel does not exist" 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 channels 1 through 12 on a primary rate interface, and the user equipment or the network attempts to use channels 13 through 23, this cause is generated.	Zero in diagnostic field
1 0 1	1 0 0 0	88	"Incompatible destination" 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).	Zero in diagnostic field
1 0 1	1 0 1 1	91	"Invalid transit network selection" This cause indicates that a transit network identification was received which is of an incorrect format.	
1 0 1	1 1 1 1	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 (for example, unknown message) class	
1 1 0	0 0 0 0	96	"Mandatory information element is missing" 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.	Information element identifier
1 1 0	0 0 0 1	97	"Message type non-existent or not implemented" 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, it is defined but not implemented by the equipment sending this cause.	Message type
1 1 0	0 0 1 0	98	"Message not compatible with call state, or message type non-existent, or not implemented" This cause is a combination of causes 97 and 101 where the sender cannot distinquish between an unexpected and an unrecognized message.	

Table 30 Cause value definitions (continued)

Cause value		Cause no.	Cause (and definition)	Diagnostics
Class	**Value**			
7 6 5	**4 3 2 1**			
1 1 0	0 0 1 1	99	"Information element non-existent or not implemented" Indicates that the equipment sending this cause has received a message which includes the 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.	Information element identifier
1 1 0	0 1 0 0	100	"Invalid information element contents" 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.	Information element identifier
1 1 0	0 1 0 1	101	"Message not compatible with call state" 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 a *Status* message was received indicating an incompatible call state.	Message type
1 1 0	0 1 1 0	102	"Recovery on timer expiry" Indicates that a procedure has been initiated by the expiry of a timer in association with error handling procedures.	Zero in diagnostic field
1 1 0	1 1 1 1	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.	Zero in diagnostic field
Interworking class				
1 1 1	1 1 1 1	127	"Interworking, unspecified" 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.	

All other values are reserved.

19.5.12 Channel identification

The purpose of the *Channel identification* information element is to identify a channel within the interface controlled by these signaling procedures (see Figure 71).

Figure 71 Channel identification information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
	Channel identification information element identifier							1
0	0	0	1	1	0	0	0	
	Length of information element							2
Ext. 1	Interface identifier present	Interface type 1	Spare 0	Pref/Excl	D-channel indicator	Information channel selection		3
Ext. 1	Interface identifier							3.1 (see Note 1)
Ext. 1	Coding Standard 0　0		Number or map	Channel or map element type				3.2
Ext. 0/1	Channel number or slot map							3.3

Note: This octet is only present if the *Interface identifier present* field, (octet 3, bit 7) is set to 1.

Interface identifier present (octet 3, bit 7)

7	
0	Interface implicitly identified
1	Interface explicitly identified in octet 3.1 (Interface identifier).

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

D-channel indicator (octet 3, bit 3)

3	
0	Channel identified is not the D-channel
1	Channel identified is the D-channel

Information channel selection (octet 3, bits 1 and 2)

2	1	**Primary interface**
0	0	Reserved
0	1	As indicated in following octets
1	0	Reserved
1	1	Any channel. Note that this value is *not* sent by the DMS-100

Interface identifier (octet 3.1)

The value of the *Interface identifier* information element is in the range 0 to 31(binary coded). The length of the *Interface identifier* information element is always 1 octet. It is assigned to the interface at subscription time.

Coding standard (octet 3.2)

7	6	
0	0	CCITT/TTC Standardized coding

All other values are reserved.

Number or map (octet 3.2)

5	
0	Channel indicated by number in the following octet
1	Channel indicated by slot map in the following octets

Channel or map element type (octet 3.2)

	4 3 2 1
	0 0 1 1 B- channel units

All other values are reserved.

Channel number or slot map (octet 3.3)

Channel number The binary number that is assigned to the channel. The channel number equals the time slot number.

Slot map The bit position in the slot map that corresponds to the time slot used by the channel is set to 1. The following table shows the mapping between the channel number and the time slot assigned to that channel.

Bit 8	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Octet**
24	23	22	21	20	19	18	17	3.3.1
16	15	14	13	12	11	10	9	3.3.2
8	7	6	5	4	3	2	1	3.3.3

1544 kbit/s

Note 1: In a *Setup* message, multiple *Channel numbers* or multiple time slots in a slot map are not accepted. The first channel encountered is used and the remainder are ignored.

Note 2: For call set up, the slot map is used.

Note 3: During call set up, the choice of channel number or slot map coding in the network-to-calling-user direction is the same as that received from the calling user.

Note 4: In *Restart* and *Restart acknowledge* messages, multiple time slots are accepted.

Note 5: In a *Restart* message, in the network-to-user direction, slot map coding is used.

Note 6: In a *Restart acknowledge m*essage, in the network-to-user direction, the choice of channel number or slot map is the same as that received from the user in the *Restart* message.

19.5.13 High-layer compatibility

The *High layer compatibility* information element (Figure 72), along with the bearer capability information element, provides a way for the remote user to check compatibility.

Figure 72 High-layer compatibility information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
	High-layer compatibility information element identifier							1
0	1	1	1	1	1	0	1	
Length of information element								2
Ext. 1	Coding standard		Interpretation			Presentation meth. of protocol profile		3
Ext. 0/1	High-layer characteristics identification							4
Ext. 1	Extended high-layer characteristics identification							4a (see Note 1)

Note 1: This octet is only present if octet 4 indicates maintenance or management.

Coding standard (octet 3)

7 6	
0 0	CCITT/TTC coding, as described following
0 1	Reserved for other international standards (see Note 1)
1 0	National standard (see Note 1)
1 1	Standard defined for the network (Public or private) present at the network side of the interface (see Note 1).

Note 1: These other coding standards should only be used when the desired high layer compatibility cannot be represented with the CCITT/TTC standardized coding.

Interpretation (octet 3)

5	4	3	
1	0	0	First (primary or only) high layer characteristics identification (in Octet 4) to be used in the call.

All other values are reserved.

Note 1: Interpretation indicates how the *High layer characteristics identification* (in Octet 4) should be interpreted.

Note 2: Currently, *Interpretation* has only a single value. However, *Interpretation,* when enhanced, will indicate how the *High layer characteristics identification* in the same information element is interpreted when multiple *High layer characteristics identifications* are used and the exact relationship between them needs to be identified (for example, sequential usage, alternative list, simultaneous usage).

Presentation method of protocol profile (octet 3)

2	1	
0	1	High -layer protocol profile (without specification of attributes)

All other values are reserved.

Note 1: Currently, *Presentation method of protocol profile* has only a single value. That is, a "profile value" is used to indicate that a service, supported by high layer protocols, is required. The necessity of other presentation methods—for example, service indications in the form of layer-by-layer indication of protocols to be used in high layers—may be introduced later.

High layer characteristics identification (Octet 4)

7 6 5	4 3 2 1	
0 0 0	0 0 0 1	Telephony
0 0 0	0 1 0 0	Facsimile group 2/3
0 1 0	0 0 0 1	Facsimile group 4 document application profile
0 1 0	0 1 0 0	Document application profile for formatted mixed-mode
0 1 0	1 0 0 0	Document application profile for processable-form
0 1 1	0 0 0 1	Teletext
0 1 1	0 0 1 0	Document application profile for videotex interworking between gateways
0 1 1	0 1 0 1	Telex
0 1 1	1 0 0 0	Message handling systems
1 0 0	0 0 0 1	OSI application (see Note 1)
1 0 1	1 1 1 0	Reserved for maintenance (see Note 2)
1 0 1	1 1 1 1	Reserved for management (see Note 2)
1 1 1	1 1 1 1	Reserved

All other values are reserved.

The coding above applies where

- *Coding standard* = CCITT standard

- *Presentation method of protocol profile* = High layer protocol profile

Code points are added only to those services for which CCITT recommendations are available

Note 1: Further compatibility checking is executed by the OSI high layer protocol.

Note 2: When this coding is included, octet 4 may be followed by octet 4a.

Extended high layer characteristics identification (Octet 4a)

7 6 5	4 3 2 1	
0 0 0	0 0 0 1	Telephony
0 0 0	0 1 0 0	Facsimile group 2/3
0 1 0	0 0 0 1	Facsimile group 4 document application profile
0 1 0	0 1 0 0	Document application profile for formatted mixed-mode
0 1 0	1 0 0 0	Document application profile for processable-form
0 1 1	0 0 0 1	Teletext
0 1 1	0 0 1 0	Document application profile for videotex interworking between gateways
0 1 1	0 1 0 1	Telex
0 1 1	1 0 0 0	Message handling systems
1 0 0	0 0 0 1	OSI application
1 0 1	1 1 1 0	Not available for assignment
1 0 1	1 1 1 1	Not available for assignment
1 1 1	1 1 1 1	Reserved

All other values are reserved.

19.5.14 Keypad facility

The *Keypad facility* information element is used to convey IA5 characters that are entered by terminal keypad, for example (see Figure 73).

Figure 73 Keypad facility information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
	Keypad facility information element identifier							1
0	0	1	0	1	1	0	0	
	Length of information element							2
Spare 0	Number digits (IA5 characters)							3 ...n

Number digits (octet 3)

The number digits are coded as shown for the *Called party number* information element in section 19.5.9 on page 206.

Note: The maximum number of digits that may be included in the *Keypad facility* information element is 32. However, the DMS-100 ignores any digits after the 24th.

19.5.15 Low-layer compatibility

The *Low-layer compatibility* information element, in conjunction with the bearer capability information element, provides a way for the remote user to check compatibility. This information element is not interpreted by the DMS-100 but is passed to the terminating user. The maximum length of the *Compatibility information* field is 14 octets (see Figure 74).

Figure 74 Low-layer compatibility information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
	Low-layer compatibility information element identifier							1
0	1	1	1	1	1	0	0	
Length of information element								2
Compatibility information								3...n

19.5.16 Notification indicator

The *Notification indicator* information element is used to indicate information associated with a call. The information element is coded as shown in Figure 75.

Figure 75 Notification indicator information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
Notification indicator information element identifier								1
0	0	1	0	0	1	1	1	
Length of information element								2
Ext.	Notification description							3
1								

Notification description (octet 3)

7 6 5	4 3 2 1	
0 0 0	0 0 0 0	User suspended
0 0 0	0 0 0 1	User resumed

All other values are reserved.

Note: If an invalid code point is received in the call active state (State N10) a *Status message* is returned.

19.5.17 Progress indicator

The *Progress indicator* information element (Figure 76) is used to describe an event which has occurred during the life of a call.

Figure 76 Progress information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
Progress indicator information element identifier								1
0	0	0	1	1	1	1	0	
Length of information element								2
Ext.	Coding standard		Spare	General location				3
1			0					
Ext.	Progress description							4
1								

Coding standard (octet 3)

7 6	
0 0	CCITT/TTC standardized coding

All other values are reserved.

General location (octet 3)

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

All other values are reserved.

Progress description (octet 4)

7 6 5	4 3 2 1	Desc no.	
0 0 0	0 0 0 1	1	Call is not end-to-end ISDN (interworking trunk facilities); further call progress information may be available in-band
0 0 0	0 0 1 0	2	Destination address is non-ISDN
0 0 0	0 0 1 1	3	Origination address is non-ISDN
0 0 0	0 1 0 0	4	Call has returned to the ISDN network
0 0 0	1 0 0 0	8	In-band information or pattern is now available

All other values are reserved.

The situations in which each of the *Progress descriptions* are supported depends on message type, call direction, and interworking conditions.

Note: The network will reject any received *Progress indicator* value other than "#2 Destination address in non-ISDN."

19.5.18 Restart indicator

The purpose of the *Restart indicator* information element (Figure 77) is to identify the class of the facility (that is, channel or all interfaces) to be restarted.

Figure 77 Restart indicator information element

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Octet
Restart indicator information element identifier								1
0	1	1	1	1	0	0	1	
Length of information element								2
Ext.	Spare				Class			3
1	0	0	0	0				

Class (octet 3)

3 2 1	
0 0 0	Indicated channel (see Note1)
1 1 0	Single interface (DMS-100 does not initiate restart with this code)
1 1 1	All channels associated with the D-channel

All other values are reserved.

Note 1: If the *Class* = 0 0 0 (octet 3, bits 1 through 3), the *Channel identification* information element must be included. This information element indicates which channel is to be restarted. If the *Channel identification* information element is not present, the interface—including the D-channel— is restarted, (that is, the class is assumed to be 1 1 0).

Chapter 20: 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 section 17.1.1, "Call states on the network or user side of the interface" on page 168 for user and network call states.)

Detailed Specification and Description Language (SDL) diagrams for the procedures specified in this section are contained in Chapter 22: "Layer 3 SDL diagrams". 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.

20.1 Call establishment at the originating interface

Before these procedures are invoked, a reliable data link connection must be established between the user and the network. 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 (Part III of this specification) are assumed.

20.1.1 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 section 19.3, "Call reference" on page 188. The *Bearer capability, Channel identification* and *Called party number* 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, it may send a *Setup* message when all channels are busy.

The *Setup* message contains all of the call information necessary for call establishment.

20.1.2 B-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

- any channel is acceptable

If no *Channel identification* information element is included, the last option is assumed to be requested. If an acceptable channel is available, the network selects that channel for the call. If the network cannot grant the preferred channel, it selects any other available B-channel associated with that D-channel.

The selected B-channel is indicated in the first message returned by the network in response to the *Setup* message (that is, a *Setup acknowledge* or a *Call proceeding* message). 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:

- #8 "Inband information or appropriate pattern is now available"

- #1 "Call is not end-to-end ISDN; further call progress information may be available in-band"

Prior to this time, the network cannot 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 tone. 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 and no acceptable alternative is specified, a *Release complete* message with *Cause* value #44 "Requested circuit/channel not available" is sent by the network as described in section 20.3 on page 241.

If no channel is available, a *Release complete* message with a *Cause* value #34 "No circuit/channel available" is sent by the network as described in section 20.3 on page 241.

Unsuccessful termination of the B-channel selection procedure by the side offering the call is accomplished by sending a *Release* message as described in section 20.3.2 on page 242. The *Release* message has *Cause* value #6 "Channel unacceptable".

20.1.3 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 section 20.3 on page 241. The *Cause* value returned is one of the following:

- #1 "Unassigned number"

- #3 "No route to destination"

- #22 "Number changed address"

- #28 "Incomplete number information element"

20.1.4 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 section 20.3 on page 241. The network returns one of the following *Cause* values:

- #57 "Bearer capability not authorized"

- #58 "Bearer capability not presently available"

- #63 "Service or option not available, unspecified"

- #65 "Bearer capability not implemented"

20.1.5 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 one of the following messages:

- in an appropriate call control message when a state change is required, (for example, *Alerting*)

- in the *Progress* message when no state change is appropriate

The *Progress indicator* information element in the message sent to the user has *Progress description* value #1 "Call is not end-to-end ISDN (interworking trunk facilities); further call progress information may be available in-band". *Progress description* value #2 "Destination address is non-ISDN" can also be returned.

If the *Progress indicator* information element is included in a call control message, the procedures described in the following apply. If the *Progress indication* information element is included in the *Progress* message, no state change occurs, but any supervisory timers are stopped. In both cases, if indicated by the *Progress indicator* information element, the user connects to—if not already connected—and 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 should include a *Progress indicator* information element with one of the following *Progress description* values:

- #1 "Call is not end-to-end ISDN (interworking trunk facilities); further call progress information may be available in-band"

- #3"Origination address is non-ISDN"

20.1.6 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 of the calling address

- enters the *Call delivered* state

When the user receives the *Alerting* message, the user may begin an internally generated alerting indication and enters the *Call delivered* state.

20.1.7 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. This stops a possible local indication of alerting.

On receipt of the *Connect* message, the calling user

- stops any user-generated alerting indications

- (optionally) sends a *Connect acknowledge* message

- enters the *Active* state

The network takes no action on receipt of a *Connect acknowledge* message if it sees the call is in the *Active* state.

20.1.8 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 section 20.3 on page 241. It uses the *Cause* provided by the terminating network or the called user.

20.2 Call establishment at the destination interface

This procedure assumes that a data link connection providing services described in the Layer 2 procedures—as outlined in Part III of this specification—exists before the first Layer 3 message (that is a *Setup* message) is transferred across the interface.

All Layer 3 messages are sent to the data link layer using a *DL-Data-Request* primitive.

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 delivered by the network.

20.2.1 Incoming call

The network indicates the arrival of a call at 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 section 18.1.10, "Setup" on page 180.

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 *Setup* message is retransmitted and timer T303 is restarted.

20.2.2 Compatibility checking

A user receiving a *Setup* message performs compatibility checking before responding to the *Setup* message. Any reference to "user" in this chapter implicitly refers to compatible user equipment.

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 section 20.1.4 on page 233.

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 or rejects the offered call using *Cause* value #88 "Incompatible destination".

Action in the event of a mismatch

An incompatible user responds to the *Setup* message with

• a *Release complete* message with *Cause* value #88 "Incompatible destination"

• enters the *Null* state

20.2.3 B-channel selection—destination

When the *Setup* message is delivered by a point-to-point data link, negotiation for the selection of a B-channel is permitted between the network and the user. Only B-channels controlled by the same D-channel can be the subject of the selection procedure.

The selection procedure is as follows:

- In the *Setup* message, the network indicates one of the following:

    - case 1: channel is indicated, no acceptable alternative

    - case 2: channel is indicated, any alternative is acceptable

    - case 3: any channel is acceptable

      The DMS-100 does not support this option o outgoing calls. A channel is always selected for the outgoing call prior to sending the *Setup* message.

- The response to these procedures is as follows:

    - for case 1 and 2, if the indicated channel is acceptable and available, the user selects it for the call

    - for case 2, if the user cannot grant the indicated channel, it selects any other available B-channel associated with the D-channel, and identifies that channel in the first message sent in response to the *Setup* message

    - for case 1, if the B-channel indicated in the first response message is not the channel offered by the network, or in case 2, the B-channel indicated in the first response message is unacceptable to the network, it clears the call by sending a *Release message* with *Cause* value #6 "Channel unacceptable"

- If no *Channel identification* information element is present in the first response message, the B-channel indicated in the *Setup* message is assumed.

- When a B-channel has been selected by the user, the user may connect to that channel.

- In case 1, if the indicated B-channel is not available, or in cases 2 and 3, if no B-channel is available, the user returns a *Release complete* message with *Cause* value

    - #44 "Requested circuit or channel not available"

    - OR, #34 "No circuit/channel available"

- The user returns to the *Null* state

20.2.4 Call confirmation
Response to Setup

When the user determines that sufficient call setup information has been received and compatibility requirements (see section 20.2.2 on page 236) have been satisfied, the user responds with a *Call proceeding,* an *Alerting,* or a *Connect* message. It enters the *Incoming call proceeding, Call received,* or *Connect request* state, respectively.

> *Note 1:* A *Progress indicator* information element may be included an *Alerting* message.

> *Note 2:* The *Call proceeding* message may be sent by a user that cannot respond to a *Setup* message with an *Alerting, Connect,* or *Release complete* message before expiration of timer T303.

An incompatible user responds by

*   sending a *Release complete* message with *Cause* value #88 "Incompatible destination"

*   entering the *Null* state

The network processes this *Release complete* message in accordance with the procedures described in , "Called user clearing during incoming call establishment" on page 239 in this section.

A busy user that satisfies the compatibility requirements indicated in the *Setup* message normally responds with a *Release complete* message with *Cause* value #17 "User busy".

The network processes this *Release complete* message in accordance with the procedures described in , "Called user clearing during incoming call establishment" on page 239 in this section.

If the user wishes to refuse the call

*   a *Release complete* message is sent with the *Cause* value #21 "Call rejected"

*   user returns to the *Null* state

The network processes this *Release complete* message in accordance with the procedures described in , "Called user clearing during incoming call establishment" on page 239 in this section.

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

The *Call proceeding* message contains a *Channel identification* information element.

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.

Called user clearing during incoming call establishment

If a *Release complete* or *Disconnect* message is received before a *Connect* message, the network

- stops timer T303 or T310 (if running)

- continues to clear the user as described in section 20.3.3 on page 242

- clears the call to the calling user with the *Cause* value received in the *Release complete* or *Disconnect* message

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. The called user is cleared in accordance with the procedures defined in section 20.3.4 on page 244 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. The called user is cleared in accordance with the procedures defined in section 20.3.4 on page 244 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. The called user is cleared in accordance with the procedures defined in section 20.3.4 on page 244 using *Cause* value #102 "Recovery on timer expiry"

20.2.5 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,

- the call may be to or from non-ISDN equipment

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 has *Progress description* value #1 "Call is not end-to-end ISDN (interworking trunk facilities); further call progress information may be available inband". *Progress description* value #3 "Origination address is non-ISDN" can also be returned.

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 section 20.2.7 on page 241.

In addition, the called user notifies the calling party of the following:

- whether the call has left the ISDN environment within the called user's premises

- possible availability of in-band information or patterns

When such situations occur, a *Progress indicator* information element is sent by the user to the network in an appropriate call control message when a state change is required (*Alerting* or *Connect,* for example). The *Progress indicator* information element has the following *Progress description* value:

- #2 "Destination address is non-ISDN"

20.2.6 Call accept

A user indicates acceptance of an incoming call by sending a *Connect* message to the network. When the *Connect* message is sent, the user starts timer T313 (the value of timer T313 is specified in Chapter 21: "List of system parameters"). 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.

20.2.7 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 which first accepted the call

- 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.

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 in accordance with the procedures defined in section 20.3.3 on page 242.

A user that has received the *Setup* message may connect to the B-channel as soon as channel selection has been completed.

20.3 Call clearing

20.3.1 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.

20.3.2 Exception conditions

Under normal conditions, call clearing is usually initiated when the user or the network sends a *Disconnect* message and follows the procedures defined in section 20.3.3 on page 242 or section 20.3.4 on page 244, respectively. The only exceptions to this rule are as follows:

- 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 (see section 20.2.3 on page 237 and section 20.1.2 on page 232) by the side offering the call. The call is terminated by sending a *Release* message as described in section 20.3.3 on page 242 and section 20.3.4 on page 244. The *Release* message has *Cause* value #6 "Channel unacceptable".

20.3.3 Clearing initiated by the user

Apart from the exception conditions identified in section 20.3.2 on page 242 and section 20.8 on page 253, the user initiates clearing by

- sending a *Disconnect* message

- starting timer T305 (the value of timer T305 is specified in Chapter 21: "List of system parameters")

- disconnecting the B-channel

- entering the *Disconnect request* state

    Note: When a user initiates call clearing by sending a *Release* message, the procedures described in section 20.3.4 on page 244 are followed.

The network enters the *Disconnect request* state upon receipt of a *Disconnect* message. This message causes the network to disconnect the B-channel and to initiate procedures for clearing the network connection to the remote user. When the B-channel used for the call has been disconnected, the network

- sends a *Release* message to the user

- starts timer T308 (the value of timer T308 is specified in Chapter 21: "List of system parameters")

- 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

- returns to 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

- returns to 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

- returns to 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. In addition, the user may indicate a second *Cause* information element with value #102 "Recovery on timer expiry"

If user timer T308 expires for the first time, the user

- retransmits the *Release* message

- restarts timer T308

In addition, the user may indicate a second *Cause* information element with a 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

- returns to the *Null* state

   Note: The restart procedures contained in section 20.7 on page 253 may be used on B-channels in the maintenance state.

20.3.3.1 Cause screening
Normally, the terminating interface on the DMS-100 receives an initial call clearing message with an associated cause. If the cause does not result in reroute attempt or inband treatment, then the originating interface on the DMS-100 sends a clearing message to the user containing the cause received from the terminating interface.

20.3.4 Clearing initiated by the network
Apart from the exceptions identified in section 20.3.2 on page 242 and section 20.8 on page 253, the network initiates clearing by

- sending a *Disconnect* message

- entering the *Disconnect indication* state

   Note: When the network initiates clearing by sending a *Release* message, the procedures in section 20.3.3 on page 242 are followed.

Clearing when tones or announcements are provided
When tones or announcements are provided in conjunction with call clearing the network sends either a *Disconnect* message or a *Progress* message (see section 20.4 on page 247).

- *Disconnect* **Message**

   When tones or announcements are provided, the *Disconnect* message contains progress indicator (PI) #8 (in-band information of appropriate pattern now available). The network starts timer T306 and enters the *disconnect indication* state.

   On receipt of the *Disconnect* message with progress indicator #8, the user: connects (if not already connected) to the B-channel to receive the tone or announcement; and then enters the *disconnect indication* state. Alternatively, to continue clearing without connecting to the tone or announcement, the user: disconnects the B-channel; sends a *Disconnect* message; starts timer T308; and enters the *release request* state.

   If the user connects to the provided tone or announcement, the user subsequently continues clearing (before the receipt of a *Release* from the

network) by: disconnecting from the B-channel; sending a *Release* message; starting timer T308; and entering the *release request* state.

On receipt of the *Release* message, the network: stops timer T306; disconnects and releases the B-channel; sends a *Release Complete* message; releases the call reference; and returns to the *null* state.

If timer T306 expires, the network continues clearing by: disconnecting the B-channel; sending a *Release* message with the cause number originally contained in the *Disconnect* message; starting timer T308; and entering the *release request* state.

- *Progress* **Message**

  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, instead of 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.

Clearing when tones or announcements are not provided

When tones or announcements are *not* provided, clearing is initiated by the network, when the network: sends a *Disconnect* message; starts timer T305; disconnects the B-channel; and enters the *Disconnect indication* state.

On receipt of the *Disconnect* message the user: disconnects the B-channel; sends a *Release* message; starts timer T308; and 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; and returns to 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; and enters the *Release request* state.

In addition to the original clearing cause, the *Release* message may contain a second *Cause* information element with a value #102 "Recovery on timer expiry".

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; and returns to 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 timer T308 expires a second time, the network: places the B-channel in a maintenance state; releases the call reference; and returns to the *Null* state.

If a *Release complete* message is not received by the user before the first expiry of timer T308 the *Release* message is retransmitted and timer T308 is restarted

In addition to the original clearing cause, the *Release* message may contain a second *Cause* information element with a value #102 "Recovery on timer expiry".

If no *Release complete* message is 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

- returns to the *Null* state

    Note: The restart procedures contained in section 20.7 on page 253 may be used on B channels in the maintenance state.

20.3.5 **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)

20.4 **In-band tones and announcements**

In-band treatment procedures apply only for PRI calls with a bearer capability (BC) of speech or 3.1 kHz audio. When inband 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".

When tones or announcements have to be provided together with a call state change, the appropriate message (for example, *Alerting)* with *a Progress indicator* information element with *Progress description* value #8 "In-band information or appropriate pattern now available" is sent simultaneously with the application of the in-band tone or announcement.

Note 1: 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 specified in section 20.3.3 on page 242.

Note 2: The protocol currently described in this specification applies at the calling user-to-network interface. The *Progress* message is not sent in the user-to-network direction.

20.5 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(s) 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 announcements be sent to the calling user

In addition, three call types need to be considered:

* type 1, within ISDN

* type 2, from non-ISDN to ISDN

* type 3, from ISDN to non-ISDN

For these procedures, the non-ISDN network provides tones and announcements as currently implemented regardless of the network connection and call scenario. An ISDN exchange acts independently of the three network connections, that is, it is independent of the possible existence and character of interworking.

The terms *originating exchange* and *terminating exchange* are used in the following description to refer to equipment such as private branch exchanges (PBXs) or central offices(COs) that are closest to the respective end users. An intermediate exchange is a PBX or CO situated between the originating and terminating exchanges.

20.5.1 Generation of audible ringback tones

The terminating exchange (either ISDN or non-ISDN) is responsible for the generation of audible ringback tones for all three types of calls.

Calls terminating on ISDN facilities

This section describes procedures for calls involving network connections that remain in the ISDN network(s) (type 1 calls) or are from non-ISDN networks but terminate on an ISDN network (type 2 calls).

In order to remain consistent with the pre-ISDN implementation, audible ringback tone is provided by the terminating exchange.

For type 1 calls, audible ringback is generated by the terminating exchange. The network assumes that the user provides other tones and announcements and therefore clears the call back to the originating user in the event of call failure.

For type 2 calls, the following procedure is performed:

- the terminating exchange determines it is a type 2 call by the presence of the *Progress indicator* information element in the *Setup* message, having *Progress description* value #1 "Call is not end-to-end ISDN (interworking trunk facilities); further call progress information may be available in-band".

- if the call proceeds through the network and successfully reaches the terminating exchange, the terminating exchange

  – determines if the endpoint terminal is available

  – if so, alerts the end-user terminal, propagates the alerting indicator back to the originating exchange and provides in-band audible ringback tone

  – when the terminal at the terminating exchange answers the call by sending a *Connect* message (or equivalent "off-hook" indication) audible ringback is removed, and the *Connect* message is propagated back towards the originating exchange

ISDN to non-ISDN calls

For this call type—call type 3— interworking occurs at the interworking exchange. When the interworking condition is detected, it is the responsibility of the interworking exchange to send a *Progress* message towards the originating side of the interface. The *Progress* message contains the *Progress indicator* information element having *Progress description* value #1 "Call is not end-to-end ISDN (interworking trunk facilities); further call progress information may be available in-band".

This is an indication that the call has left the ISDN network and that audible ringback is provided in-band from the terminating exchange. The *Progress*

message, in conjunction with interexchange signalling, causes cut through from the ISDN originating exchange to the interworking exchange. Further, the interworking exchange monitors the outgoing non-ISDN trunking facilities for answer and disconnect supervision. These conditions, upon detection, are translated into *Connect* or *Disconnect* messages, respectively, for the ISDN side of the call.

20.5.2 Generation of busy tones

In-band busy tones are generated as close as possible to the calling user, allowing network resources used to reach the terminating exchange to be released. The user can subscribe to have the network provide busy tone as a subscription option.

ISDN to ISDN (call type 1)

Upon notification that the called user is busy, the terminating exchange generates a *Disconnect* message with *Cause* value #17 "User busy" towards the originating side. In response to this message, the originating exchange disconnects the B-channel and generates the in-band busy tone locally.

Non-ISDN to ISDN (call type 2)

Upon notification that the called user is busy, the terminating exchange generates an appropriate clearing message towards the originating side. In response to this message from the ISDN network, the interworking exchange generates the busy tone towards the originating user.

ISDN to non-ISDN (call type 3)

In this call type, the busy tone is generated by the terminating exchange. In this call type, a *Progress* message with *Progress indicator* information element with *Progress description* value #1 is sent towards the originating user by the interworking exchange indicating that the call is not end-to-end ISDN and that call progress information is only available in-band. The *Progress* message causes cut through from the originating exchange to the interworking exchange.

20.5.3 Announcements

Calls within an ISDN network may still have treatment applied, involving in-band information, for example, tones or voice announcements.

The cut-through procedures ensure that in-band tones may be provided. Therefore, the network or user may insert in-band tones or announcements after returning or receiving the initial response to the *Setup* message.

20.6 Restart procedure

The restart procedure is used to return channels and interfaces to an idle condition. The procedure is 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. This is due to the absence of a response to the *Release* message (to restart that specific channel).

- when adding or returning B channels to service from a Maintenance or Out of Service State

- (optionally) on data link establishment at time of system initialization

20.6.1 Sending Restart

A *Restart* message is sent by the network or user to return channels or interfaces to the *Null* state. The *Channel identification* information element must be present in the *Restart* message when a specified channel, or interface other than the one containing the D-channel, is returned to the idle condition. If the *Channel identification* information element is absent, this indicates that the interface containing the D-channel requires restarting.

In the event of a global restart, the *Restart* message is sent without any channel identification information.

After transmitting the *Restart* message, the sender

- enters the *Restart request* state

- starts timer T316

- waits for a *Restart acknowledge* message

No further *Restart* message is sent until a *Restart acknowledge* message is received, or timer T316 expires.

When the *Restart acknowledge* message is received

- timer T316 is stopped. This frees the channels and call reference values for reuse. (Note that in the DMS-100, the call is cleared prior to sending a *Restart* message and therefore call reference values are ready for reuse prior to sending that message.)

- sender enters the *Null* state

If a *Restart acknowledge* message is not received prior to the expiry of timer T316, one or more *Restart* messages are sent until a *Restart acknowledge* message is returned. Meanwhile, no calls can be placed or accepted over the channel or interface by the originator of the *Restart* message.

After two unsuccessful restart attempts, an indication will be provided to the appropriate maintenance entity. The channel or interface is considered to be in an out-of-service condition until maintenance action has been taken. Further restart attempts may be made.

In the event of a global *Restart*, there is no restriction on the number of restart attempts. The message will continue to be resent until it is successful.

The *Restart* and *Restart acknowledge* messages contain the global call reference value (all zeroes) with which the *Restart request* state is associated. These messages are transferred using the appropriate point-to-point data link in the multiple frame mode using the *DL-Data-Request* primitive.

20.6.2 Receipt of Restart

After receiving a *Restart* message, the recipient

• enters the *Restart* state associated with the global call reference

• starts timer T317

• initiates the appropriate internal actions to return the specified channels to the idle condition and call references to the *Null* state

• after completion of internal clearing, a *Restart acknowledge* message is transmitted to the originator

• enters the *Null* state

If timer T317 expires prior to completion of internal clearing, a primitive should be transmitted to the system management entity. No *Restart acknowledge* is sent in this instance.

> *Note:* Even if all call references are in the *Null* state, and all channels are in the idle condition, the receiving entity transmits a *Restart acknowledge* message to the originator after receiving a *Restart* message.

20.6.3 Restart collisions

A Restart collision occurs when a *Restart* has been sent and a *Restart* message is received before a *Restart acknowledge* message is received. If both sides of the interface have initiated simultaneous restart requests, each request is managed independently. If the same channels or interface are specified, these are not considered free until the restart procedures are completed (see Figure 78).

Figure 78 Restart collision

Note 1:: X and Y can be a single channel, multiple channels, or an interface.

Note 2: If X = Y, the channels or interface are not available for call processing until both sides have reponded to the Restart request
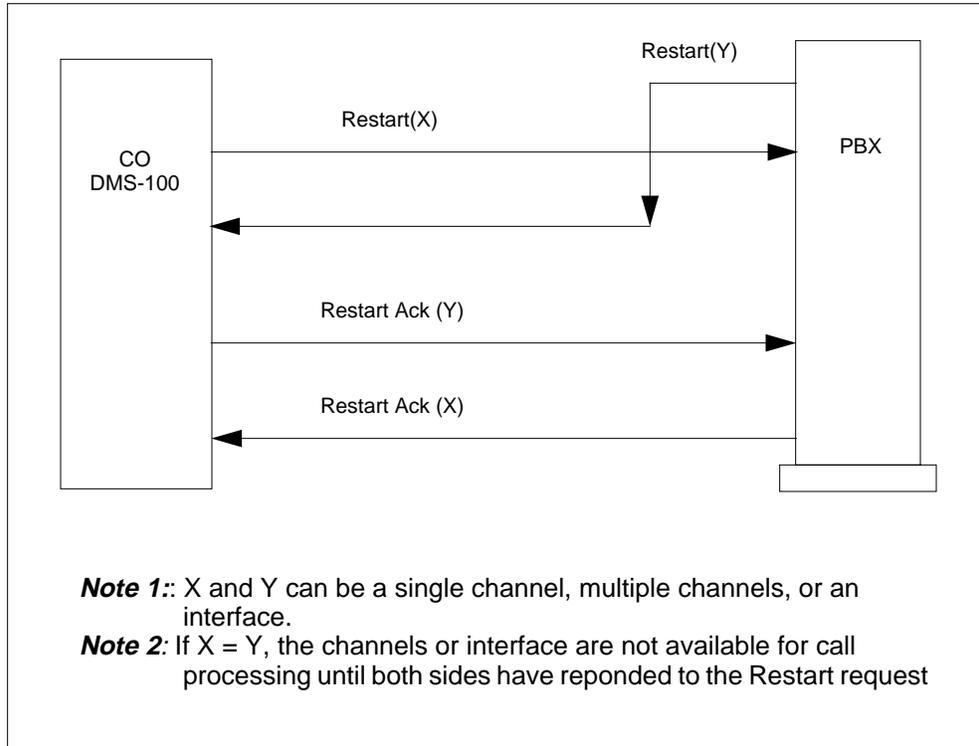
20.7 Call collisions

Call collisions cannot occur in the network. Any simultaneous incoming or outgoing calls are managed separately and are assigned different call references.

Channel selection conflicts may occur if an incoming call and outgoing call select the same channel. This is resolved by the network through the channel selection mechanisms described in section 20.1.2 on page 232 and section 20.2.3 on page 237.

In such conflicts, the network gives priority to the incoming call over the call request received from the user. It clears the outgoing call if the B-channel cannot be

• allocated by the network

• accepted by the user originating the call

20.8 Handling of error conditions

All procedures transferring signaling information by using the protocol discriminator of "Q.931 user-network call control messages" are applicable

only to those messages which pass the checks described in section 20.8.1 on page 254 through section 20.8.7 on page 258.

The following paragraphs detail the procedures for the treatment of error conditions.

The network may establish a threshold for the number of messages or information elements received that are either incorrect or are not understood. The network does not release calls if the threshold is exceeded.

The section 20.8.1 on page 254 through section 20.8.7 on page 258 are listed in order of precedence.

20.8.1 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. That is, the network continues to operate as if the message had not been received. (See section 19.2, "Protocol discriminator" on page 188 for further details).

20.8.2 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. For a single octet reference value, the message must be at least 4 octets in length; for a two-octet reference value the message must be at least 5 octets in length.

20.8.3 Call reference error
Invalid call reference format

In the *Call reference* information element, if octet 1, bits 5 through 8 are not set to 0 0 0 0, 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 section 19.3, "Call reference" on page 188 for further details.)

When a message is received specifying the "dummy" call reference, this message is ignored.

Call reference procedural errors

- Whenever any message—except *Setup*, *Release*, *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* message is received that specifies a call reference value which is not recognized as relating to an active call or to a call in progress, a *Release complete* message with *Cause* value #81 "Invalid call reference value" is returned. This message specifies the call reference value of the received message.

- When a *Release complete* message is received specifying a call reference value which is not recognized as relating to an active call or to 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* 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 of section 20.8.11 on page 262 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".

20.8.4 Message type or message sequence errors

Whenever an unexpected message—except *Release* or *Release complete*—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, two exceptions to this procedure exist:

- 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 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 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 *Cause* value #16 "Normal call clearing"

        – 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

20.8.5 General information element errors

The general information element error procedures may also apply to information elements in code sets other than 0. The diagnostics in the *Cause* information element may indicate information elements other than those in code set 0 by applying the locking shift procedures as described in section 19.5, "Other information elements" on page 192.

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 the network or user receives a message containing an out-of-sequence
information element, it may ignore this information element and continue to
process the message.

If this information element is mandatory, and the network or user chooses to
ignore this out-of-sequence information element, the error handling procedure
for missing mandatory information elements as described in "Mandatory
information element content error" (section 20.8.6 on page 257) are followed.

If the ignored information element is not mandatory, the receiver continues to
process the message.

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.

20.8.6 Mandatory information element errors
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. 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 section 20.3 on page 241).
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".

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. 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 which 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 section 20.3 on page 241). 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. A *Status* message is returned with *Cause* value #100, "Invalid information element contents".

20.8.7 Non-mandatory information element errors

The following paragraphs identify actions on information elements not recognized as mandatory.

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 section 20.8.6 on page 257 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 may be returned. 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 the unrecognized information element. If multiple unrecognized information elements occurred in the message, the diagnostic field only contains the identifier of the first.

- Subsequent actions are determined by the sender of the unrecognized information elements. If a clearing message contains more than one unrecognized information element, the error is reported to the local user as follows:

  — When a *Disconnect* message is received that has more than one 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 contains the first information element identifier that is unrecognized.

  — When a *Release* message is received that has more than one 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.

  — When a *Release complete* message is received that has more than one unrecognized information element, no action is taken on the unrecognized information.

Note: Inclusion of the diagnostics is optional. The diagnostic field of *Cause* value #99 helps the network decide which recovery procedure to use when a *Status* message is received. Therefore, it is recommended that the user provide *Cause* value#99 with a diagnostic field.

Non-mandatory information element content error
When a message is received which 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 may be returned 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 element that has invalid contents.

Information elements with a length exceeding the maximum length (given in Section 3 of this specification) are treated as an information element with content error. A *Status* message is returned with *Cause* value #100, "Invalid information element contents". However, access information elements— *Called party subaddress, Lower layer compatibility,* for example— a *Status* message is returned with *Cause* value #43, "User information discarded"

20.8.8 Data link reset

Whenever a Q.931 entity 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 dis-establishment phase (states N11, N12, N19, U11, U12, and U19), no action is taken

- Calls in the establishment phase (states N1, N3, N4, N6, N7, N8, N9, U1, U3, U4, U6, U7, U8 and U9) are cleared according to the procedures defined in section 20.3 on page 241

- For calls in the active state (state N10), a *Status enquiry* is sent from the network to the user. For calls in the active state (state U10), a *Status enquiry* may be sent from the user to the network (see section 20.8.10 on page 261 and section 20.8.11 on page 262).

20.8.9 Data link failure

Whenever a Q.931 entity 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 carried out:

- Any calls not in an active state are cleared internally

- For any call in the active state, without a timer running, timer T309 is started (if timer T309 is implemented)

  Note: If timer T309 is already running, it is not restarted.

- The Q.931 entity 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, the Q.931 entity carries out the following procedures:

- 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 (see section 20.8.10 on page 261)

- If timer T309 expires prior to data link re-establishment, the network

  — clears the network connection

  — clears the 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

20.8.10 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. This may, in particular, apply to procedural error conditions described in section 20.8.8 on page 260 and section 20.8.9 on page 260.

After sending the *Status enquiry* message, timer T322 is started 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 does not directly affect the call state of either the sender or receiver. The side that receives the *Status* message inspects the *Cause* information element. If the *Status* message has *Cause* value

#97 "Message type non-existent or not implemented", timer T322 continues to run—waiting for an explicit response to the *Status enquiry* message.

If a *Status* message is received that has *Cause* value #30 "Response to status enquiry" the following events occur:

•   timer T322 is stopped

•   call is cleared if the status of the network side is not compatible with that on the user side

If timer T322 expires, and a *Status* message is received with *Cause* value #97 "Message type non-existent or not implemented", the call is cleared if the status of the network side is not compatible with that on the user side.

If timer T322 expires before a *Status* message is received, the call is cleared to both the calling and called parties with *Cause* value #41 "Temporary failure".

20.8.11 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) 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 options. If a DMS-100 is acting as the network a *Status enquiry* is sent out when the received state is incompatible and the procedures in section 20.8.10 on page 261 are followed.

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 left as an implementation option decision.

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 a *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 changes to 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 are an implementation option. If other procedures are not defined, the receiver clears the call with the appropriate procedure defined in section 20.3 on page 241. It uses the *Cause* specified in the received *Status* message. If a DMS-100 is acting as the network, it 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 Q.931 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.

> *Note:* Further action as a result of a higher layer activity (for example, system or layer management) is implementation dependent (including the retransmission of the *Restart* message).

Except for the above case, the error handling procedures—when receiving a *Status* message that specifies the global call reference—are implementation options.

Chapter 21: List of system parameters

21.1 Introduction

This chapter 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 precise details are found in Chapter 20: "Call control procedures", which should be considered the definitive description.The time-out values shown in these tables are recommended. They are modifiable by the telephone operating company.

This chapter is divided into two tables; Table 31 describes the timers on the network side of the interface and Table 32 describes the tables on the user side of the same interface. Northern Telecom does not support the user side of the interface at this time. The user side table is included for reference and guidance only.

Table 31 Timers on the network side of the interface

Timer number	Time-out value (secs)			State	When started	When stopped (normally)	Action taken on expiry
	Def	Min	Max				
T301	180	1	1023	N7	On receiving *Alerting* message	On receiving *Connect* message	Clear call
First start of T303	4	1	30	N6	On sending *Setup* message	On receiving *Call proceeding, Alert, Connect,* or *Release complete* message	Resend *Setup* message. Restart T303 If *Release complete* message is received, clear the call

Table 31 Timers on the network side of the interface (continued)

Timer number	Time-out value (secs)			State	When started	When stopped (normally)	Action taken on expiry
	Def	Min	Max				
Second start of T303	4	1	30	N6	On re-sending *Setup* message	On receiving *Call proceeding, Alert, Connect, Release complete* message	Clear network connection. Send *Release complete* message to called user Enter *Null* state
T305	30	1	80	N12	On sending *Disconnect* message without progress indicator #8	On receiving *Release* or *Disconnect* message	Send *Release* message. Start T308
T306	30	1	180	N12	On sending *Disconnect* message with progress indicator #8	On receiving *Release* or *Disconnect* message	Send *Release* message. Start T308
First start of T308	4	1	10	N19	On sending *Release* message	On receiving *Release* or *Release complete* message	Resend *Release* message. Restart T308
Second start of T308	4	1	10	N19	On re-sending *Release* message	On receiving *Release* or *Release complete* message	Invoke *Restart* procedures for the B-channel. Enter state N0
T309	90	1	120	Any stable state	On receiving *DL-Disconnect* Calls in stable state not lost	On receiving *DL-Reconnect*	Clear network connection
T310	180	1	200	N9	On receiving *Call proceeding* message	On receiving *Alerting, Connect,* or *Disconnect* message	Clear call in accordance with paragraph , Called user clearing during incoming call establishment, page 239
First start of T316	120	1	200	REST 1	On sending *Restart* message	On receiving *Restart acknowledge* message	Resend *Restart* message. Restart T316

Table 31 Timers on the network side of the interface (continued)

Timer number	Time-out value (secs)			State	When started	When stopped (normally)	Action taken on expiry
	Def	Min	Max				
Second start of T316	120	1	200	REST 1	On re-sending *Restart* message	On receiving *Restart acknowledge* message	Notify maintenance (system initialization)
T317	100	1	180	REST 0	On receiving *Restart* message	When call references cleared internally	Notify internal maintenance entity. Cleared channels placed in *Null* state. Place uncleared channels in an unavailable state
T322	4	1	30	Any, but not N0, N11, N12, N19	On sending *Status enquiry* message	Receipt of *Status, Disconnect, Release,* or *Release complete* message	Initiate call clearing

Table 32 Timers on the user side of the interface (see Note)

Timer number	Typical value (sec)	State	When started	When stopped (normally)	Action taken on expiry
First start of T303 (optional)	4	U1	On sending *Setup* message	On receiving *Call proceeding, Alert, Connect,* or *Release complete* message	Resend *Setup* message. Restart T303
Second start of T303 (optional)	4	U1	On re-sending *Setup* message	On receiving *Call proceeding, Alert, Connect, Release complete* message	Send *Release complete* message Enter *Null* state
T305	30	U11	On sending *Disconnect* message	On receiving *Release* or *Disconnect* message	Send *Release* message. Start T308
First start of T308	4	U19	On sending *Release* message	On receiving *Release* or *Release complete* message	Resend *Release* message. Restart T308

Table 32 Timers on the user side of the interface (see Note) (continued)

Timer number	Typical value (sec)	State	When started	When stopped (normally)	Action taken on expiry
Second start of T308	4	U19	On re-sending *Release* message	On receiving *Release* or *Release complete* message	Invoke *Restart* procedures for the B-channel Enter state N0
T309	90	Any stable state	On receiving DL-disconnect Calls in stable state not lost	On receiving *DL-Reconnect*	Release network connection
T310 (optional)	10	U3	On receiving *Call proceeding*	On receiving *Alerting, Connect, Progress,* or *Disconnect* message	Send *Disconnect* message
T313	4	U8	On sending *Connect* message	On receiving *Connect acknowledge* message	Send *Disconnect* message
First start of T316	120	REST 1	On sending *Restart* message	On receiving *Restart acknowledge* message	Resend *Restart* message. Restart T316
Second start of T316	120	REST 1	On re-sending *Restart* message	On receiving *Restart acknowledge* message	Notify maintenance (system initialization)
T317	< T316	REST 0	On receiving *Restart* message	When call references cleared internally	Notify internal maintenance entity.
T322	4	Any, but not U0, U11, U12, U19	On sending *Status enquiry* message	Receipt of *Status, Disconnect, Release,* or *Release complete* message	Initiate call clearing

Note: Northern Telecom does not support the user side of the interface at this time. This table is for reference only.

Chapter 22: Layer 3 SDL diagrams

22.1 Introduction

This chapter includes overview and detailed SDL diagrams which show Q.931 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 the prime source. Similarly, in the event of conflict between overview SDL and detailed SDL diagrams, the detailed SDL diagrams should be the prime source.

Northern Telecom does not support the user side of the interface at this time. The SDLs that are shown in the following figures for the user side are for reference only.

Figure 79 and Figure 80 show a key to the Q.931 protocol control SDL diagrams for network side and user side respectively.

Figure 81 through Figure 85 show overview control SDL diagrams for the user side (for reference only).

Figure 86 through Figure 101 show detailed control SDL diagrams for the user side (for reference only).

Figure 102 through Figure 105 show detailed SDL diagrams for the global call reference to be applied to the network side.

Figure 106 through Figure 111 show overview control SDL diagrams for the network side.

Figure 112 through Figure 129 show detailed control SDL diagrams for the network side.

Figure 79 Key to Q.931 protocol control SDL diagrams: network side
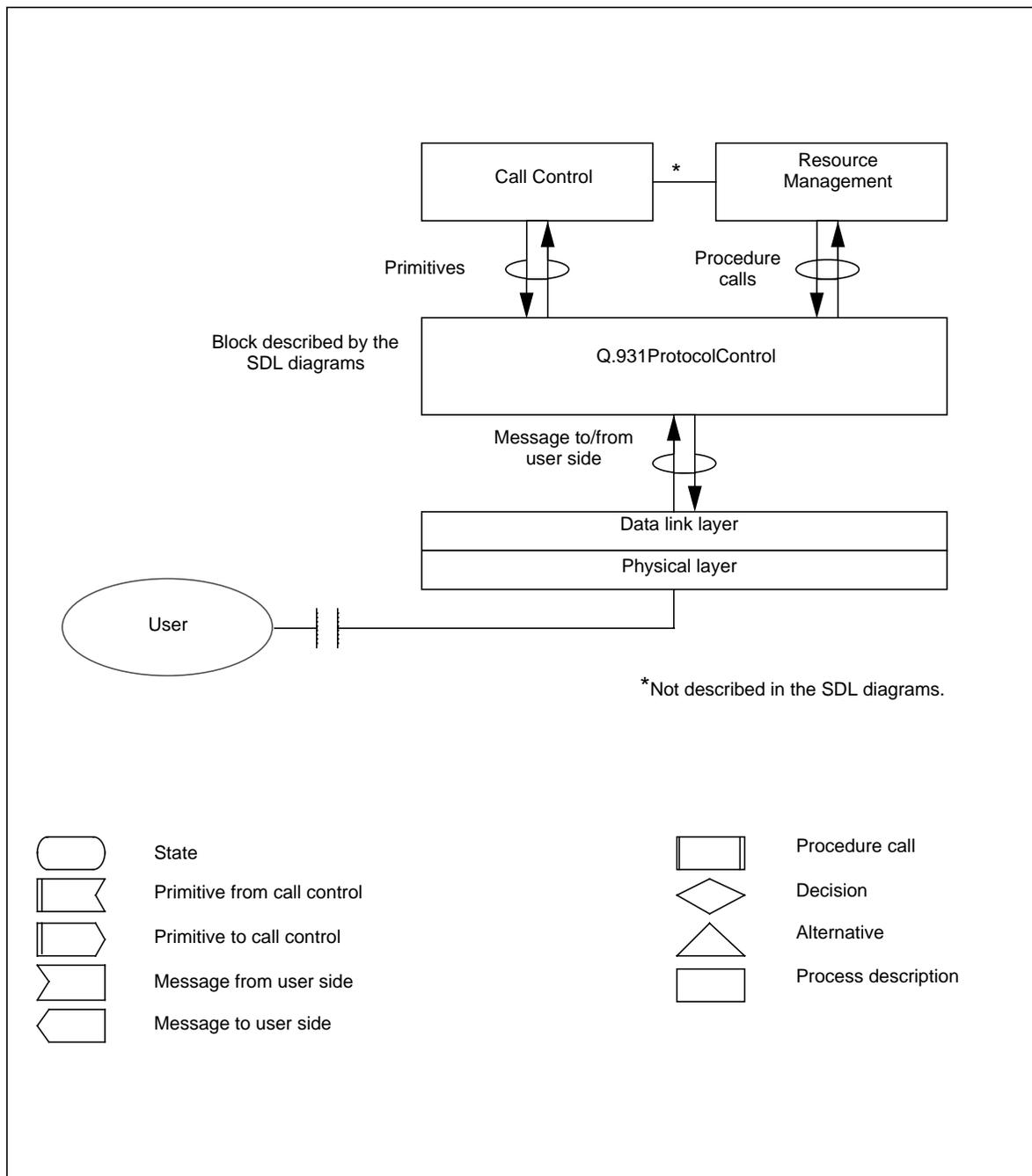
Figure 80 Key to Q.931 protocol control SDL diagrams: user side (see Note)

*Not described in the SDL diagrams.

Note: Northern Telecom does not support the user side of the interface at this time.

The figure is for reference only.
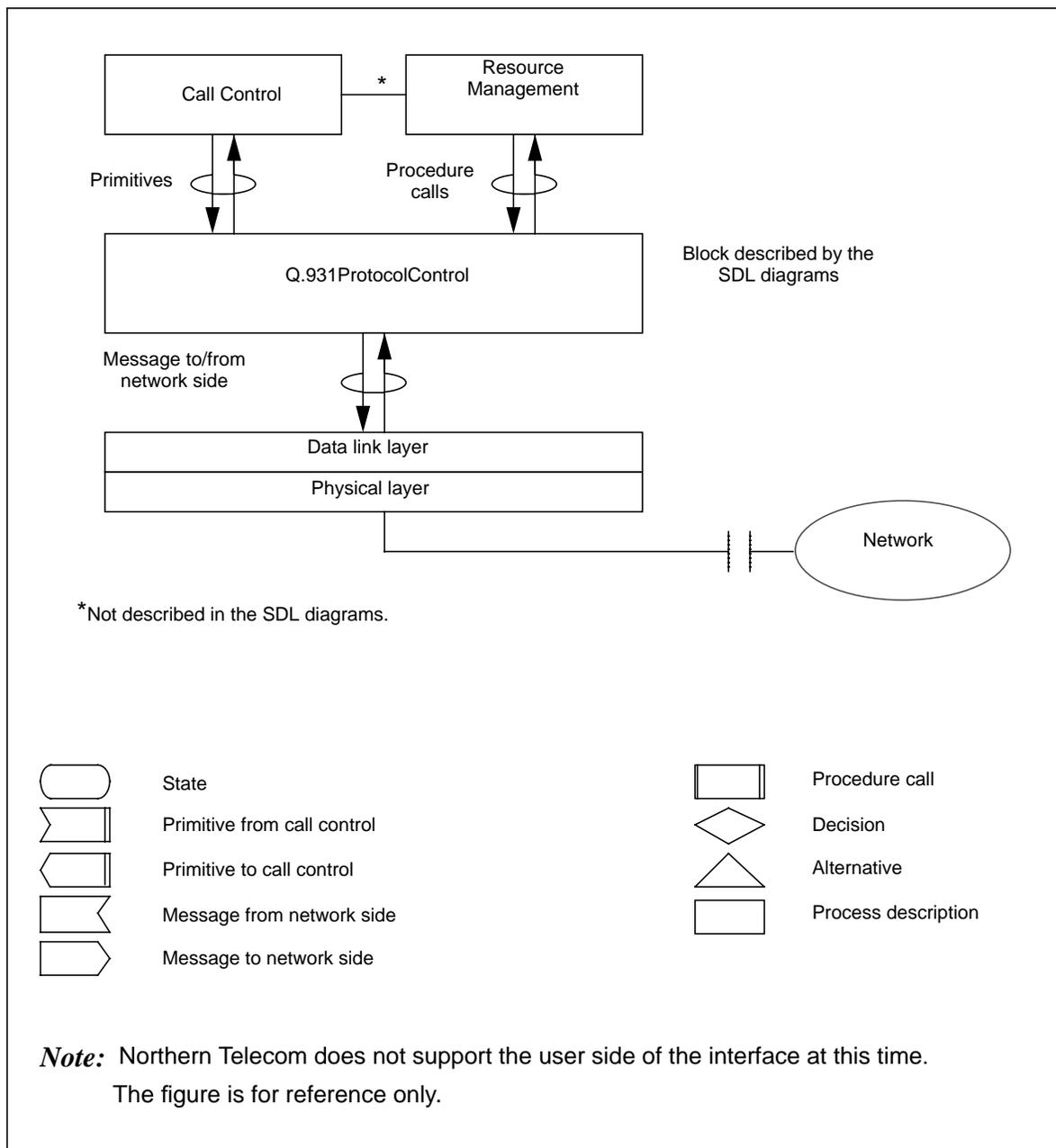
Figure 81 Overview protocol control: user side (1 of 5)—Outgoing set up procedure (1 of 2)

Note: Northern Telecom does not support the user side of the interface at this time. The figure is for reference only.
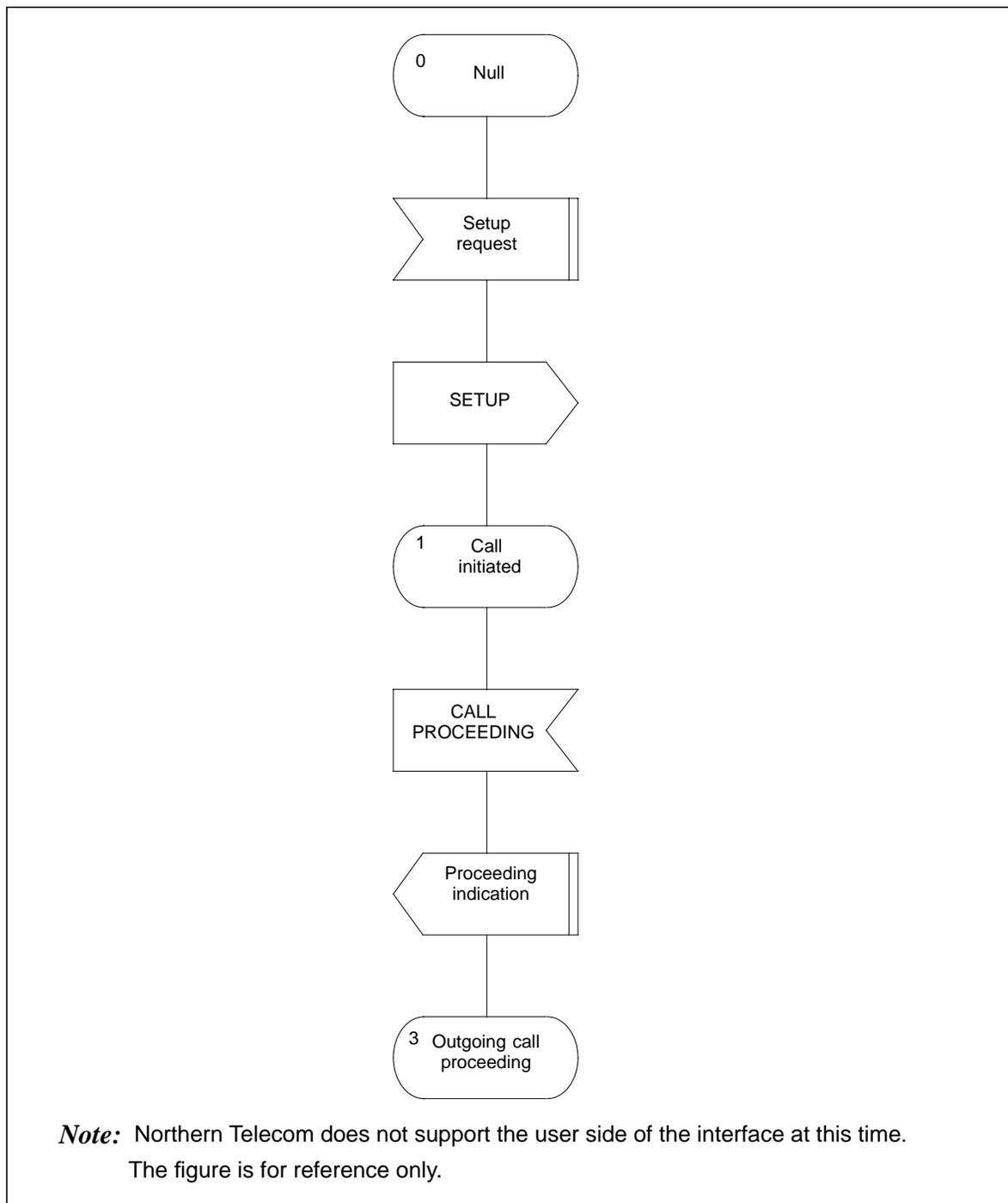
Figure 82 Overview protocol control: user side (2 of 5)—Outgoing set up procedure (2 of 2)

Note: Northern Telecom does not support the user side of the interface at this time. The figure is for reference only.
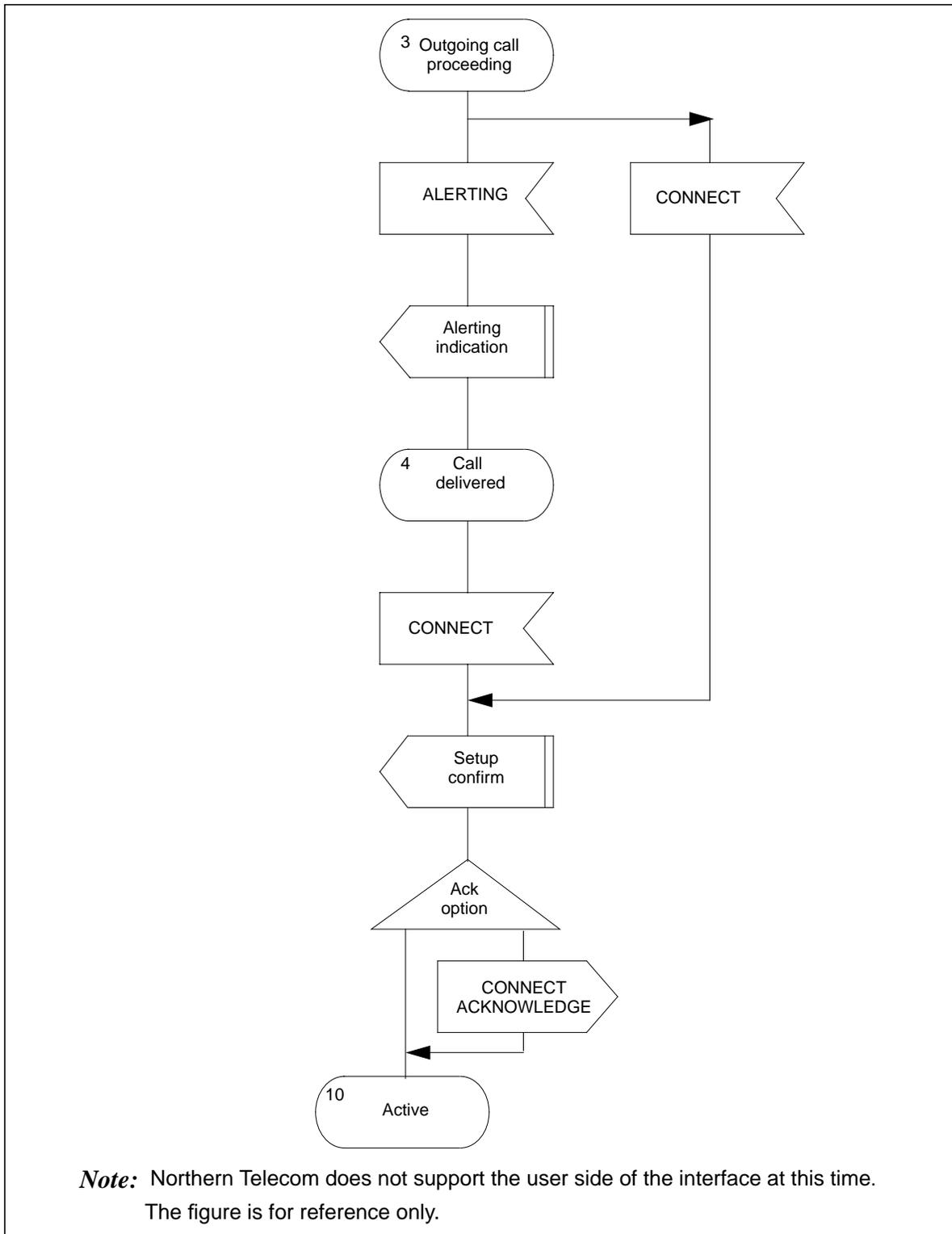
Figure 83 Overview protocol control: user side (3 of 5)—Incoming setup procedure (1 of 2)

Note: Northern Telecom does not support the user side of the interface at this time.
The figure is for reference only.
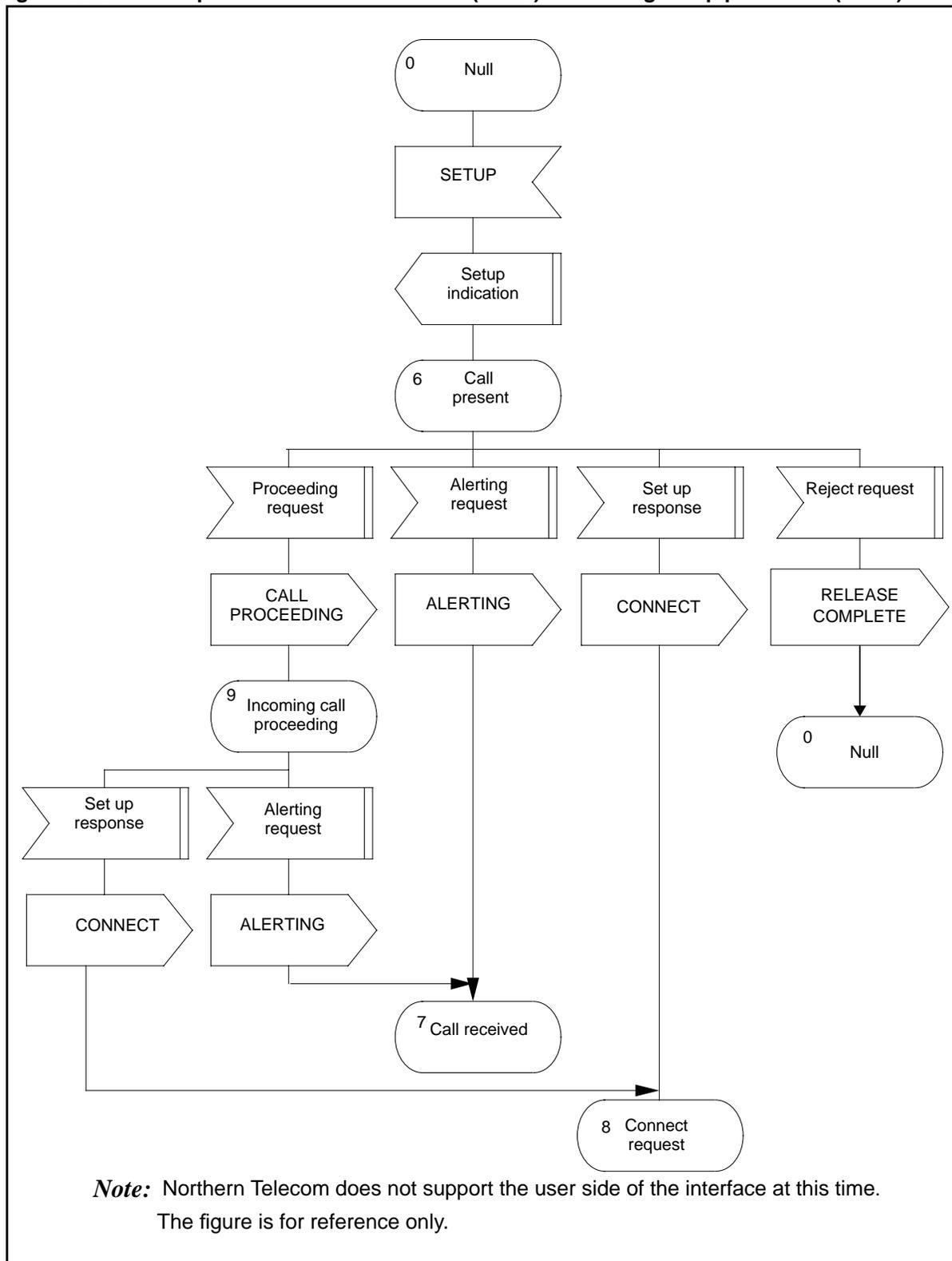
Figure 84 Overview protocol control: user side (4 of 5)—Incoming set up procedure (2 of 2)
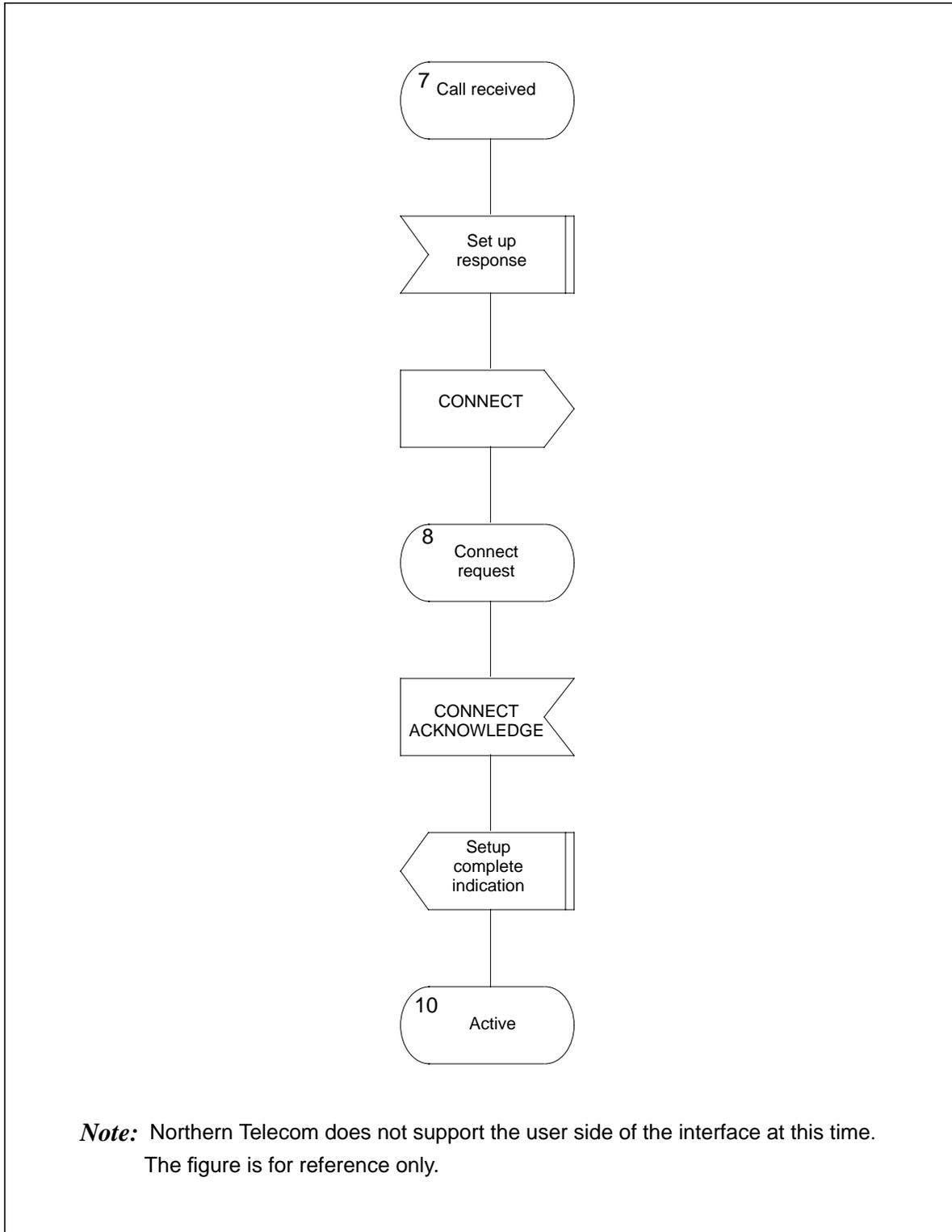
Note: Northern Telecom does not support the user side of the interface at this time. The figure is for reference only.

Figure 85 Overview protocol control: user side (5 of 5)—Clearing procedure (1 of 1)
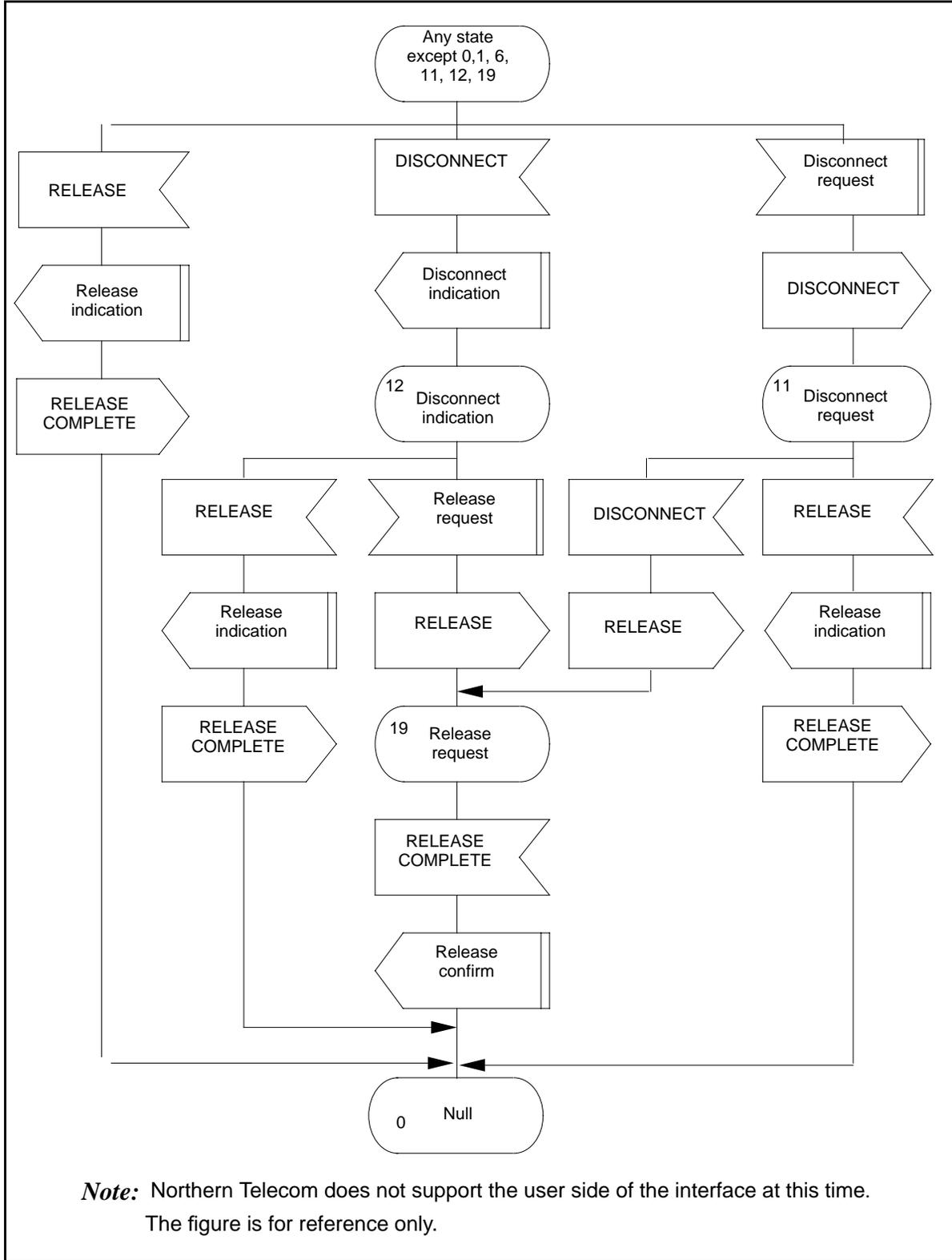
Note: Northern Telecom does not support the user side of the interface at this time.
The figure is for reference only.

Figure 86 Detailed protocol control: user side (1 of 16)
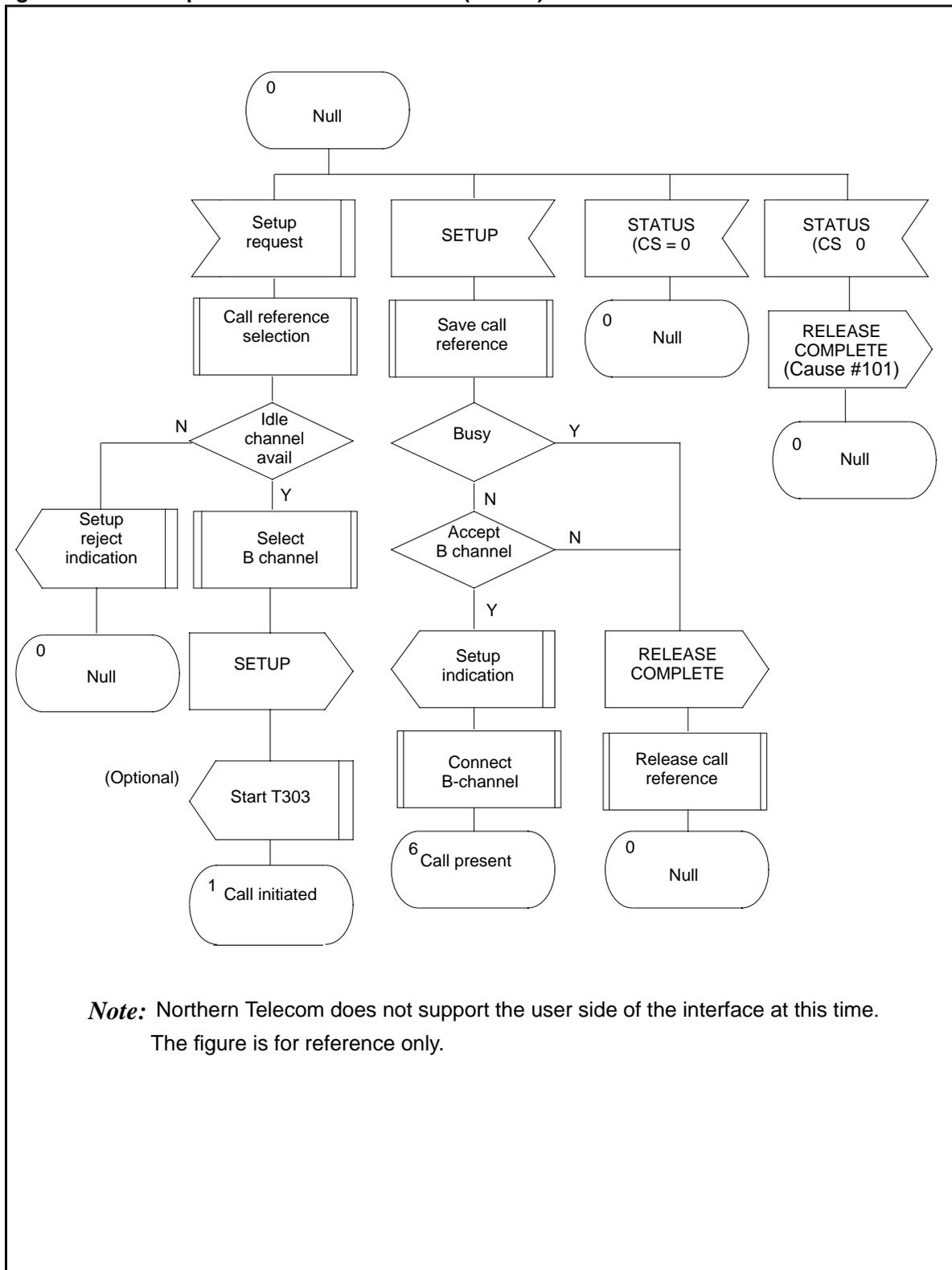
Note: Northern Telecom does not support the user side of the interface at this time. The figure is for reference only.

Figure 87 Detailed protocol control: user side (2 of 16)
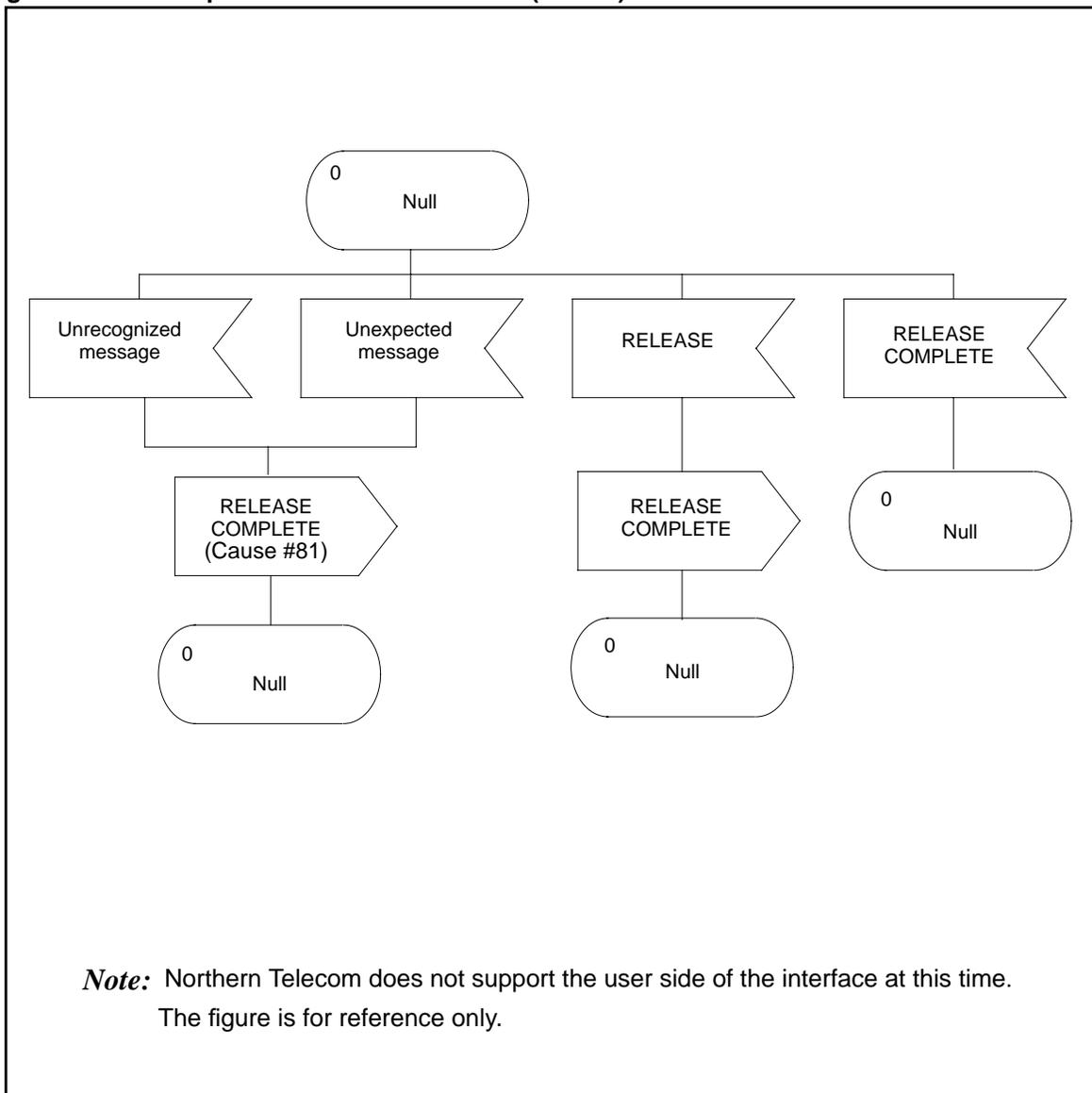
Note: Northern Telecom does not support the user side of the interface at this time. The figure is for reference only.

Figure 88 Detailed protocol control: user side (3 of 16)

Note: Northern Telecom does not support the user side of the interface at this time.
The figure is for reference only.
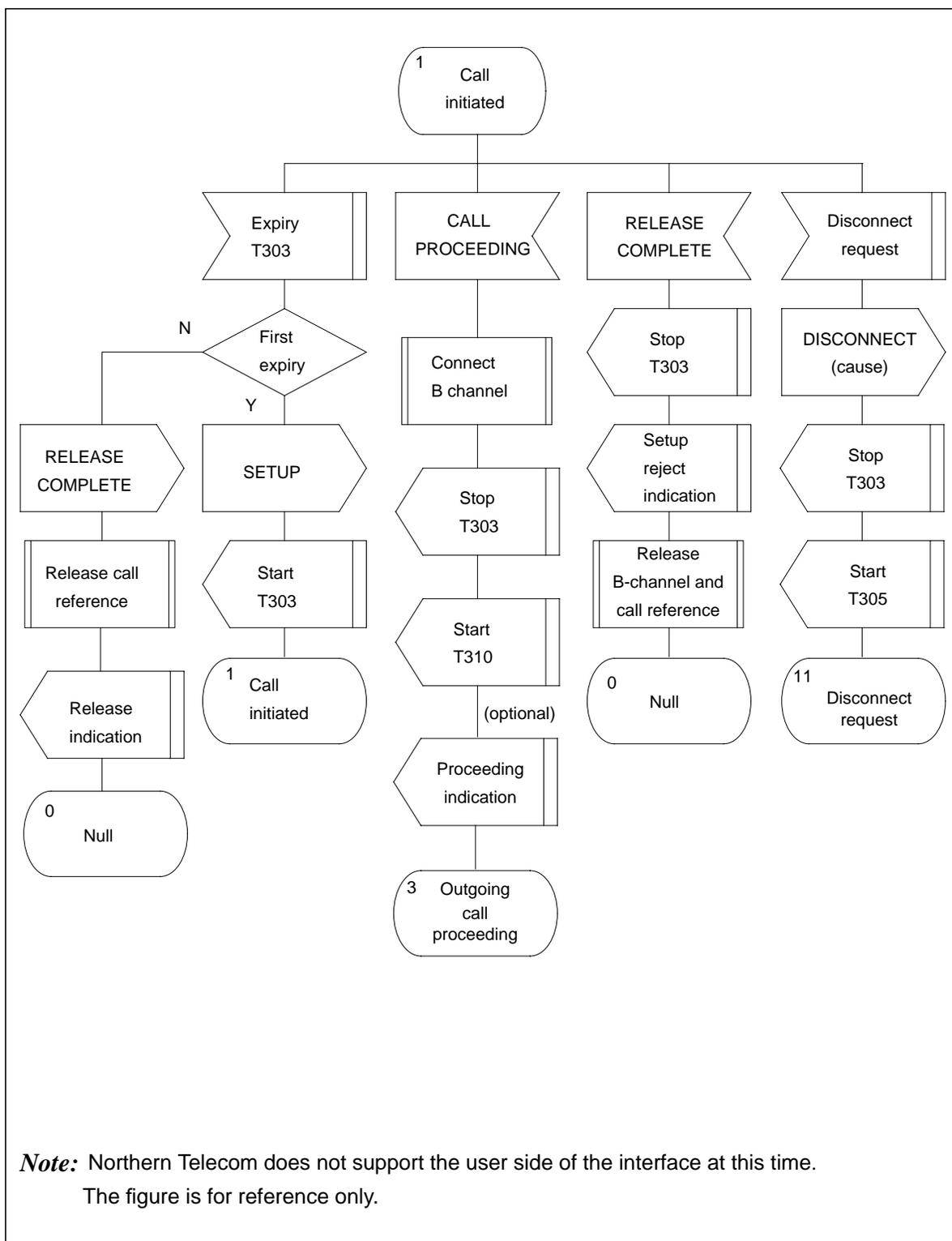
Figure 89 Detailed protocol control: user side (4 of 16)

Note: Northern Telecom does not support the user side of the interface at this time.
The figure is for reference only.
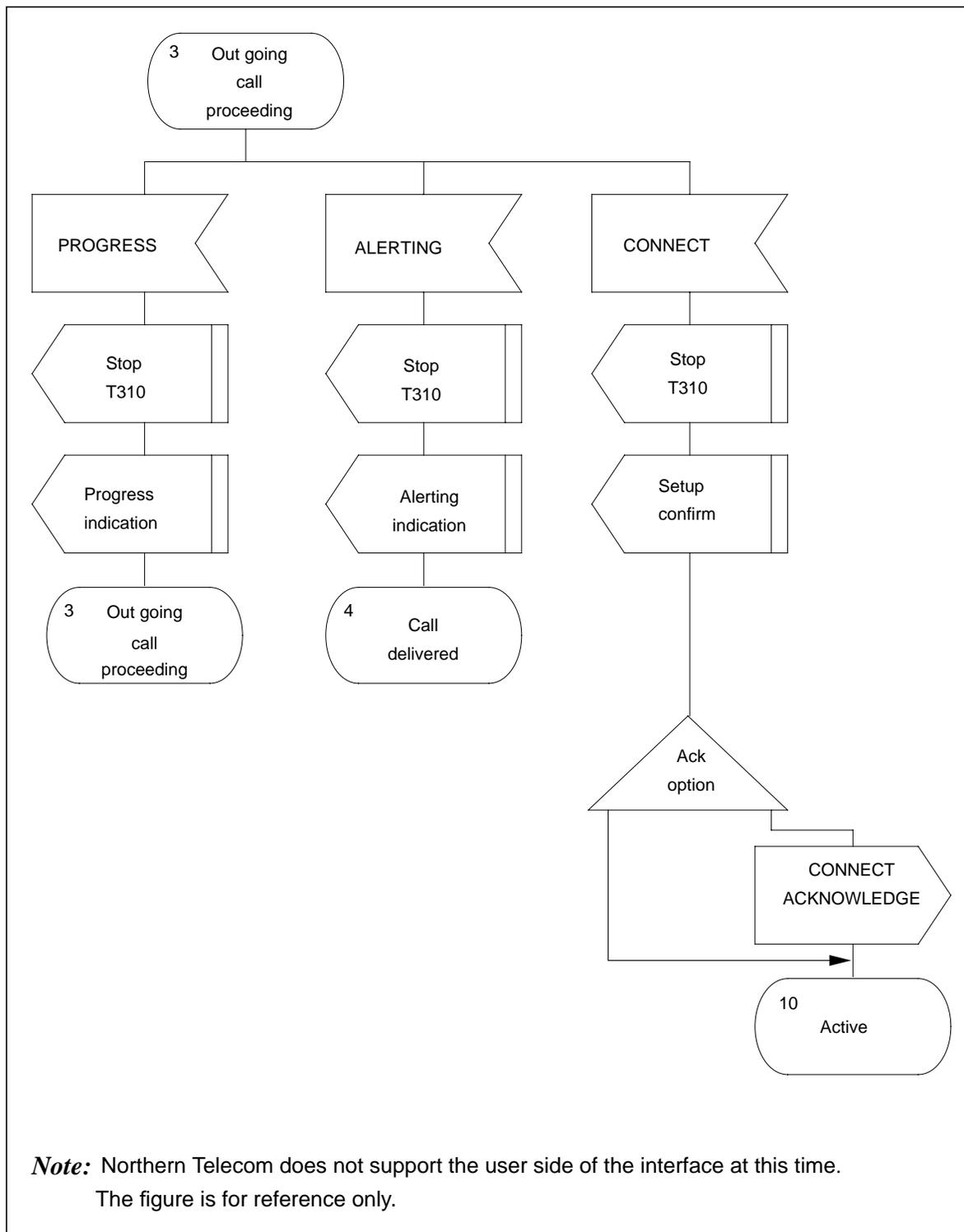
Figure 90 Detailed protocol control: user side (5 of 16)

Note: Northern Telecom does not support the user side of the interface at this time. The figure is for reference only.
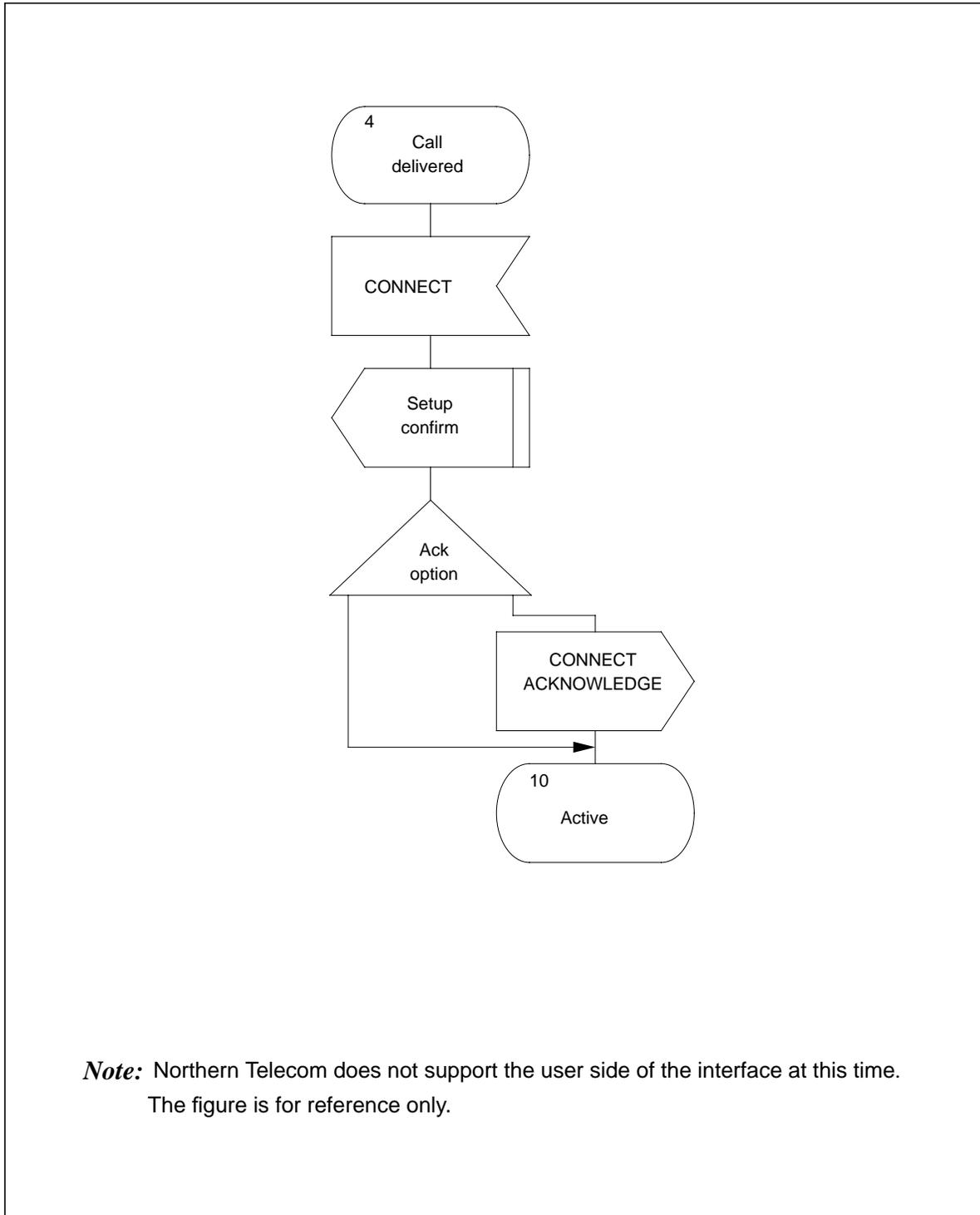
Figure 91 Detailed protocol control: user side (6 of 16)

Note: Northern Telecom does not support the user side of the interface at this time. The figure is for reference only.
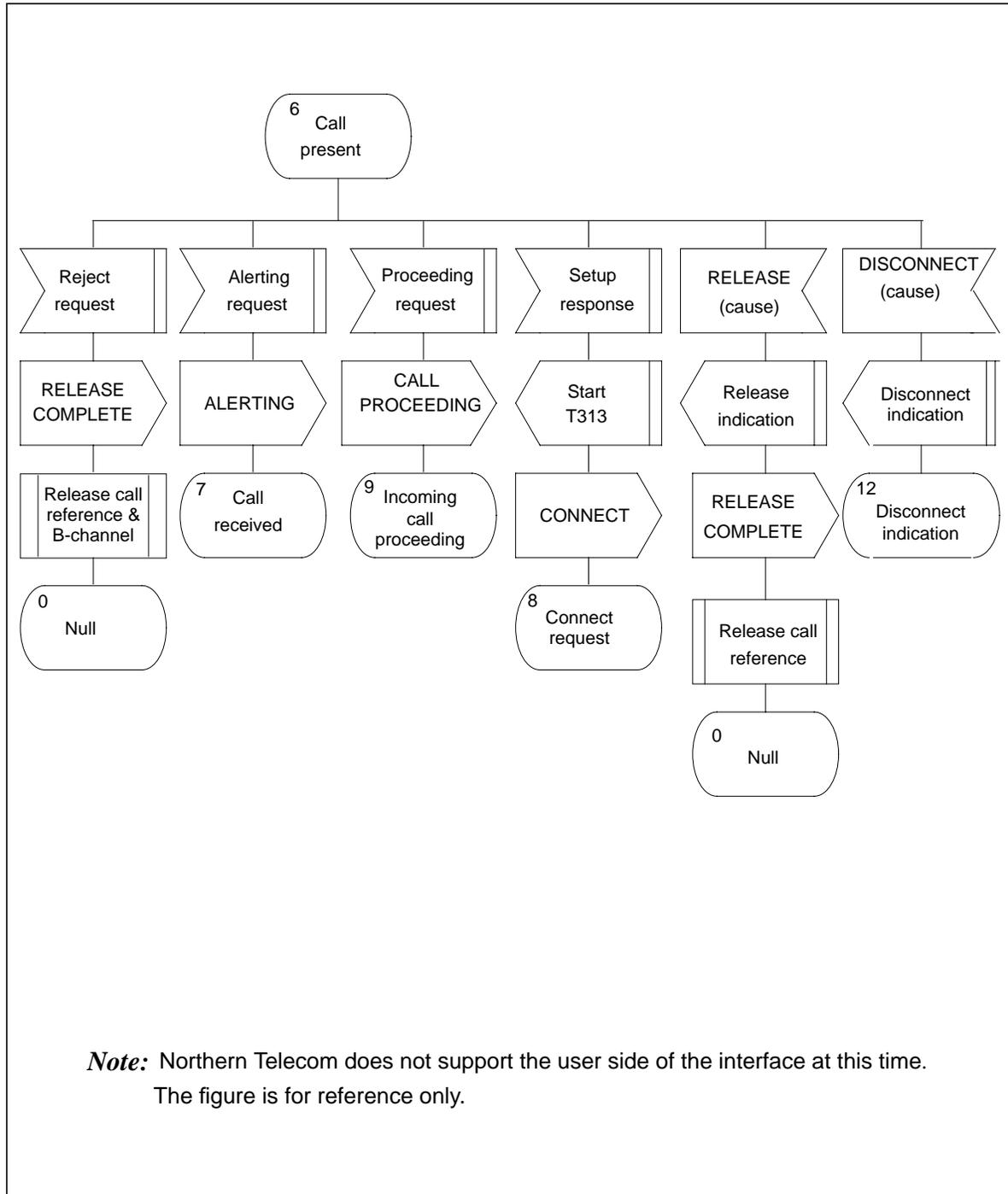
Figure 92 Detailed protocol control: user side (7 of 16)
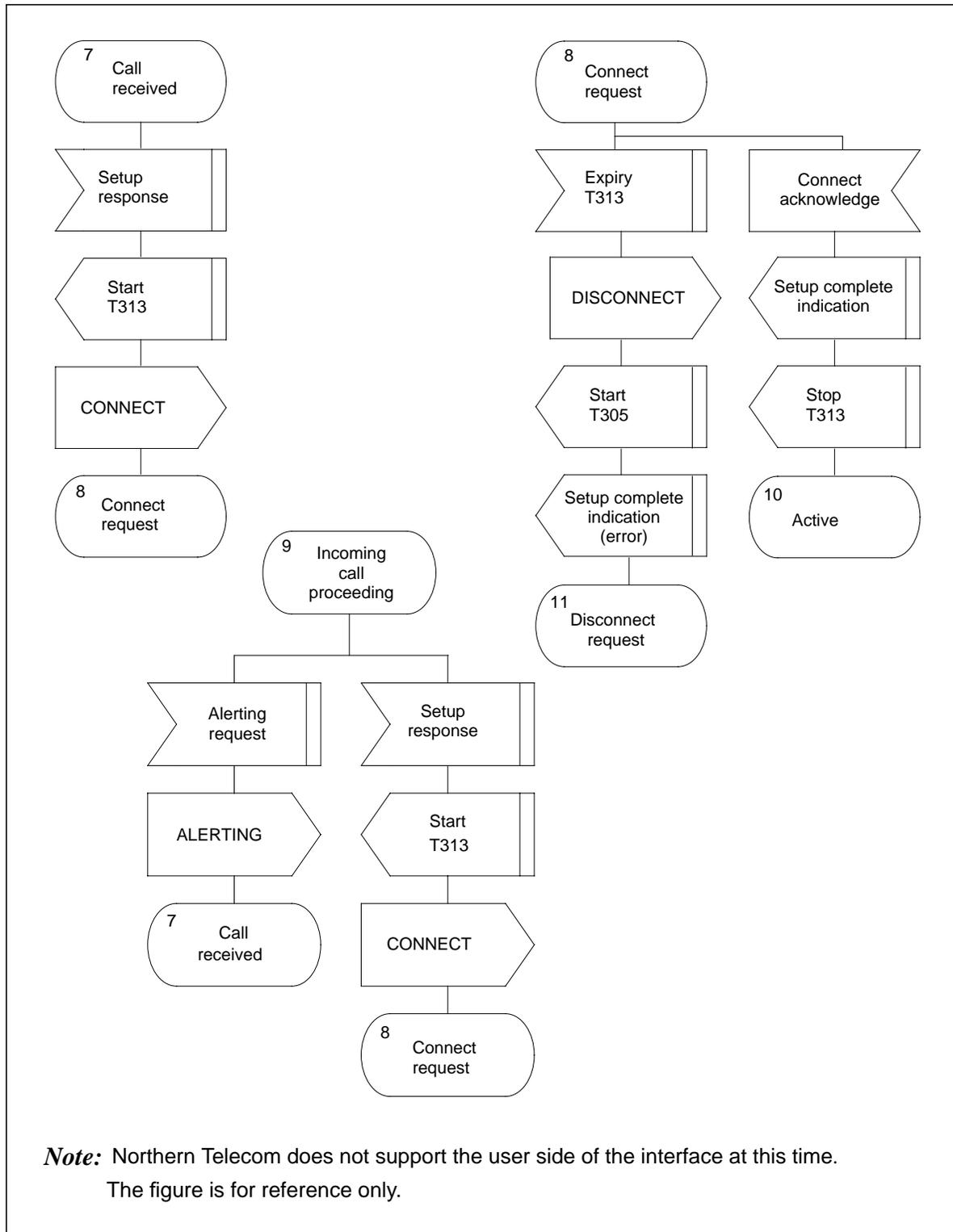
Note: Northern Telecom does not support the user side of the interface at this time.
The figure is for reference only.

Figure 93 Detailed protocol control: user side(8 of 16)

```
                        ┌──────────────┐
                        │ 11           │
                        │ Disconnect   │
                        │ request      │
                        └──────┬───────┘
              ┌────────────────┼────────────────┐
      ┌───────┴────┐    ┌──────┴─────┐    ┌──────┴─────┐
      │ RELEASE  <─┤    │ DISCONNECT<┤    │ Expiry     │
      │            │    │            │    │ T305       │
      └──────┬─────┘    └──────┬─────┘    └──────┬─────┘
      ┌──────┴─────┐    ┌──────┴─────┐    ┌──────┴─────┐
      │ Stop       │    │ Stop       │    │ Start      │
      │ T305       │    │ T305       │    │ T308       │
      └──────┬─────┘    └──────┬─────┘    └──────┬─────┘
      ┌──────┴─────┐    ┌──────┴─────┐    ┌──────┴─────┐
      │ Release    │    │ Start      │    │ RELEASE    │
      │ B-channel  │    │ T308       │    │            │
      └──────┬─────┘    └──────┬─────┘    └──────┬─────┘
      ┌──────┴─────┐    ┌──────┴─────┐    see Note
      │ Release    │    │ Disconnect │    ┌──────┴─────┐
      │ indication │    │ indication │    │ Release    │
      └──────┬─────┘    └──────┬─────┘    │ indication │
      ┌──────┴─────┐    ┌──────┴─────┐    └──────┬─────┘
      │ RELEASE    │    │ RELEASE    │    ┌──────┴─────┐
      │ COMPLETE   │    │            │    │ 19         │
      └──────┬─────┘    └──────┬─────┘    │ Release    │
      ┌──────┴─────┐    ┌──────┴─────┐    │ request    │
      │ Release call│   │ 19         │    └────────────┘
      │ reference  │    │ Release    │
      └──────┬─────┘    │ request    │
      ┌──────┴─────┐    └────────────┘
      │ 0          │
      │ Null       │
      └────────────┘
```

Note: After receiving this primitive, call control process should release the B-channel

Note: Northern Telecom does not support the user side of the interface at this time. The figure is for reference only.

Figure 94 Detailed protocol control: user side (9 of 16)
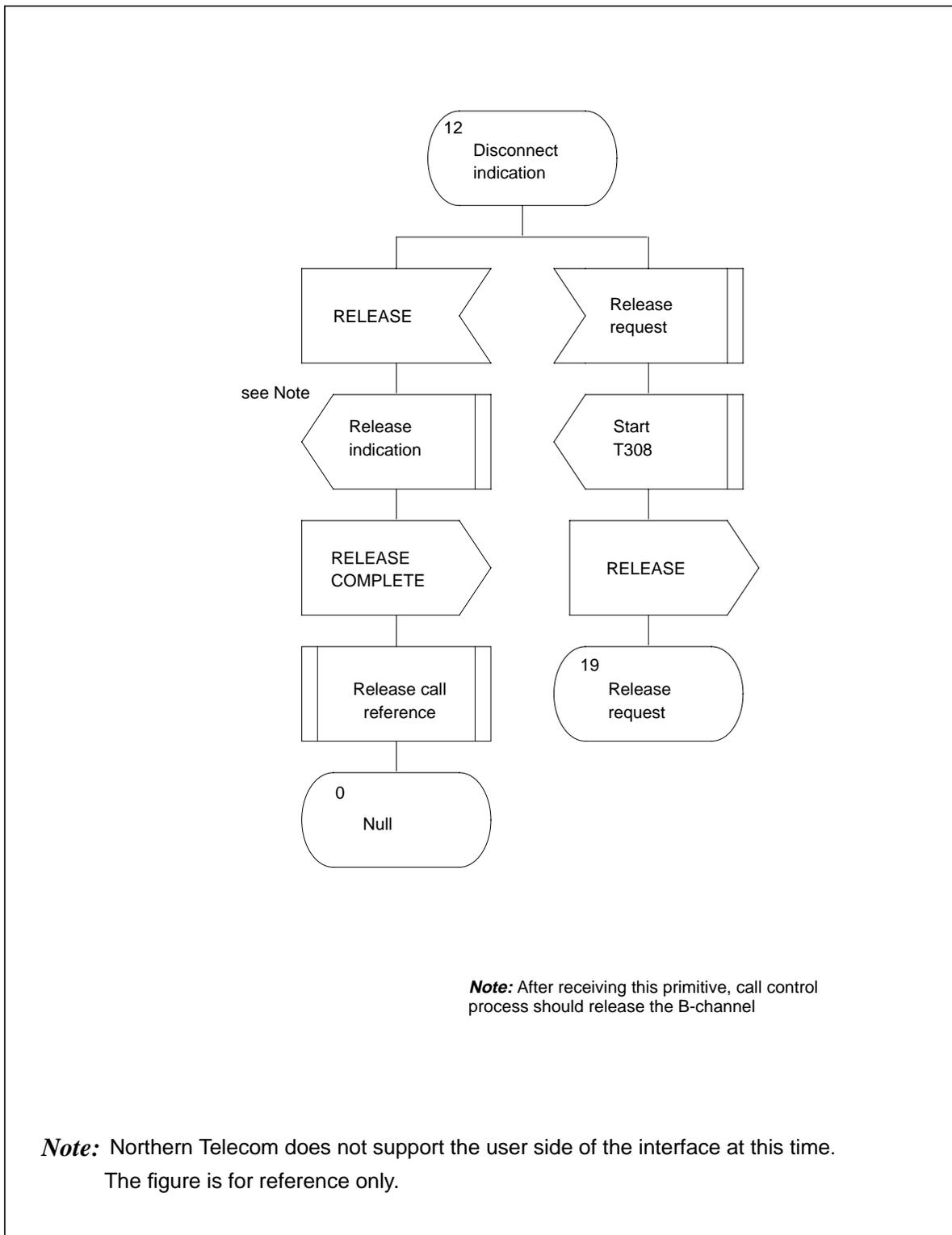
Figure 95 Detailed protocol control: user side (10 of 16)

Note: After receiving this primitive, call control process should release the B-channel

Note: Northern Telecom does not support the user side of the interface at this time. The figure is for reference only.
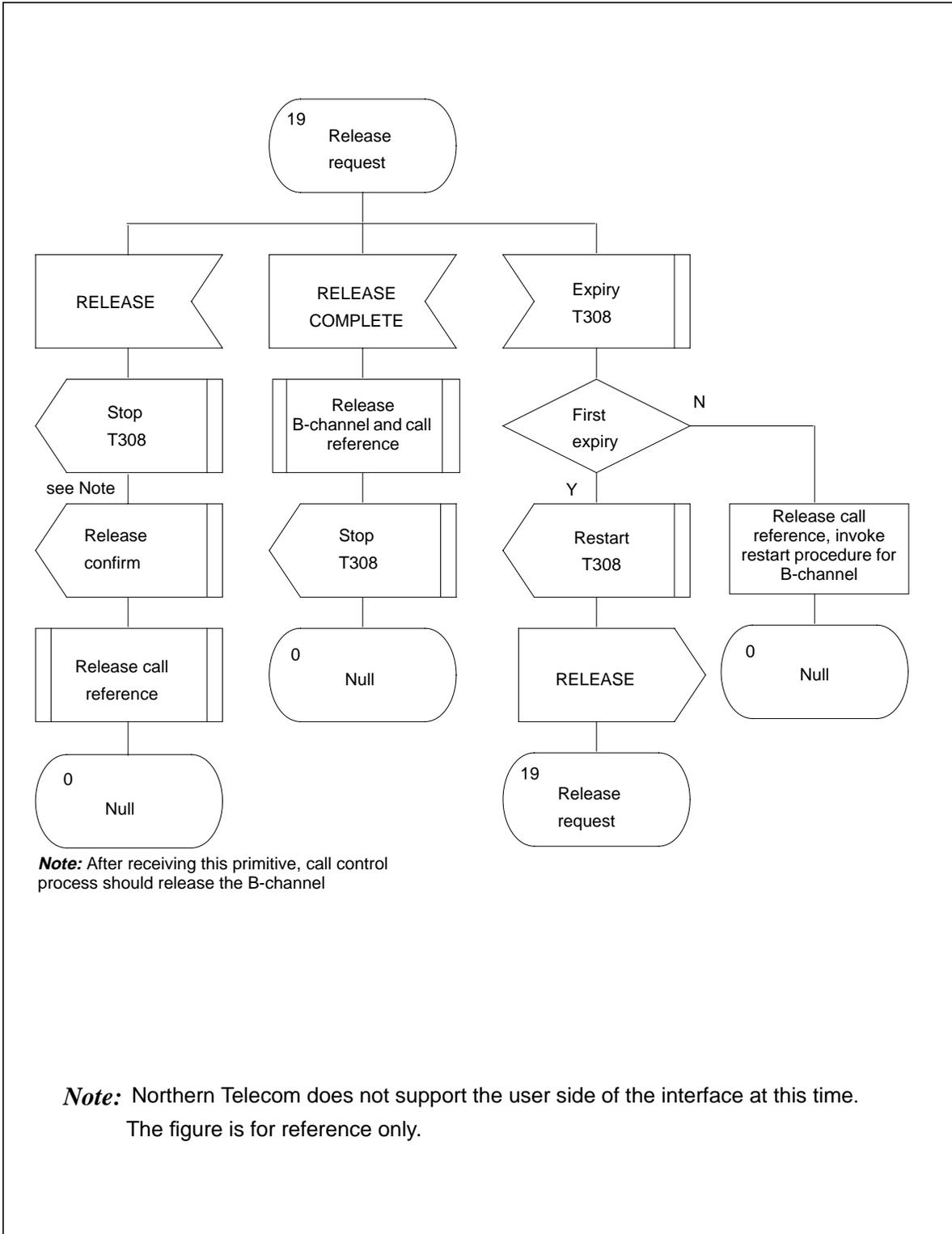
Figure 96 Detailed protocol control: user side (11 of 16)

Note: Action on receipt of STATUS indicating a compatible call state is implementation dependent.

Note: Northern Telecom does not support the user side of the interface at this time. The figure is for reference only.
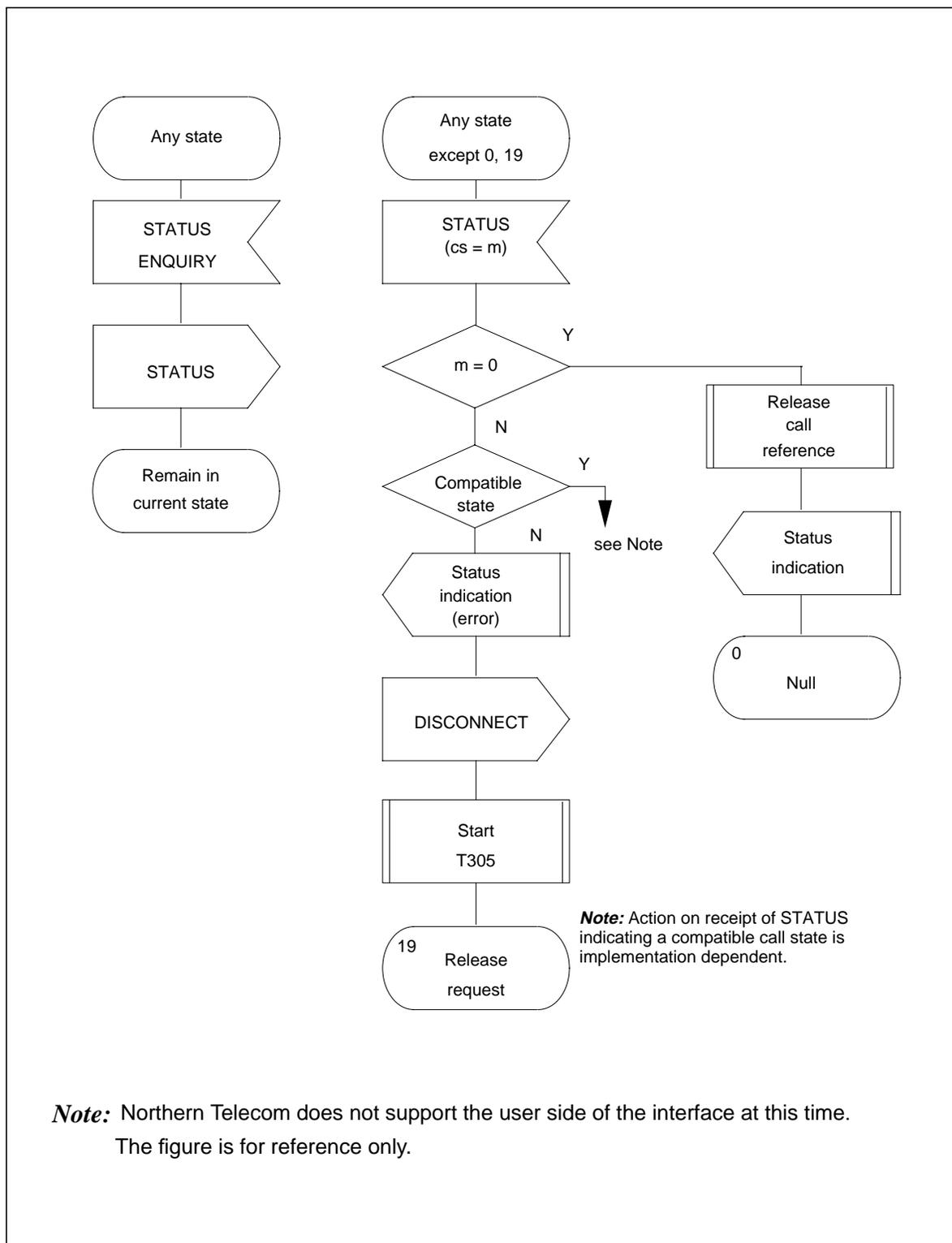
Figure 97 Detailed protocol control: user side (12 of 16)

Note: Northern Telecom does not support the user side of the interface at this time. The figure is for reference only.
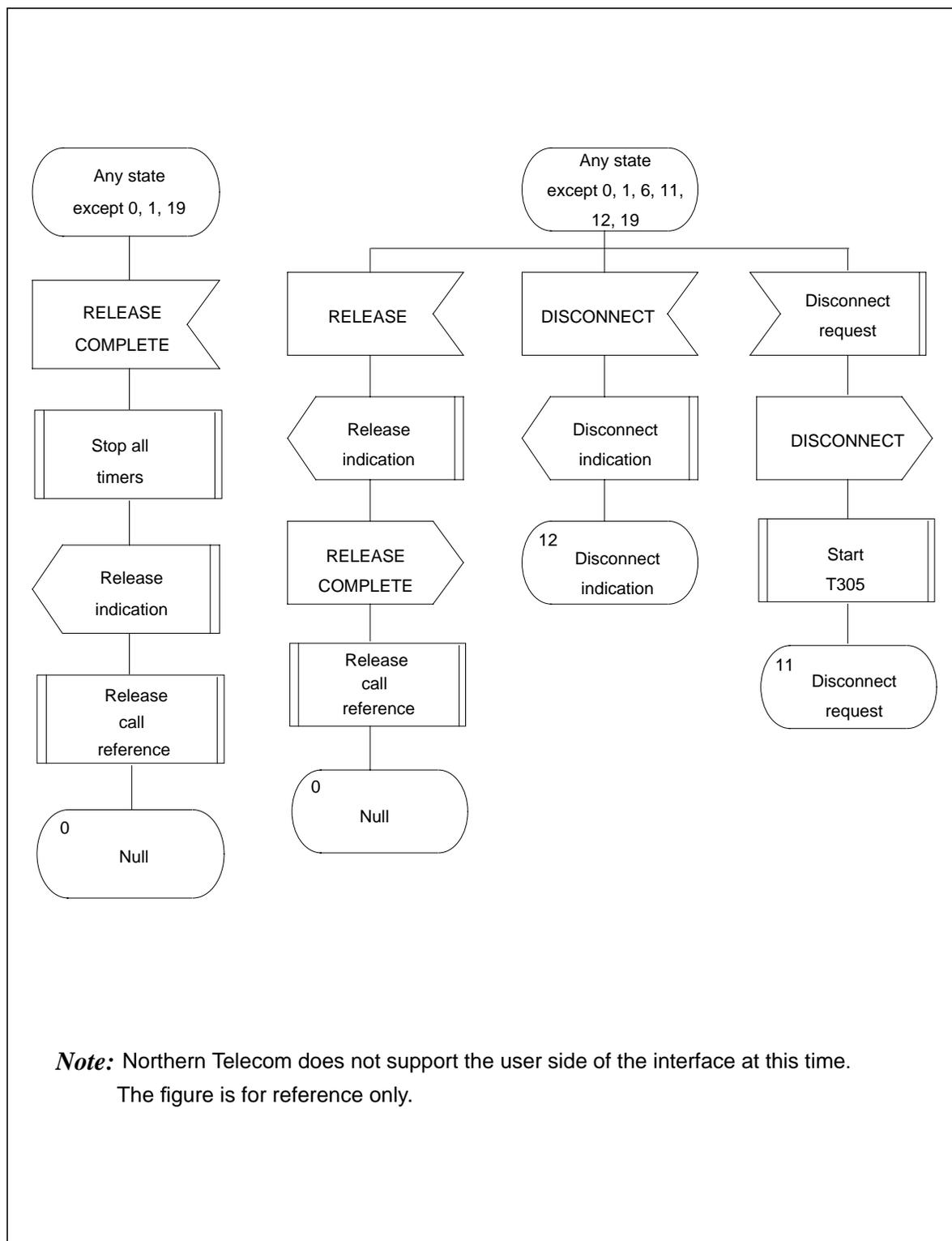
Figure 98 Detailed protocol control: user side (13 of 16)

Note: Except RELEASE or RELEASE COMPLETE

Note: Northern Telecom does not support the user side of the interface at this time. The figure is for reference only.
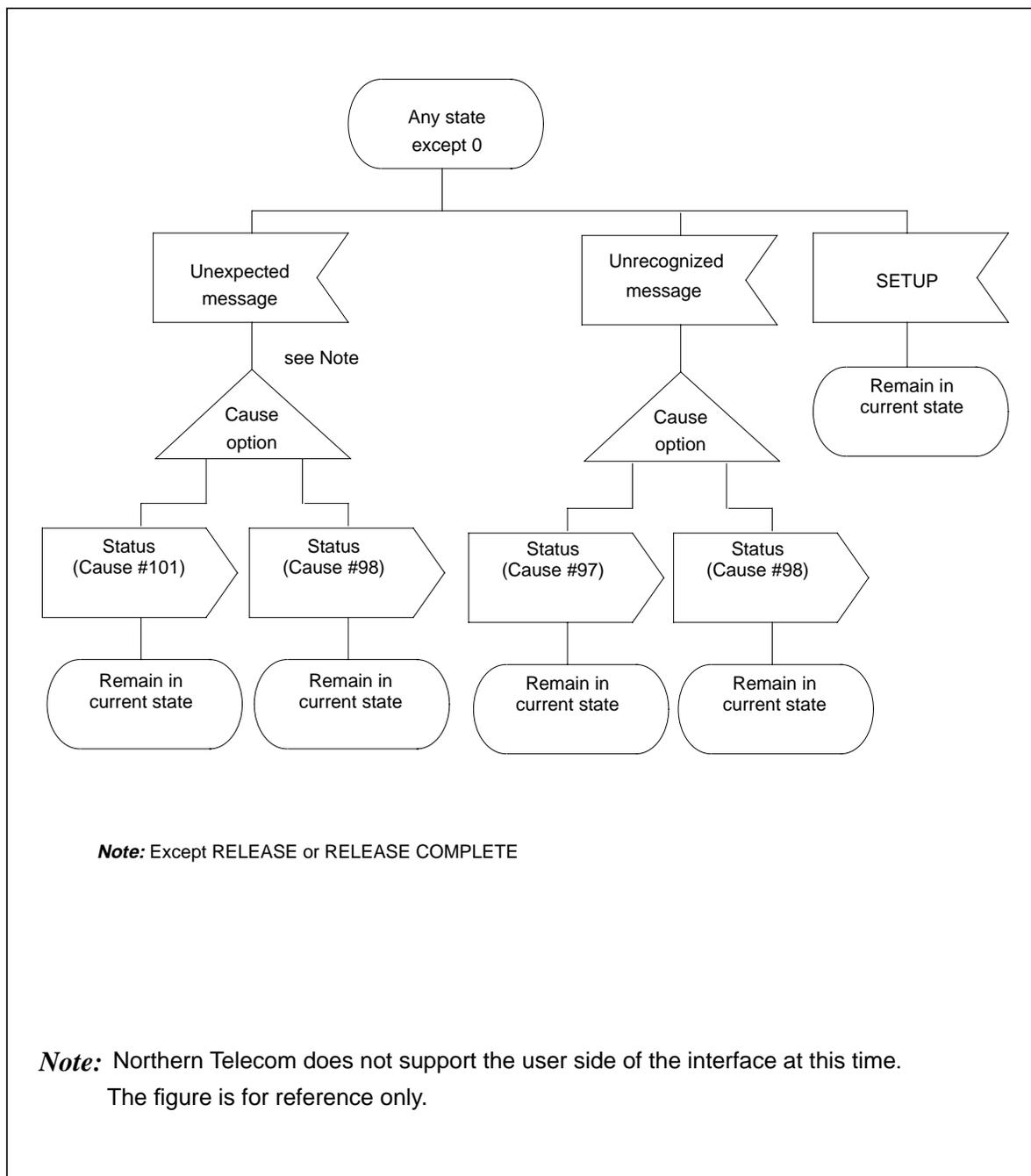
Figure 99 Detailed protocol control: user side (14 of 16)

Note 1: Except SETUP, RELEASE COMPLETE, and DISCONNECT.

Note 2: These messages are recognized by the user and expected messages in the state.

Note 3: See procedures for specific states

Note 4: Release the B channel

Note: Northern Telecom does not support the user side of the interface at this time.
The figure is for reference only.
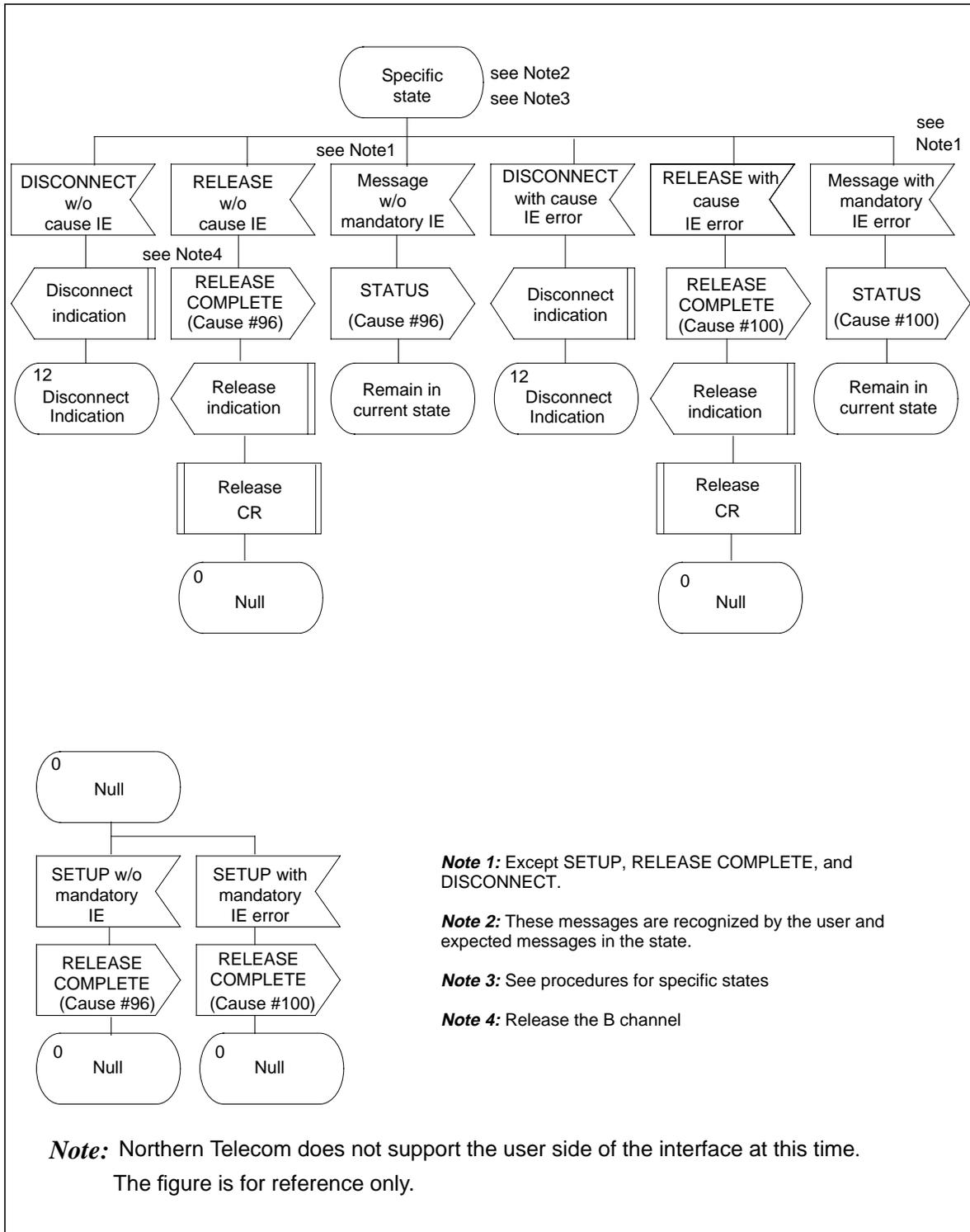
Figure 100 Detailed protocol control: user side (15 of 16)

Note: Northern Telecom does not support the user side of the interface at this time. The figure is for reference only.
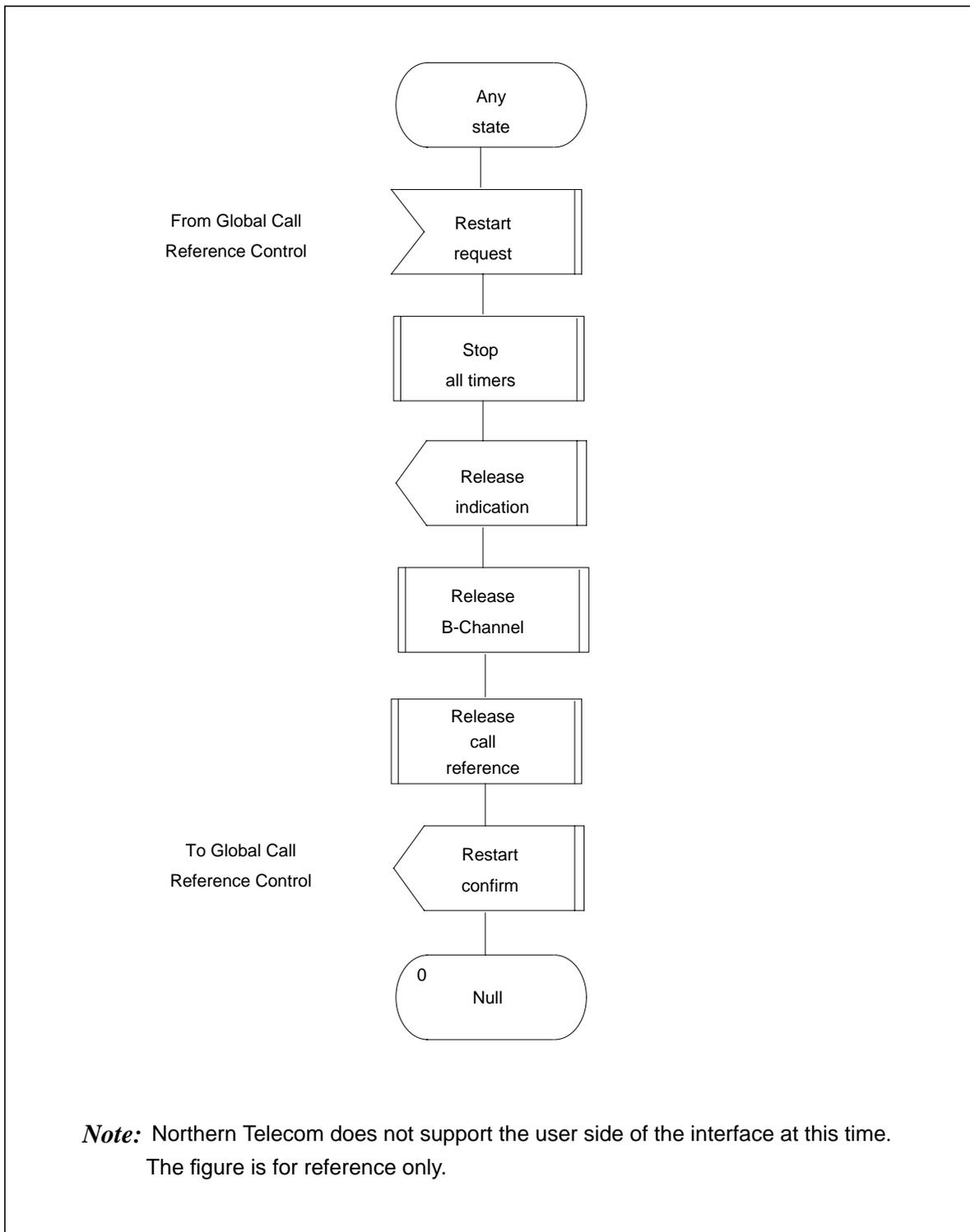
Figure 101 Detailed protocol control: user side (16 of 16)

Note: Northern Telecom does not support the user side of the interface at this time.

The figure is for reference only.
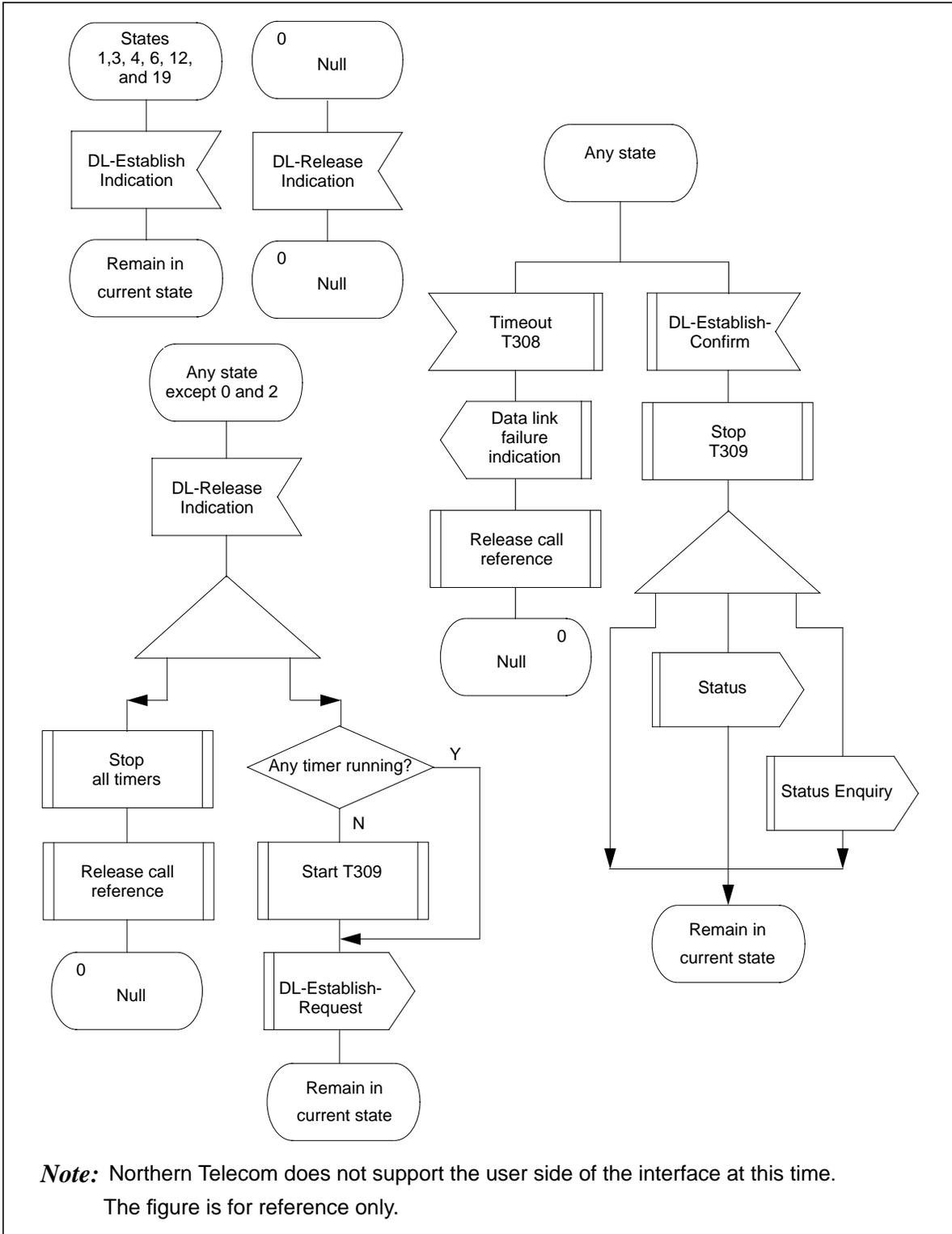
Figure 102 Detailed protocol control for the global call reference (1 of 4)
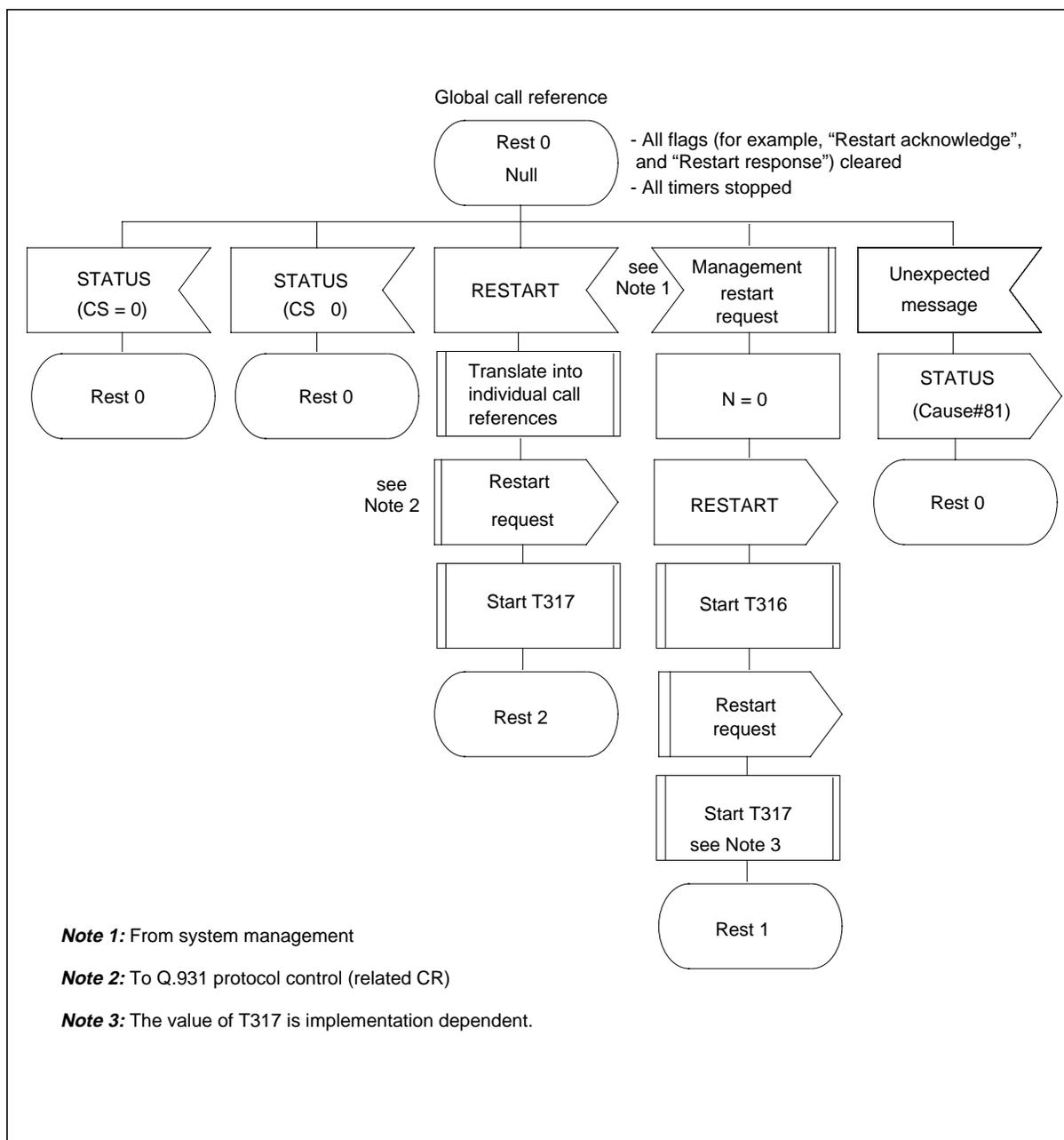
Figure 103 Detailed protocol control for the global call reference (2 of 4)
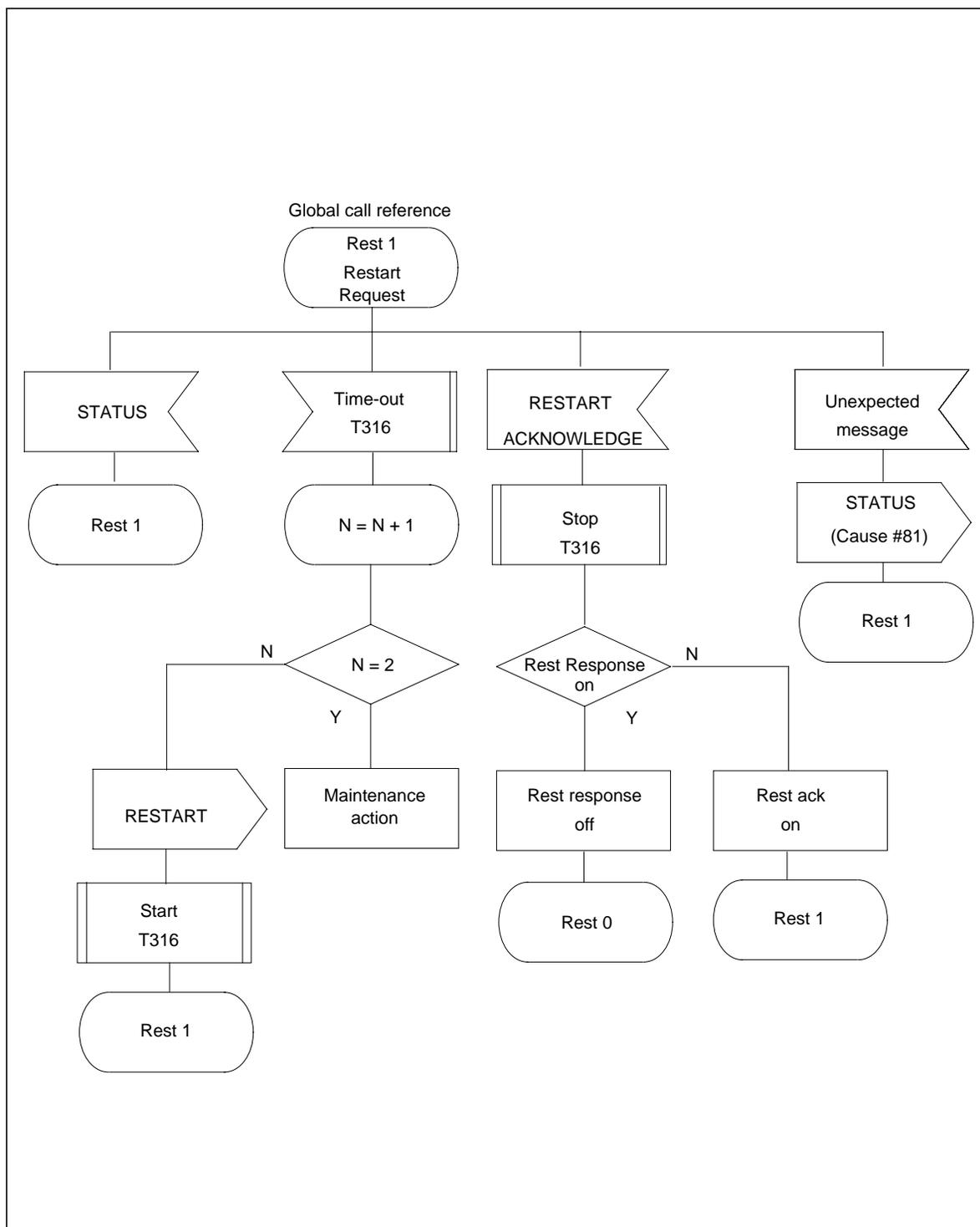
Figure 104 Detailed protocol control for the global call reference (3 of 4)
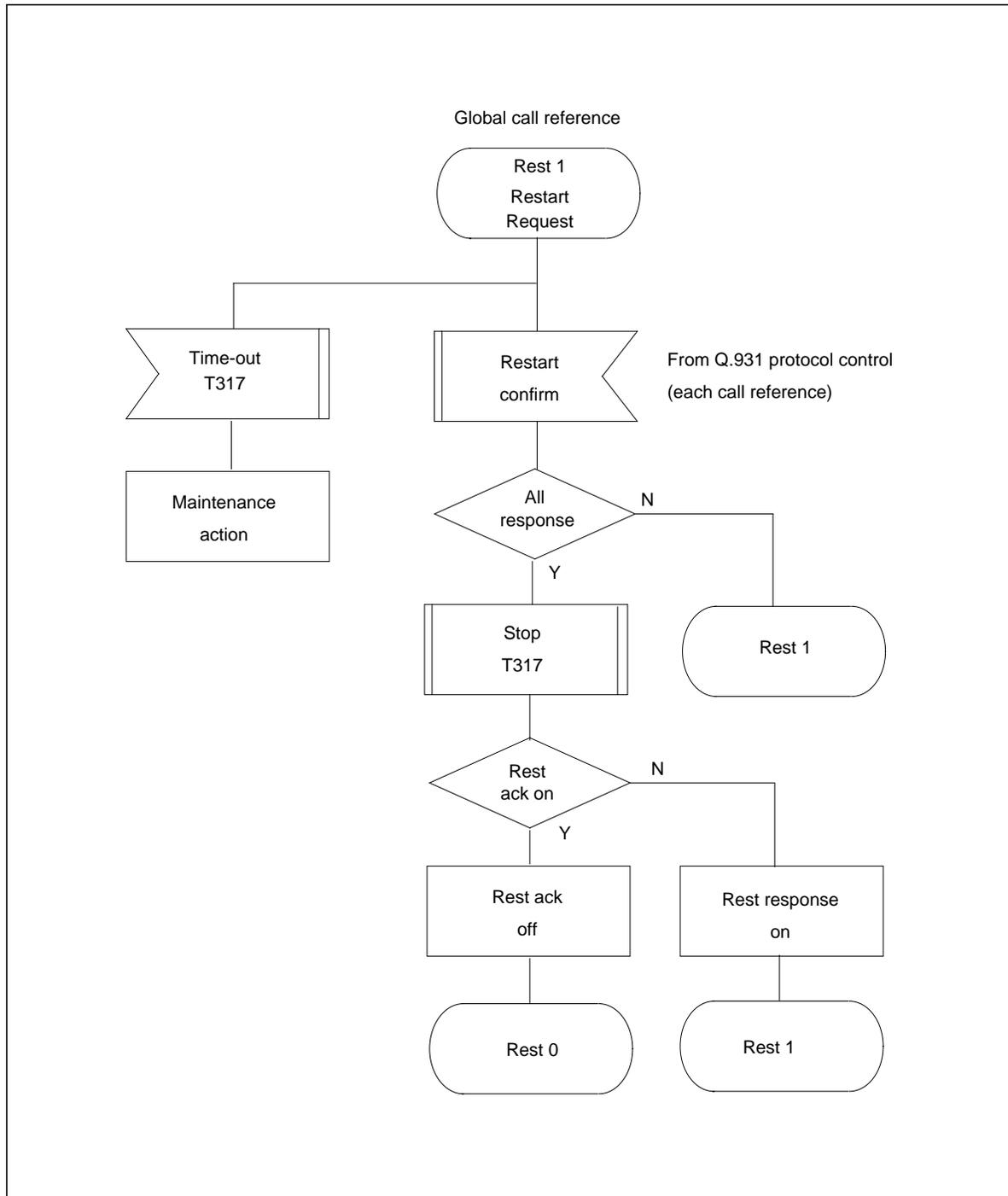
Figure 105 Detailed protocol control for the global call reference (4 of 4)

Global call reference

Rest 2
Restart

| STATUS | Time-out T317 | Restart confirm | From Q.931 protocol control (each call reference) | Unexpected message |

Rest 2

Maintenance action

All response

N

Y

Stop T317

Rest 2

STATUS (Cause #81)

Rest 2

RESTART ACKNOWLEDGE

Rest 0
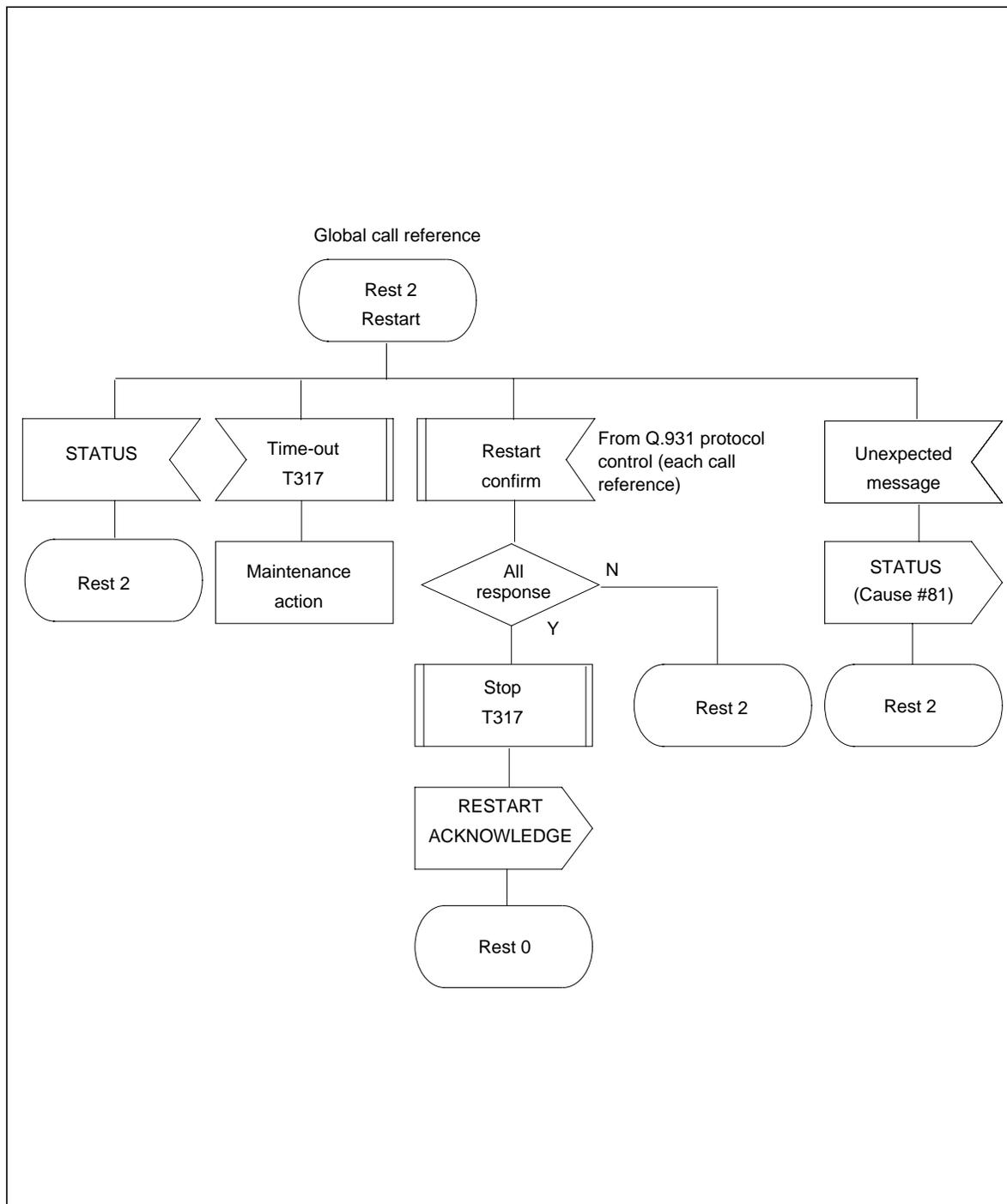
Figure 106   Overview protocol control: network side (1 of 6)—Outgoing set up procedure (1 of 2)
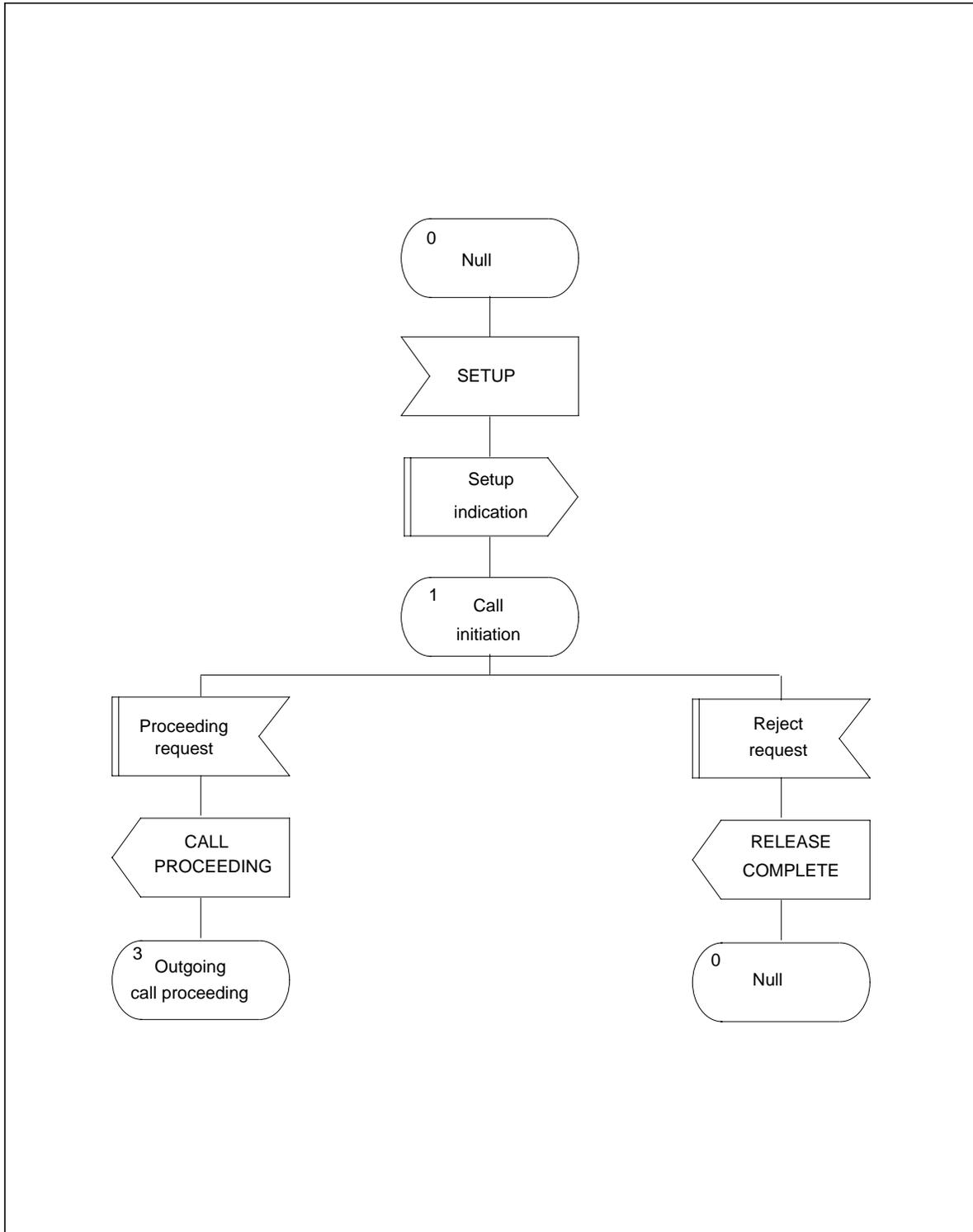
Figure 107 Overview protocol control: network side (2 of 6)—Outgoing set up procedure (2 of 2)
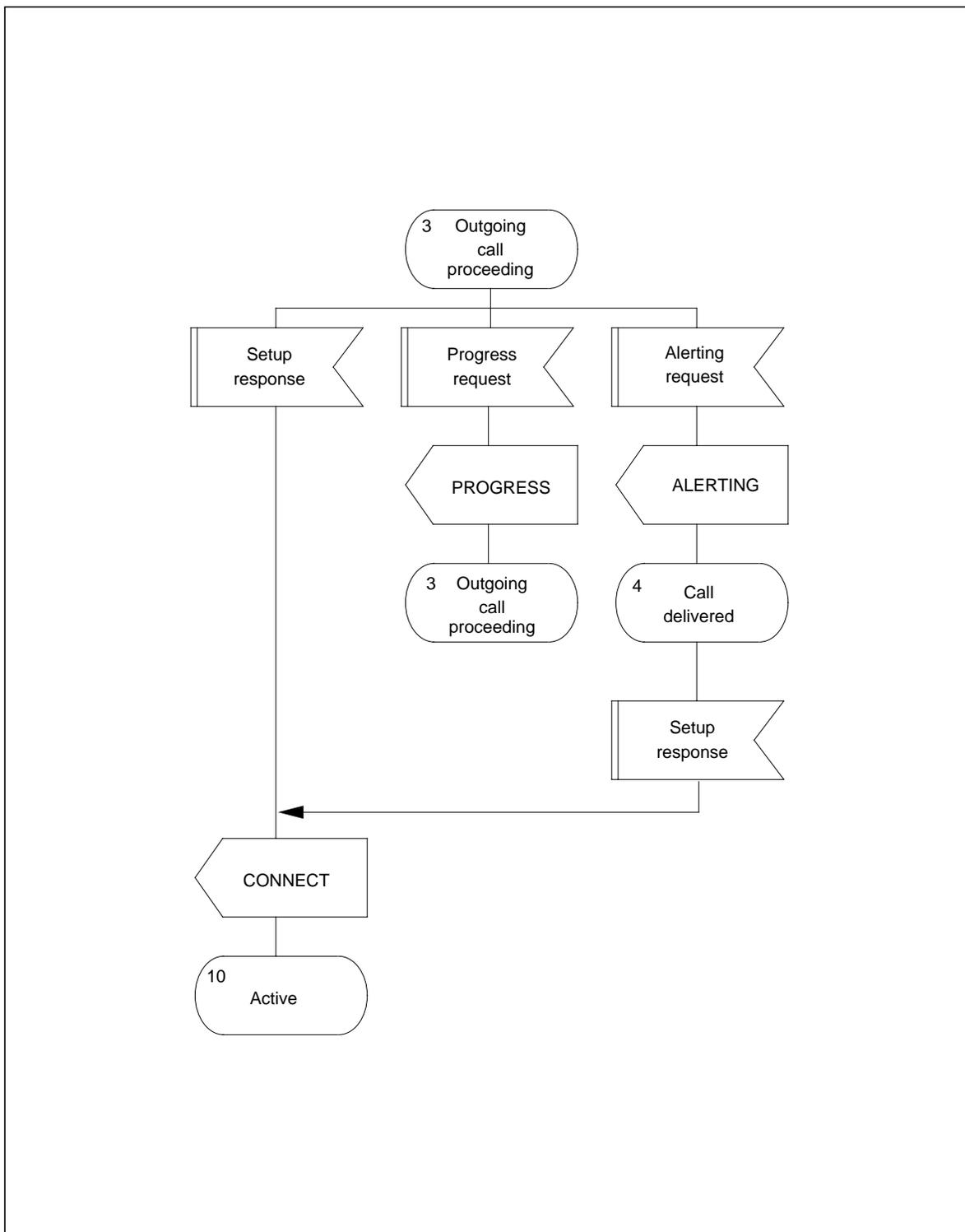
Figure 108 Overview protocol control: network side (3 of 6)—Incoming set up procedure (1 of 2)
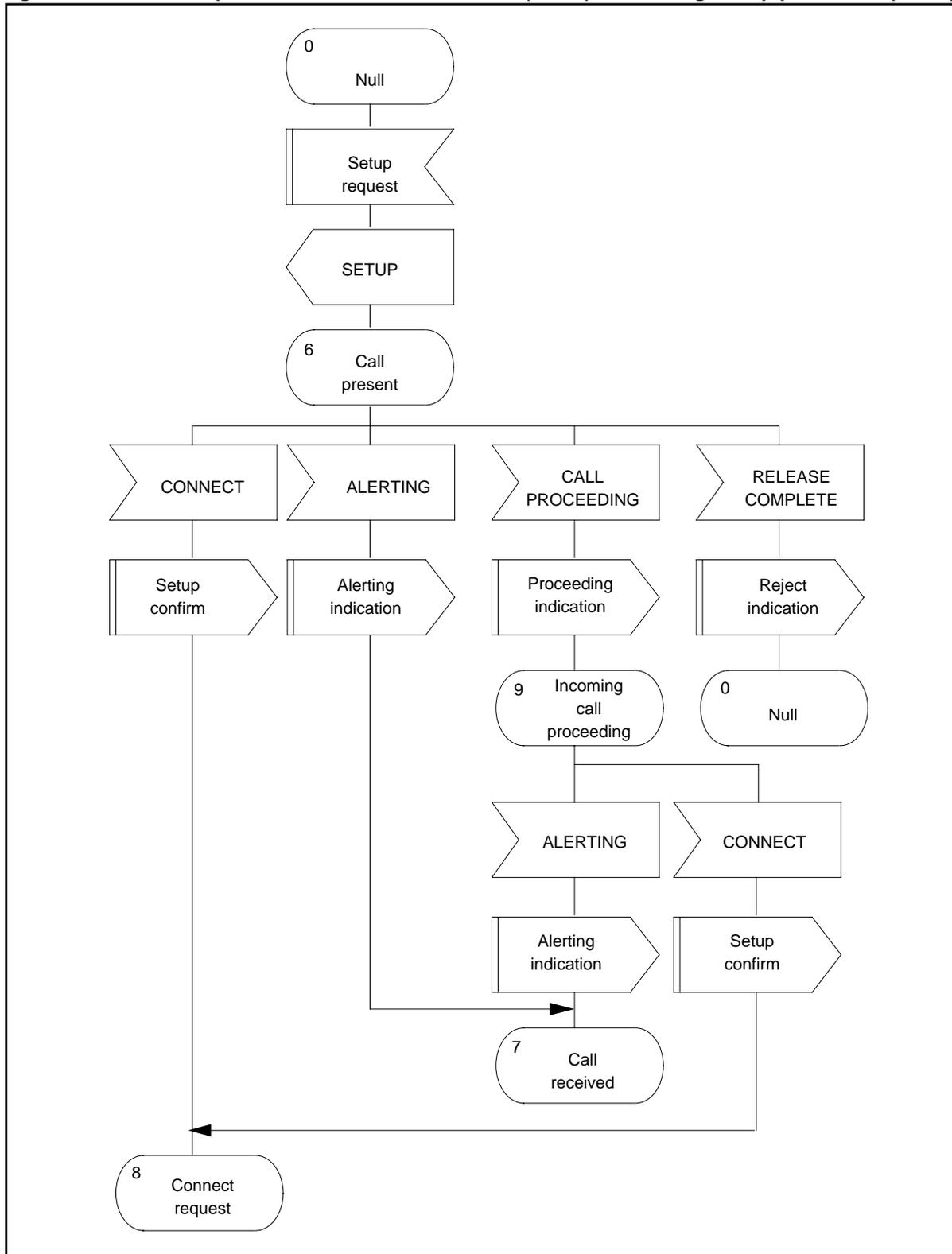
Figure 109 Overview protocol control: network side (4 of 6)—Incoming set up procedure (2 of 2)
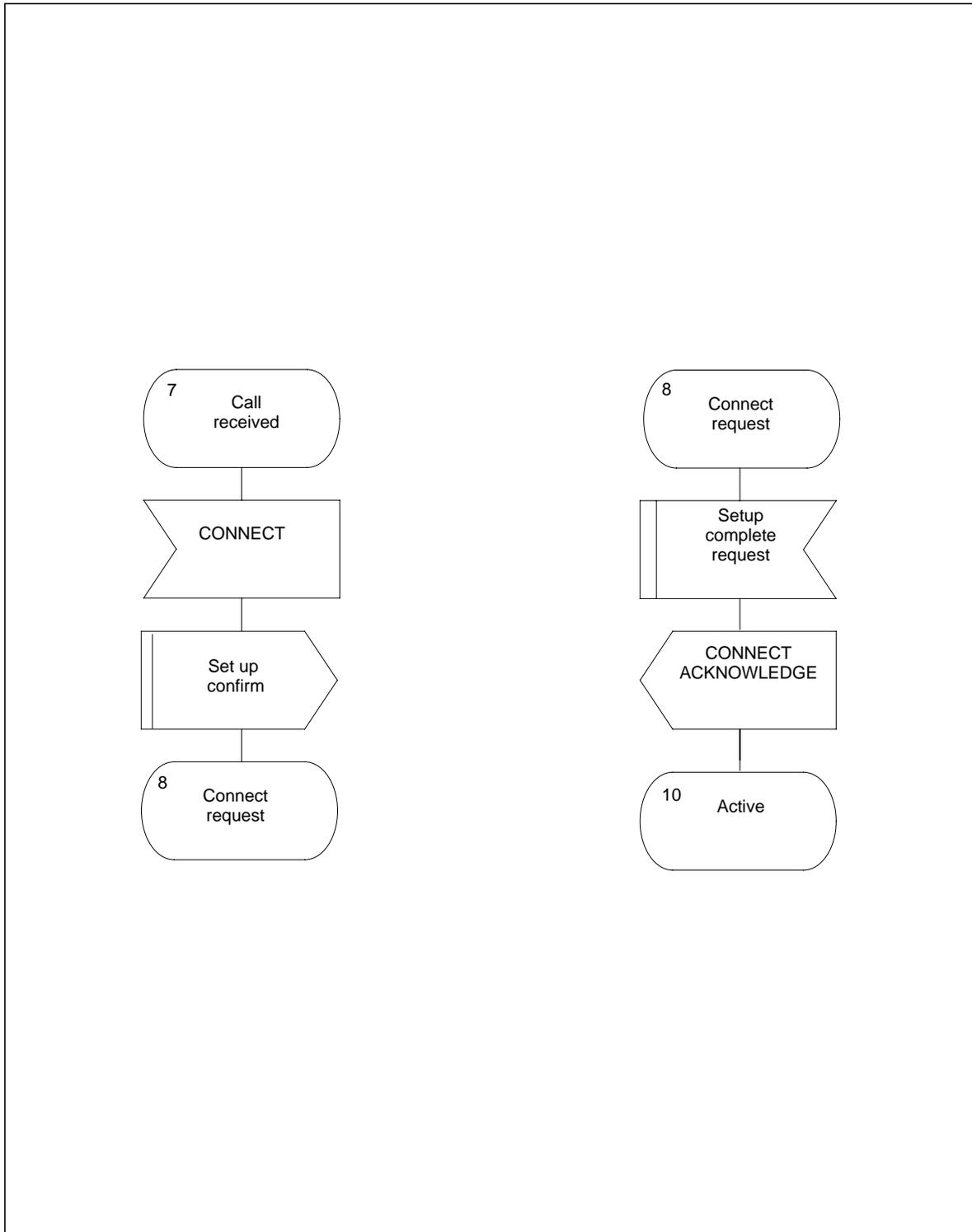
Figure 110 Overview protocol control: network side (5 of 6)—Clearing procedure (1 of 2)
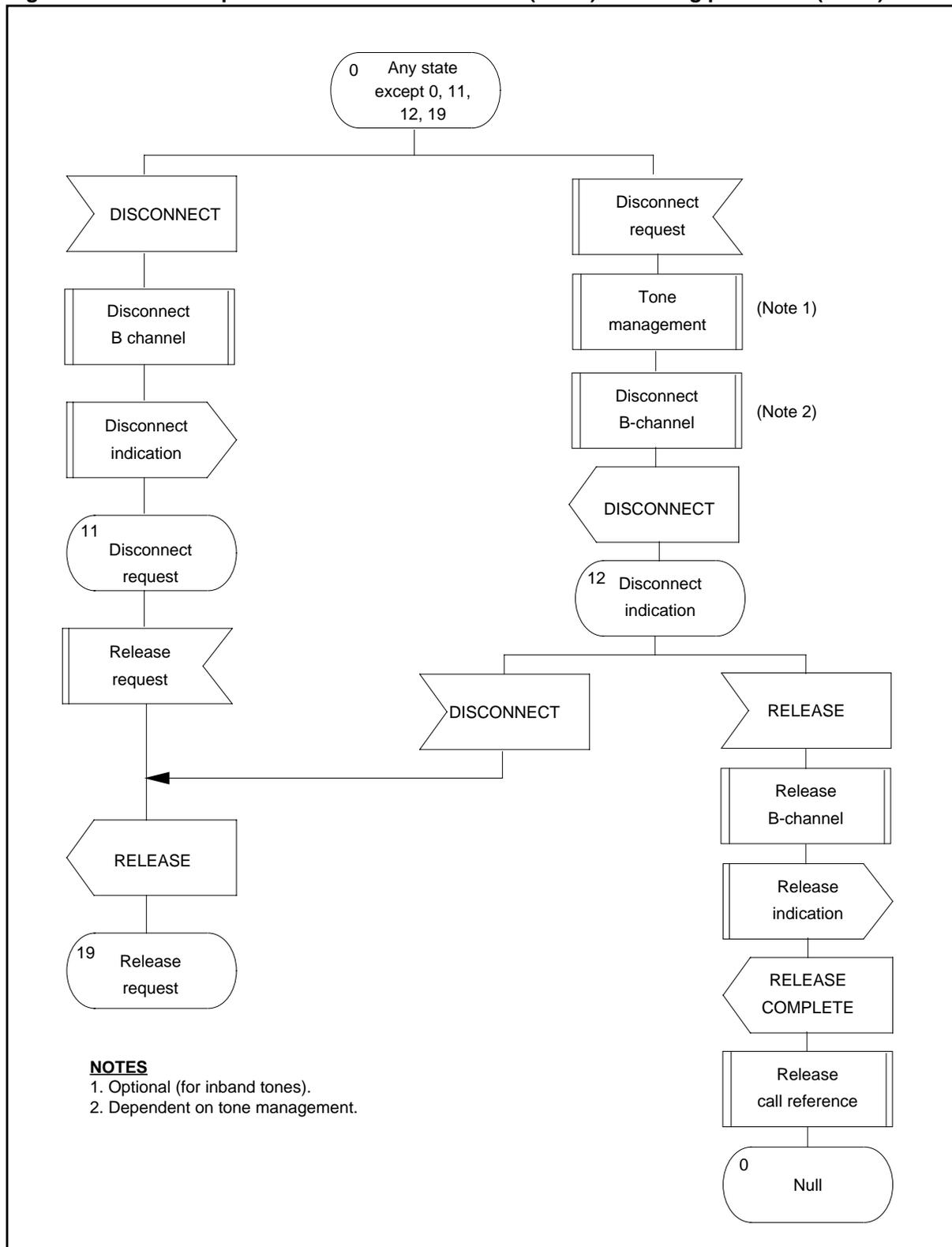
Figure 111 Overview protocol control: network side (6 of 6)—Clearing procedure (2 of 2)

```
                    ┌──────────────────┐
                  ( 19    Release      )
                  (       Request      )
                    └────────┬─────────┘
                             │
                    ┌────────┴─────────┐
                   <    RELEASE        │
                   <    COMPLETE       │
                    └────────┬─────────┘
                             │
                  ┌──────────┴──────────┐
                  │ │   Release      │ │
                  │ │ B-channel and  │ │
                  │ │ call reference │ │
                  └──────────┬──────────┘
                             │
                  ┌──────────┴──────────┐
                  │ │   Release         >
                  │ │   confirm         >
                  └──────────┬──────────┘
                             │
                    ┌────────┴─────────┐
                  ( 0                   )
                  (        Null         )
                    └──────────────────┘
```
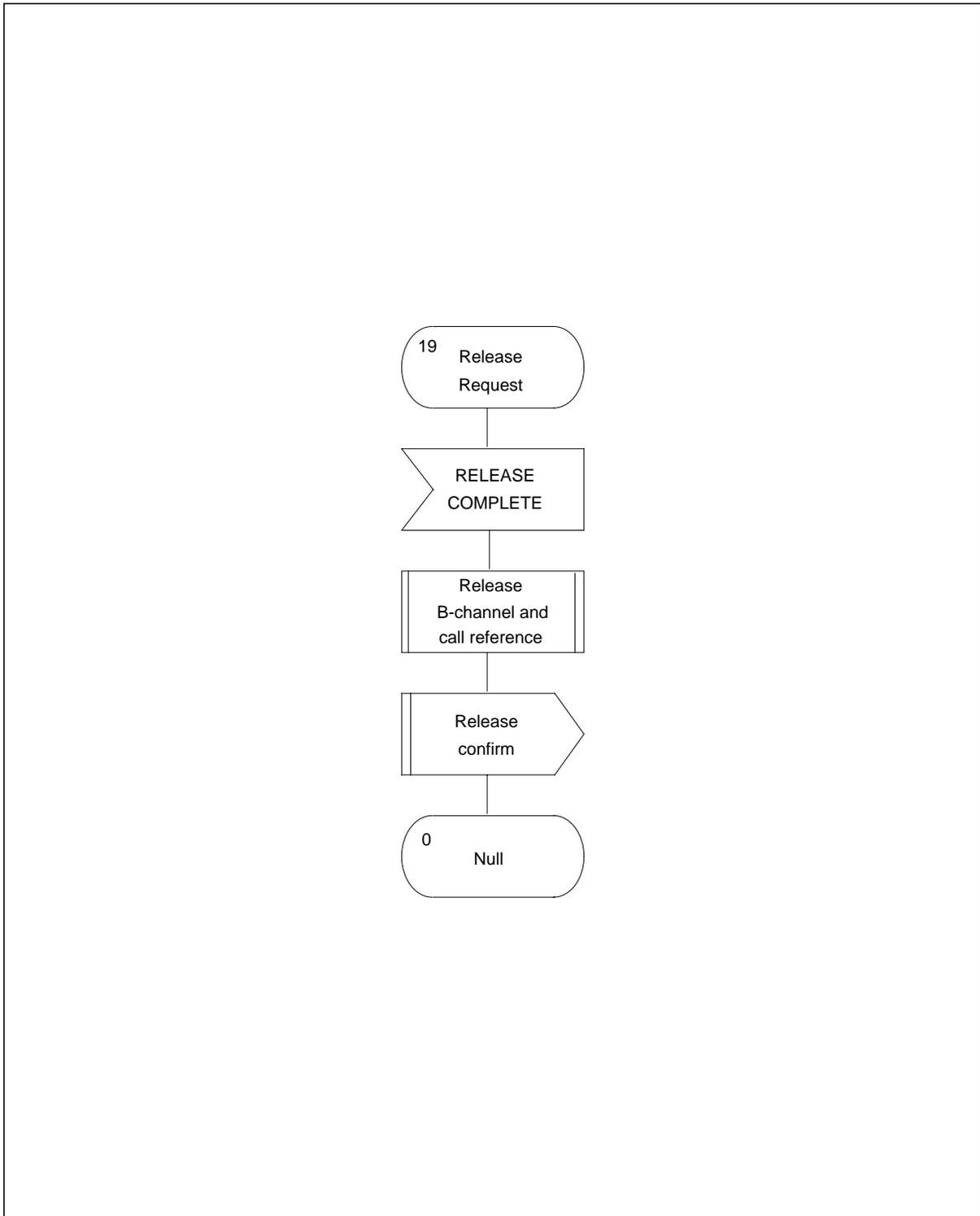
Figure 112 Detailed protocol control: network side (1 of 18)
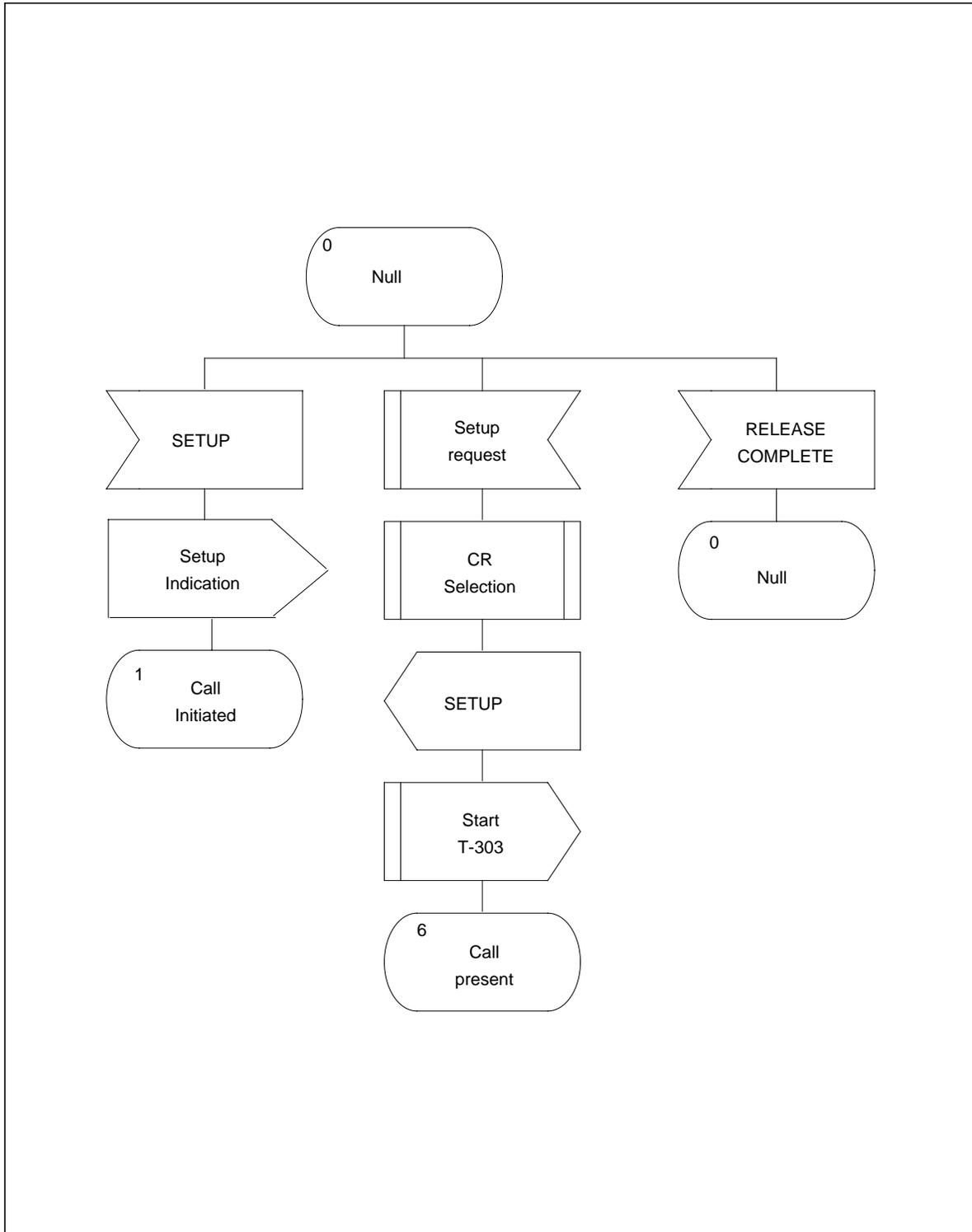
Figure 113 Detailed protocol control: network side (2 of 18)
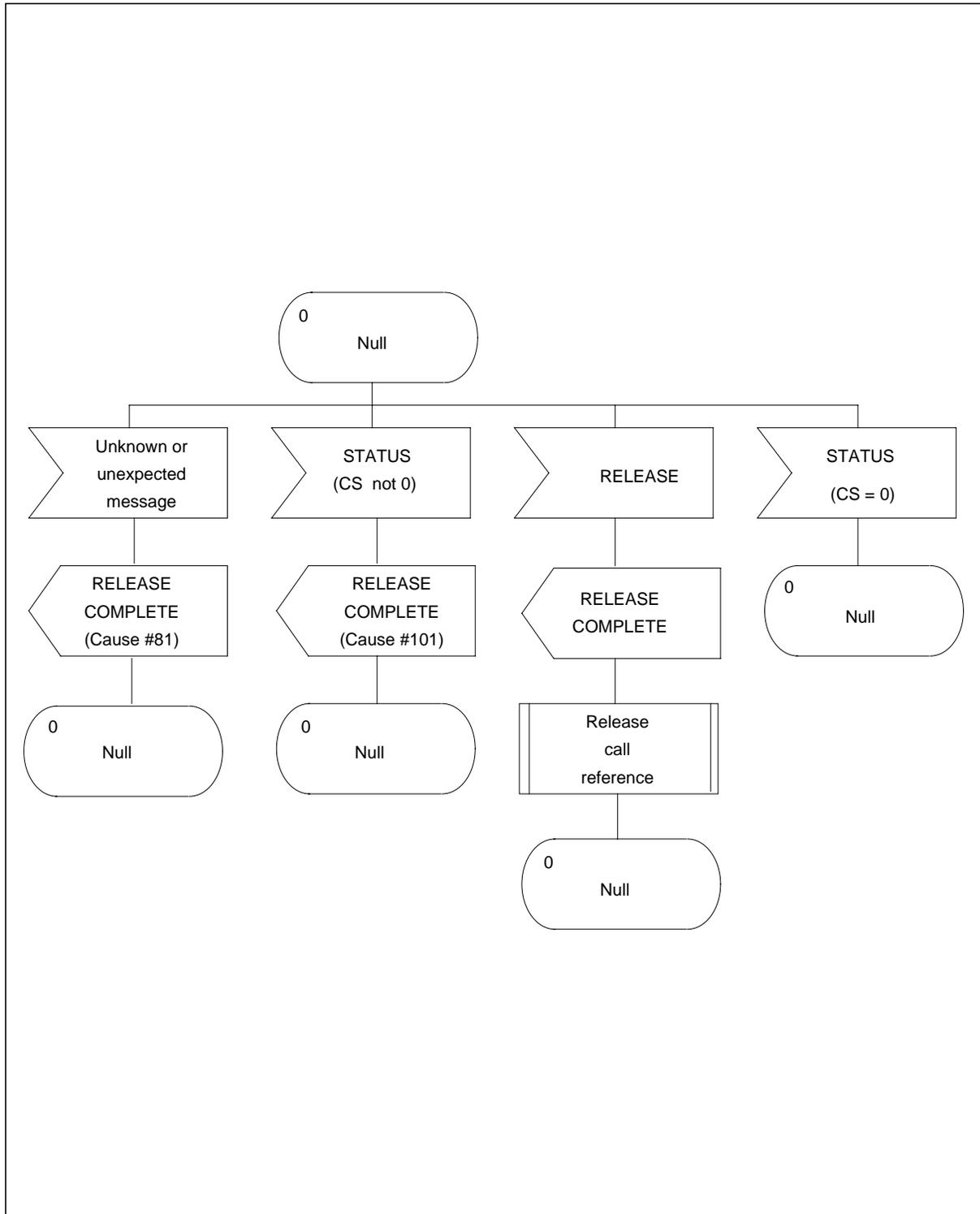
Figure 114 Detailed protocol control: network side (3 of 18)
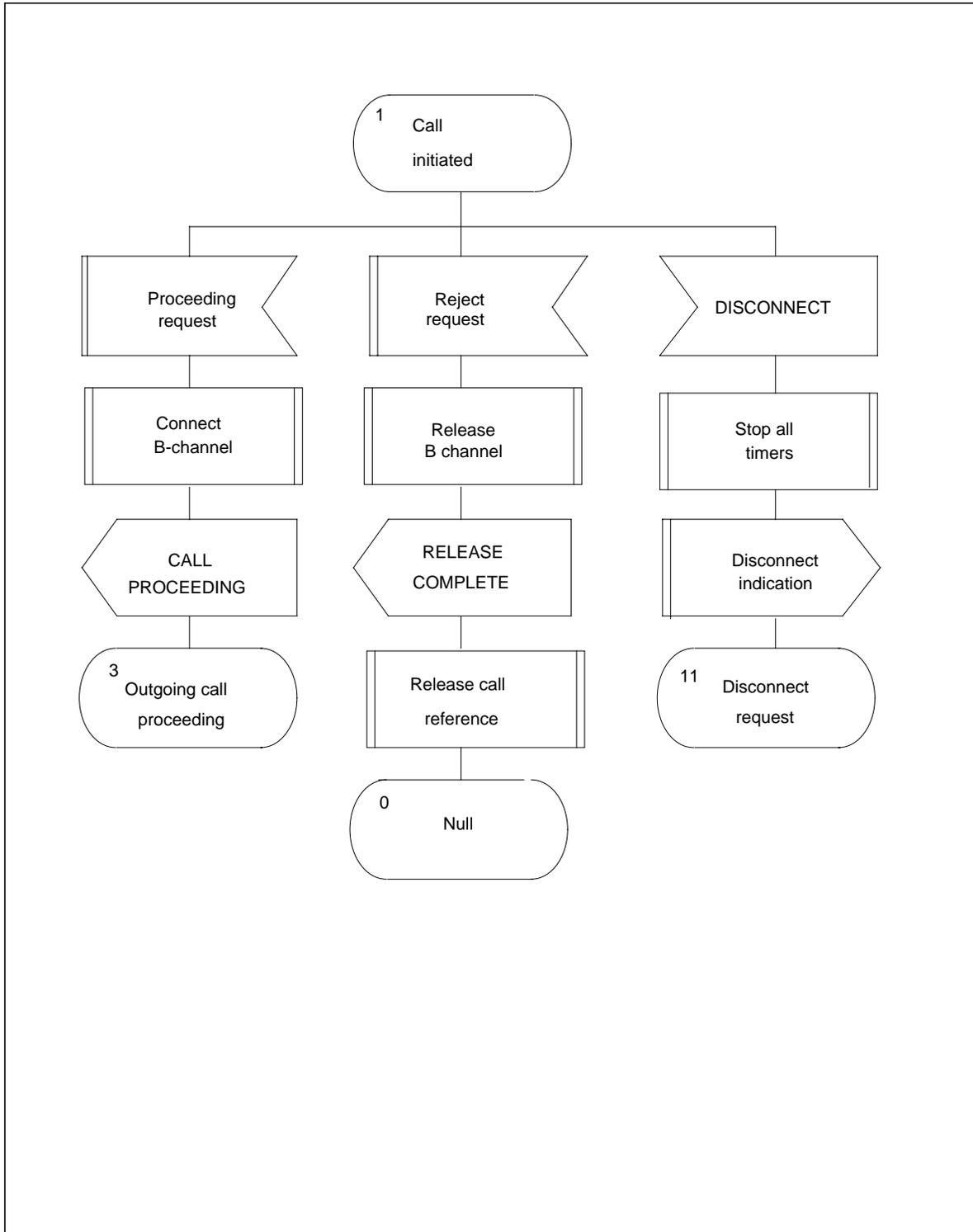
Figure 115 Detailed protocol control: network side (4 of 18)
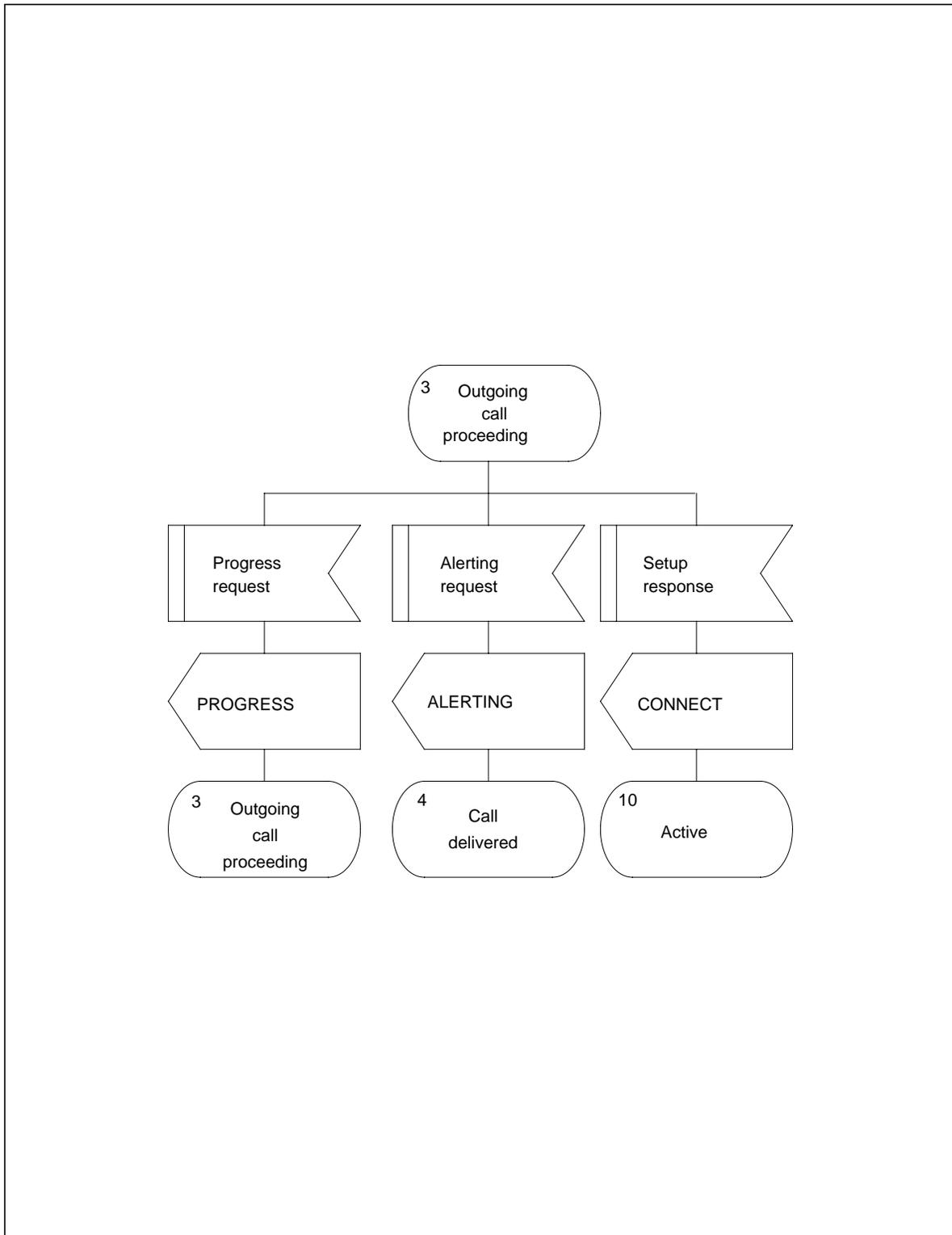
Figure 116 Detailed protocol control: network side (5 of 18)
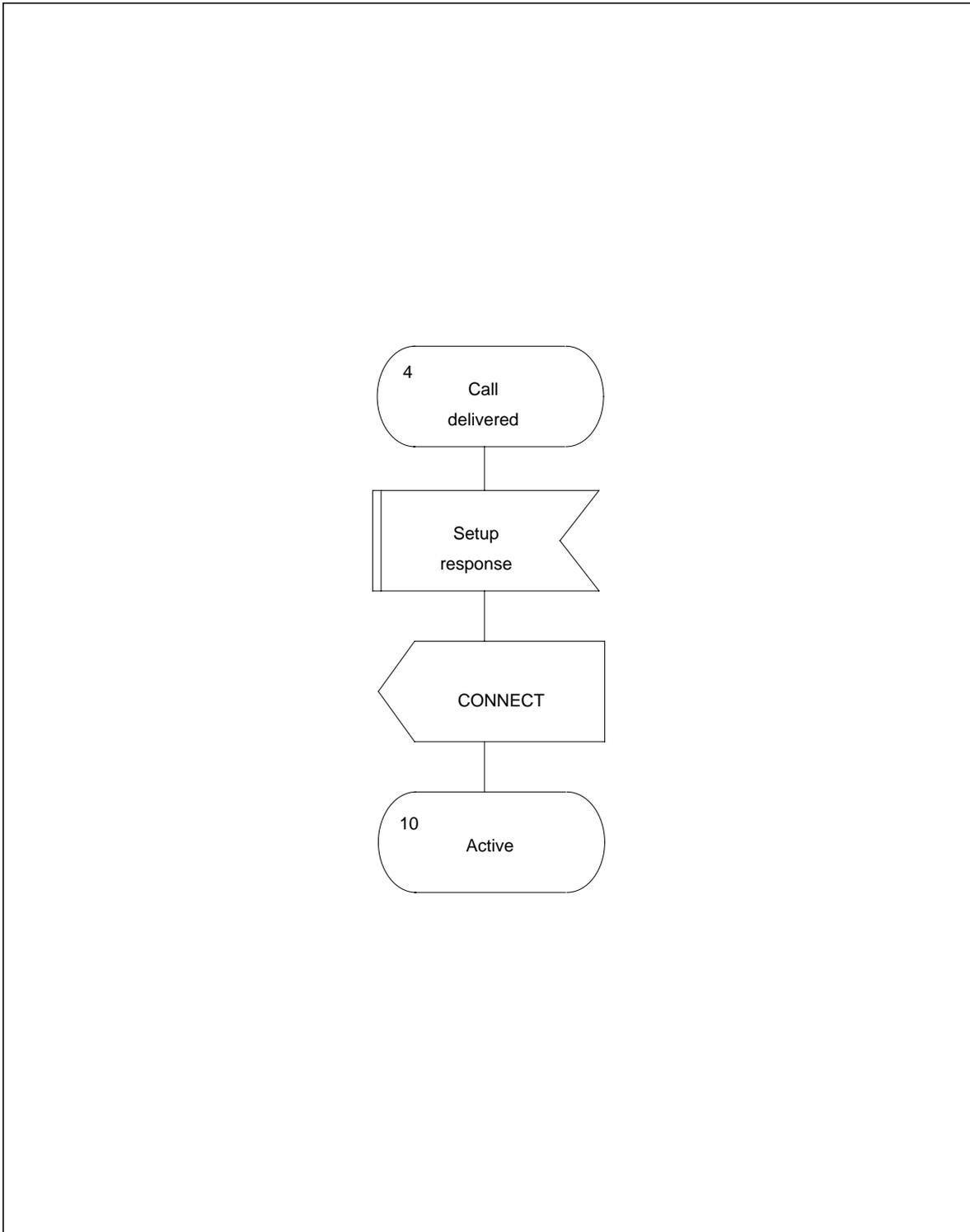
Figure 117 Detailed protocol control: network side (6 of 18)
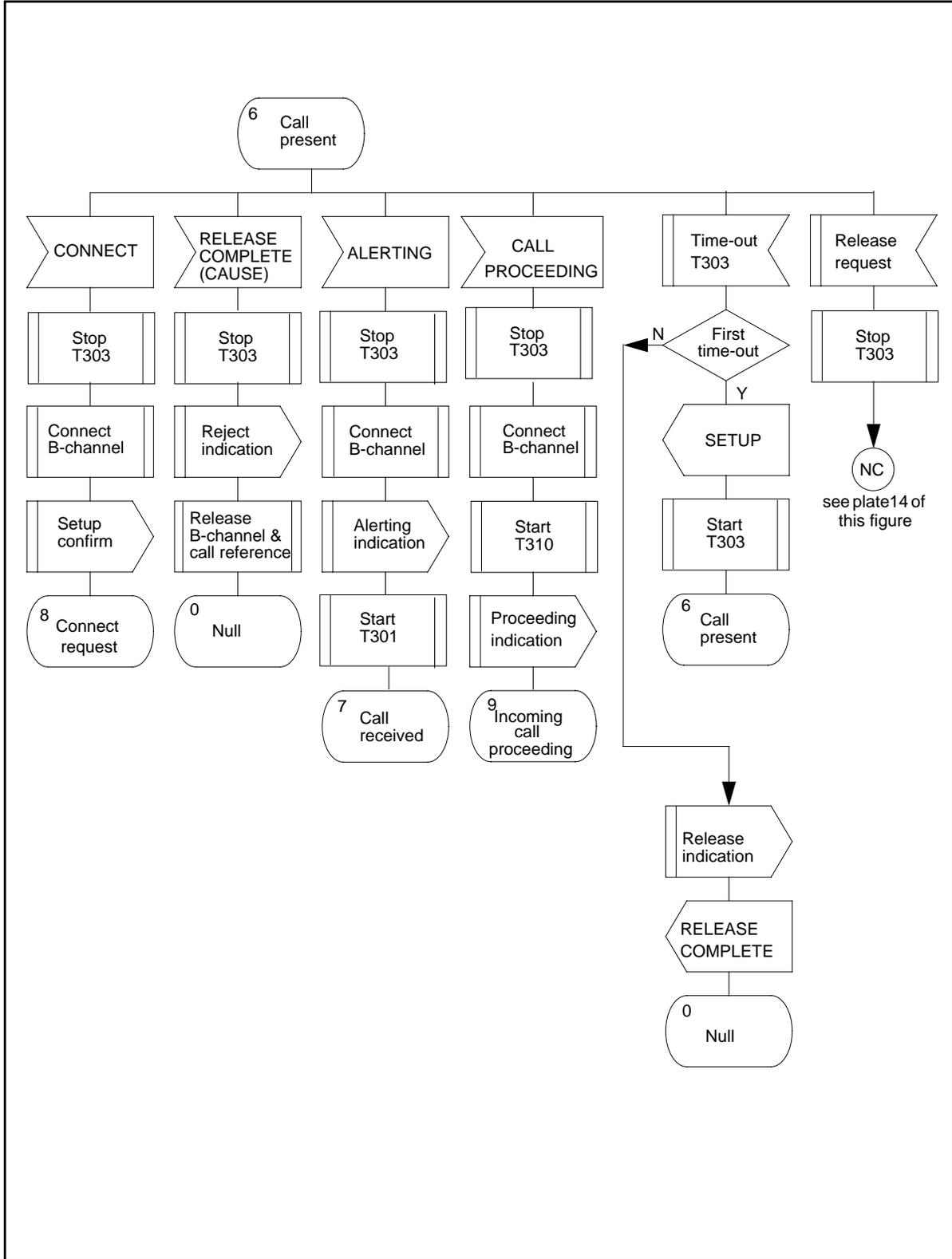
Figure 118 Detailed protocol control: network side (7 of 18)
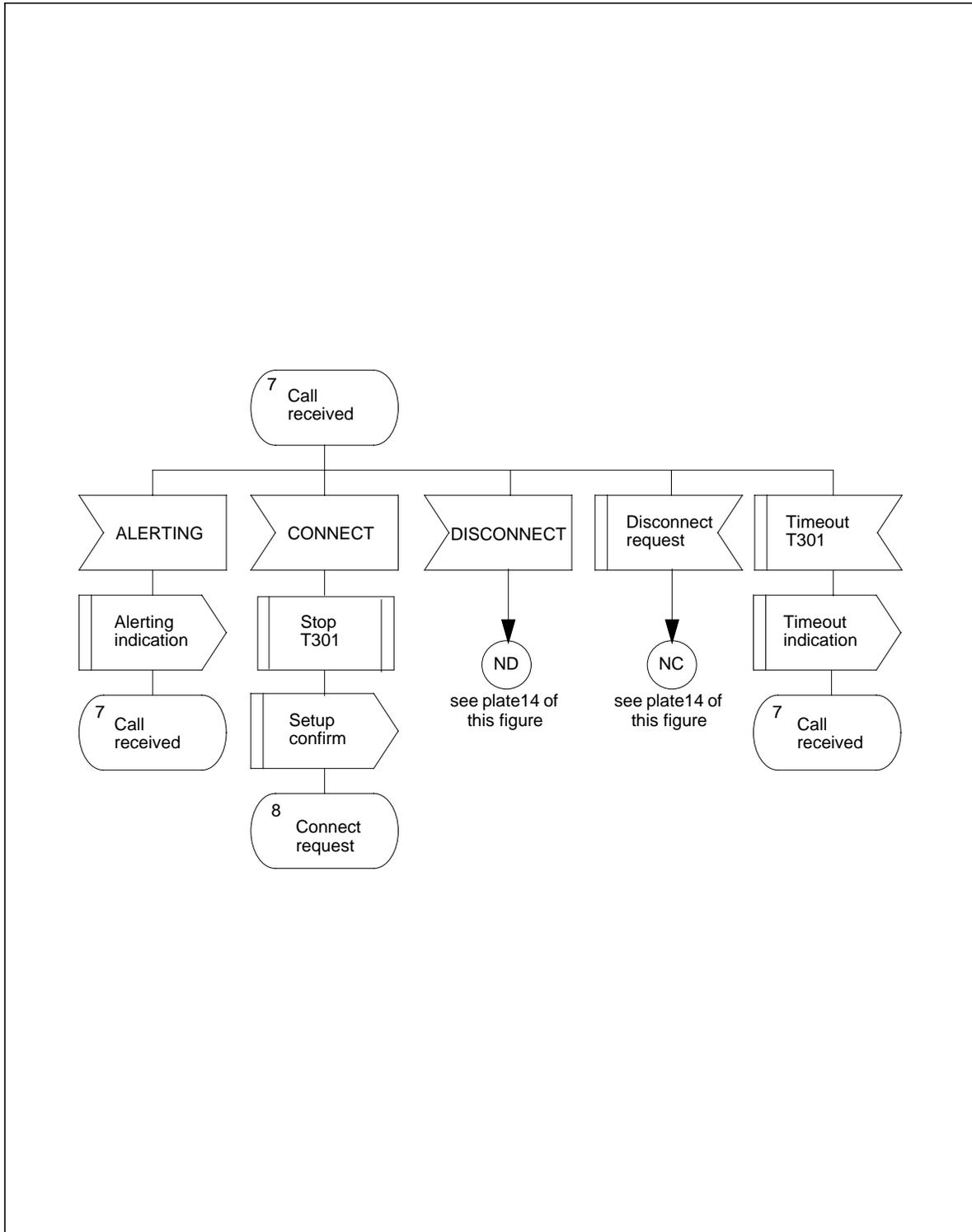
Figure 119 Detailed protocol control: network side (8 of 18)
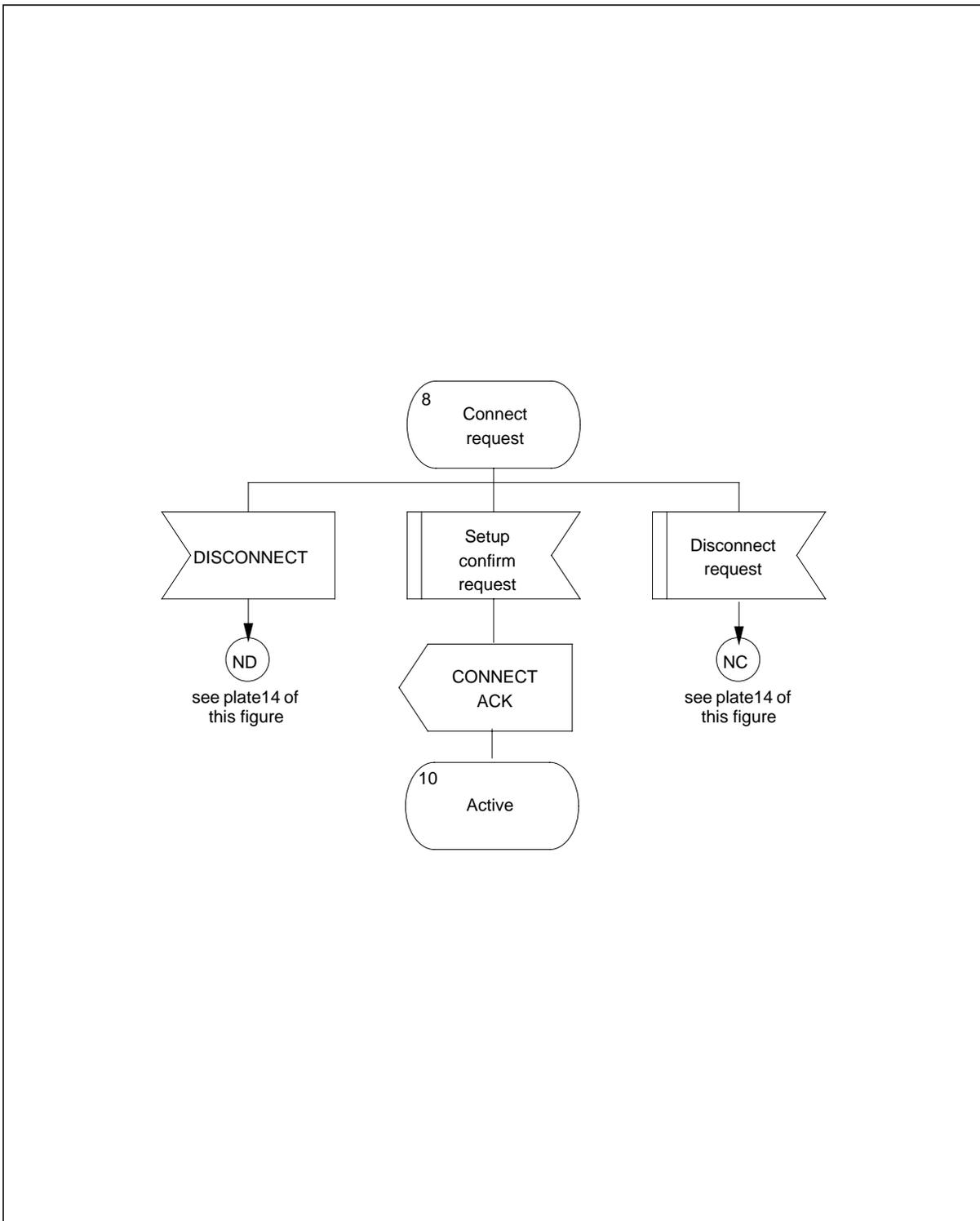
Figure 120 Detailed protocol control: network side (9 of 18)
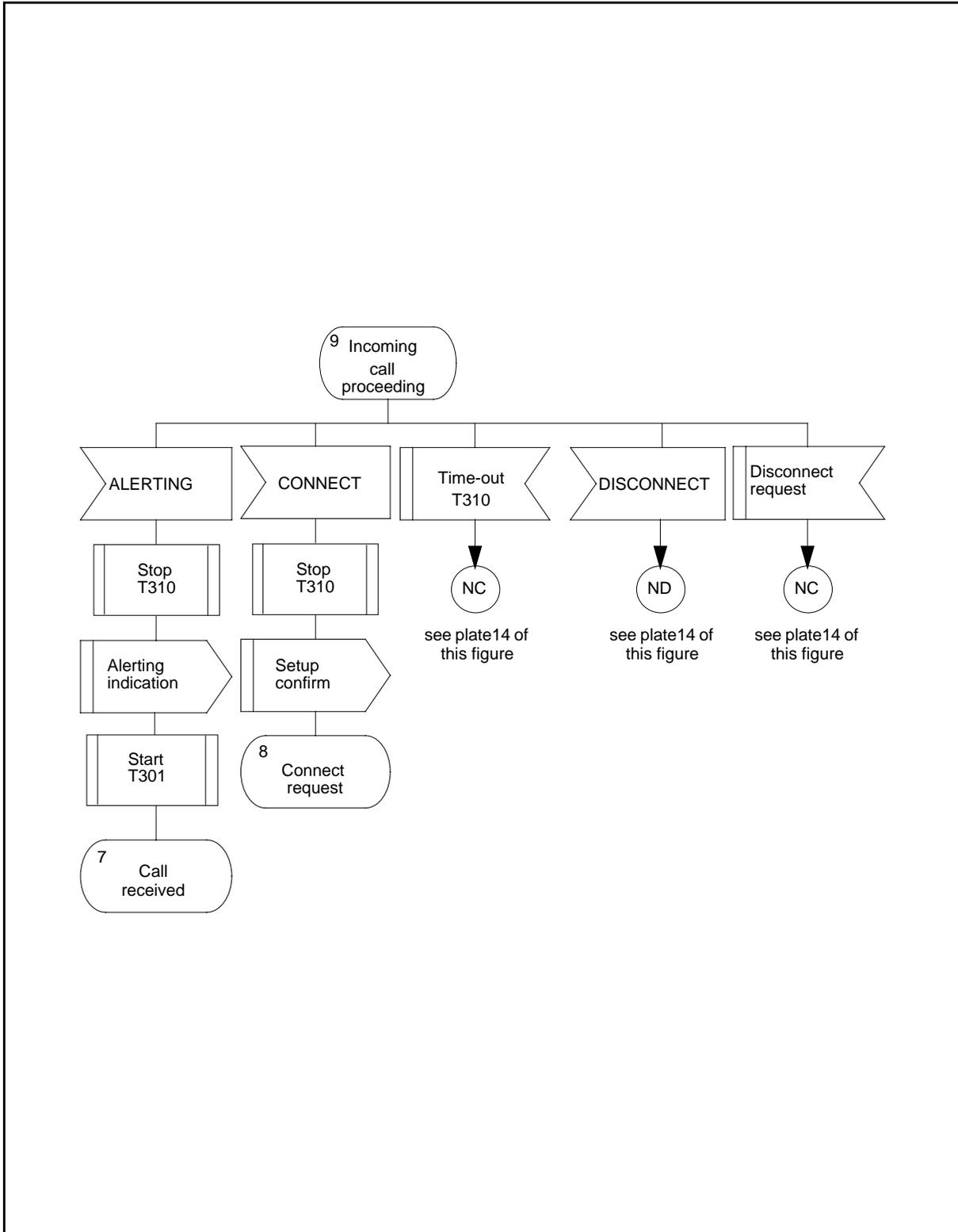
Figure 121 Detailed protocol control: network side (10 of 18)
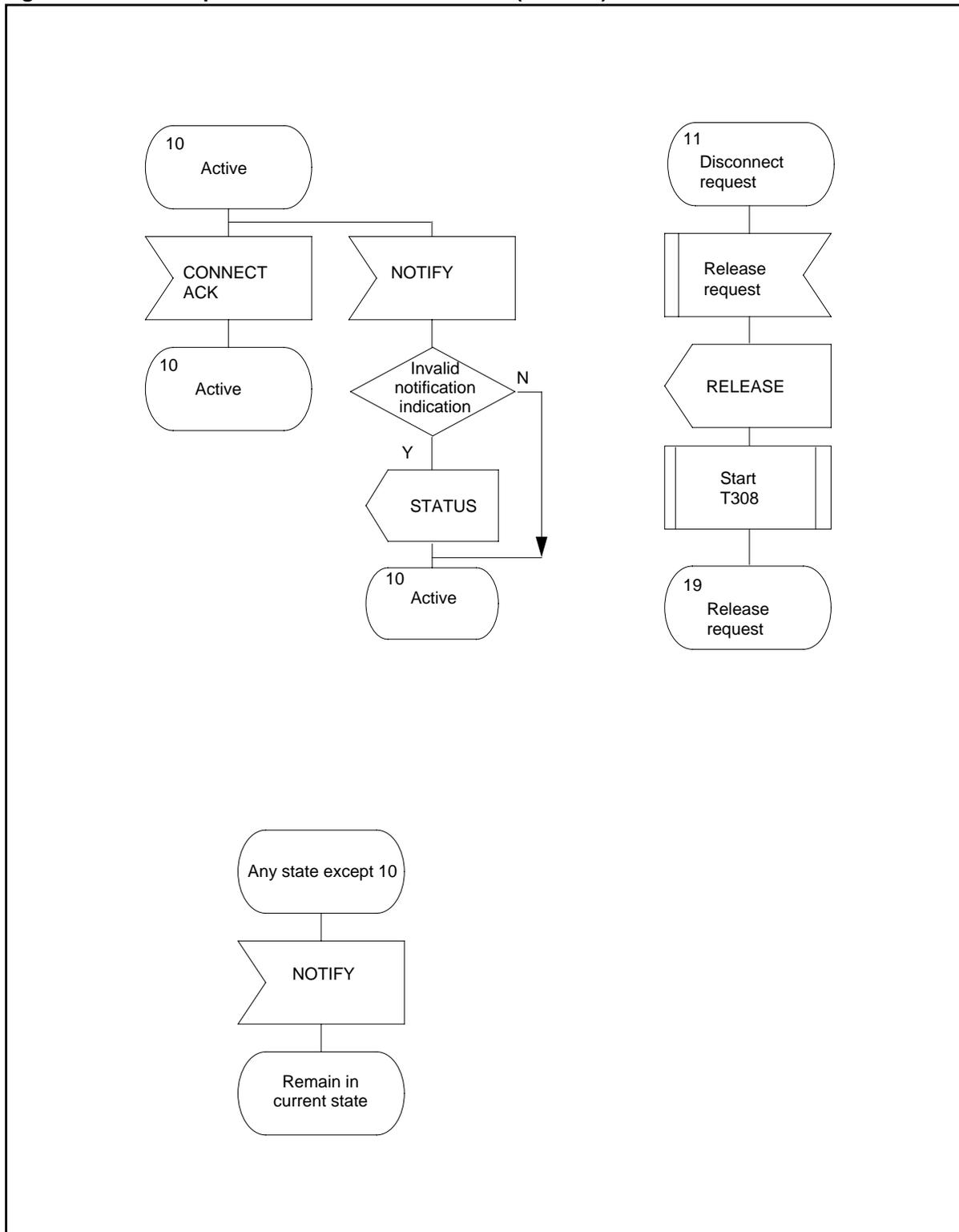
Figure 122 Detailed protocol control: network side (11 of 18)
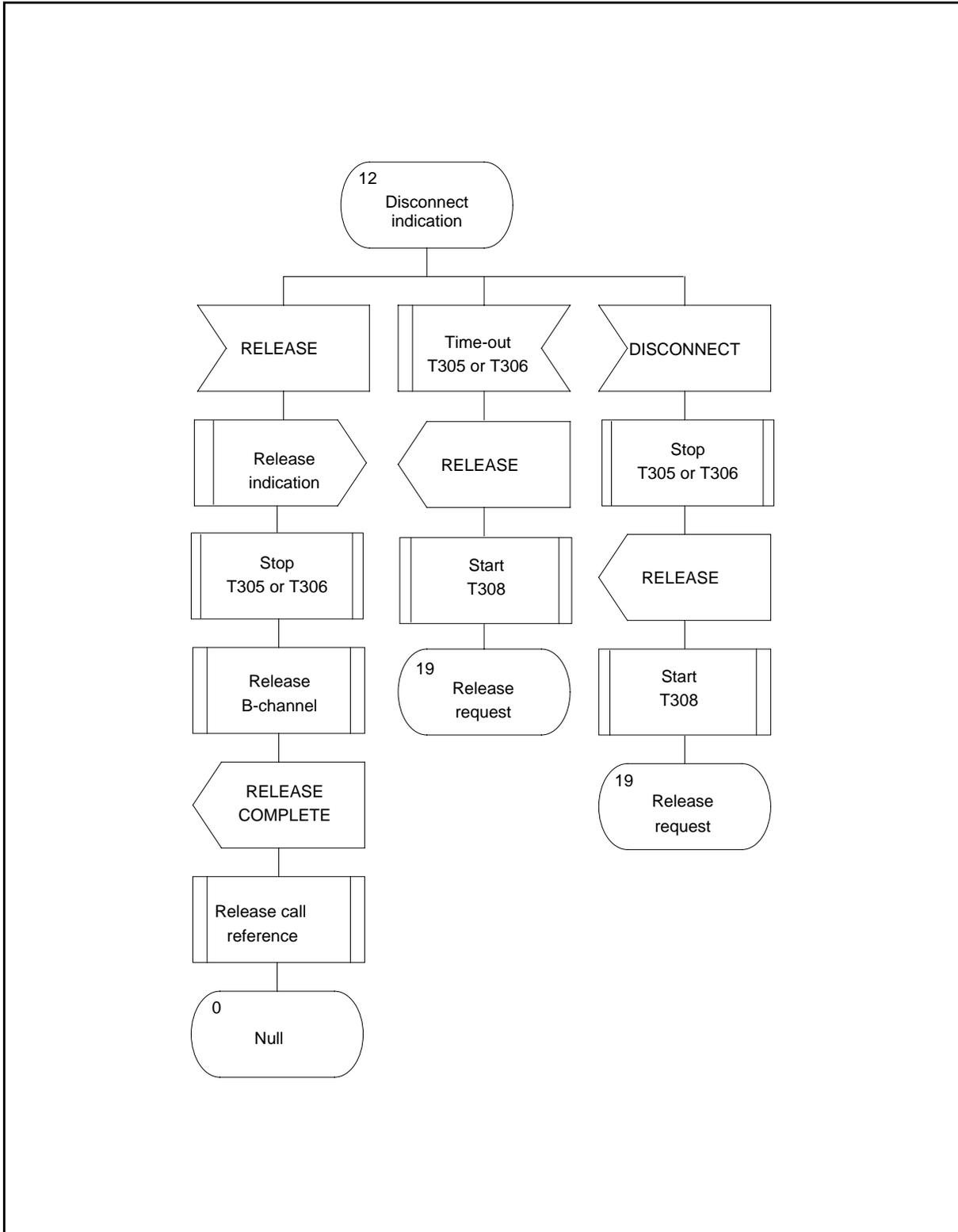
Figure 123 Detailed protocol control: network side (12 of 18)
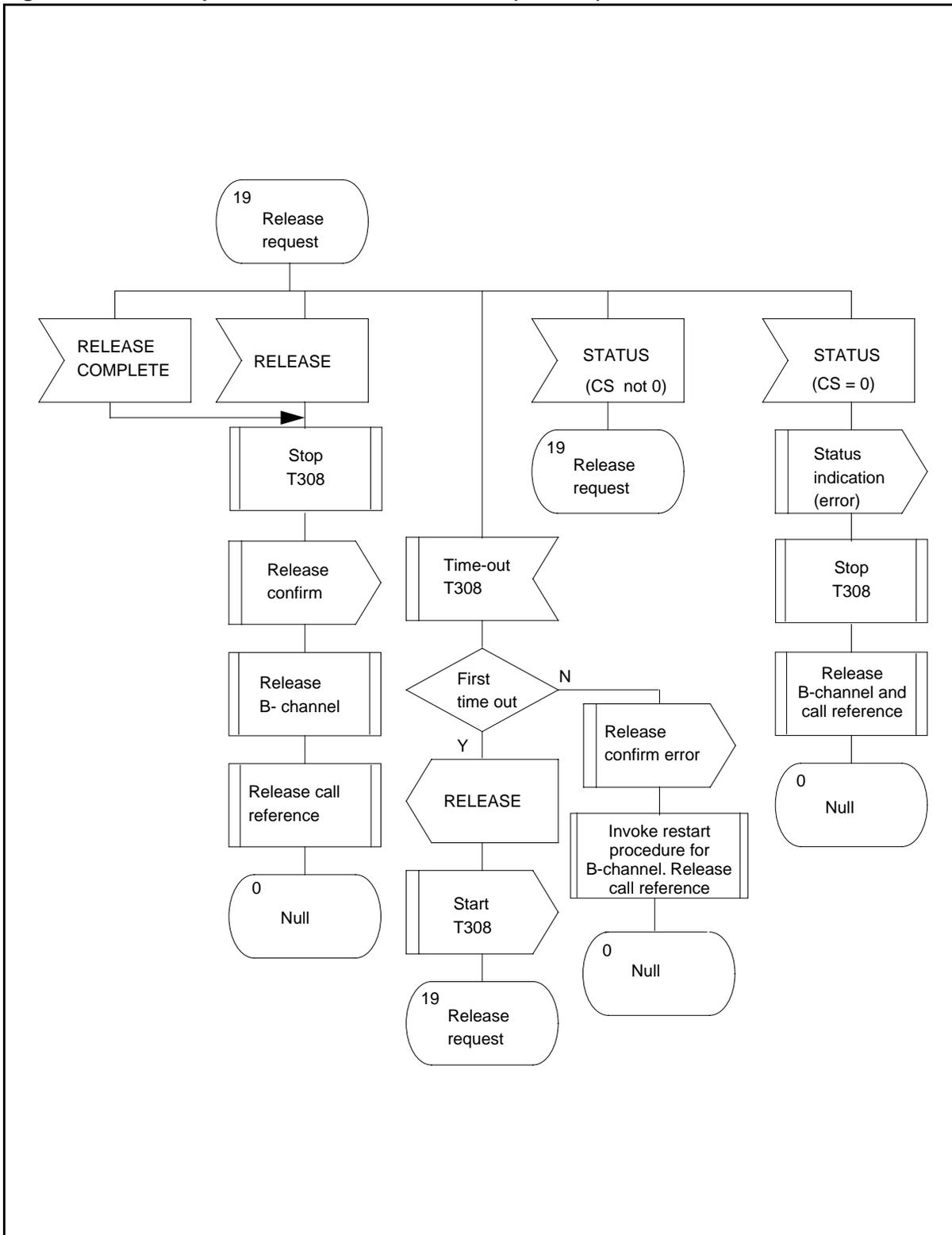
Figure 124 Detailed protocol control: network side (13 of 18)
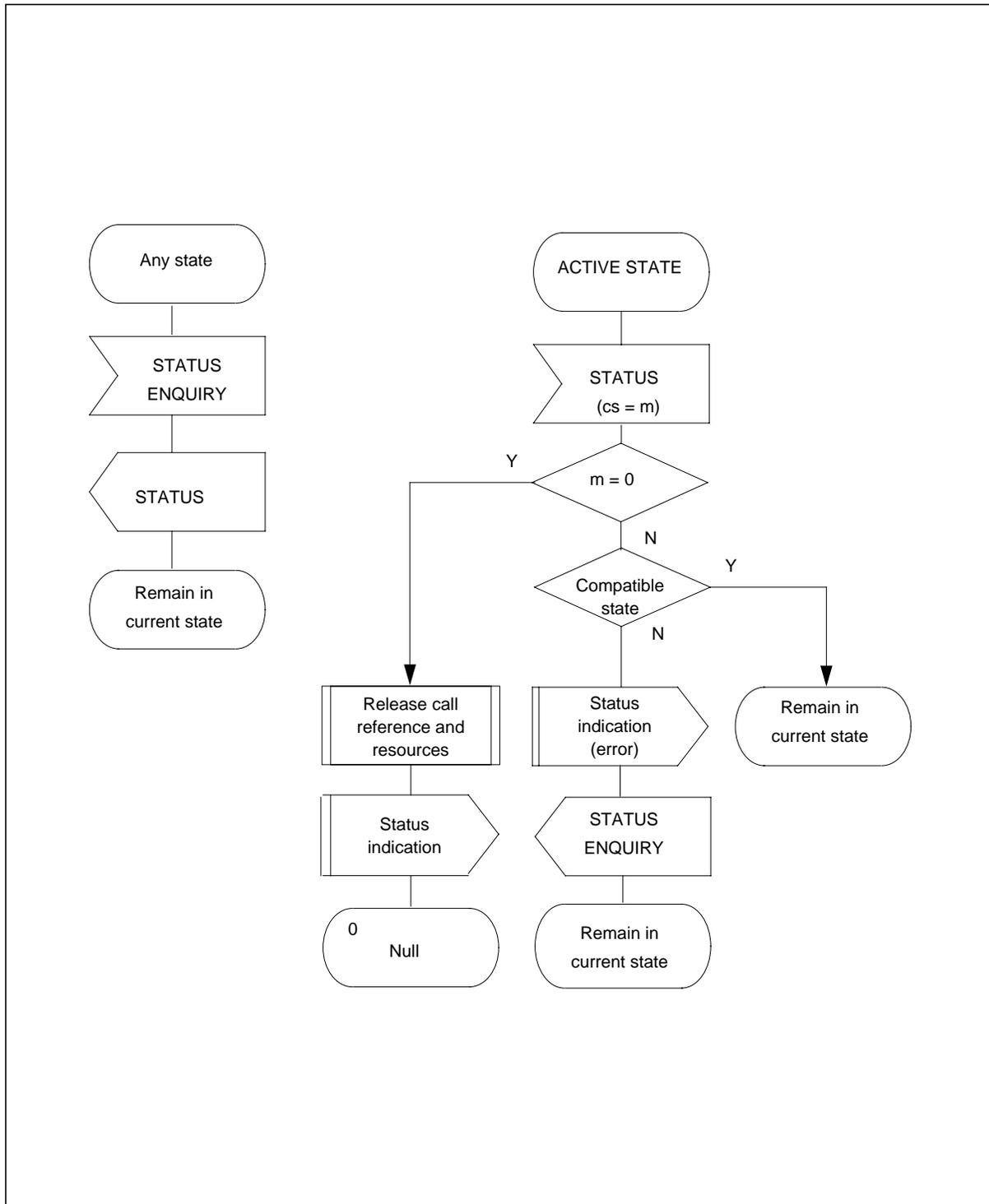
Figure 125 Detailed protocol control: network side (14 of 18)
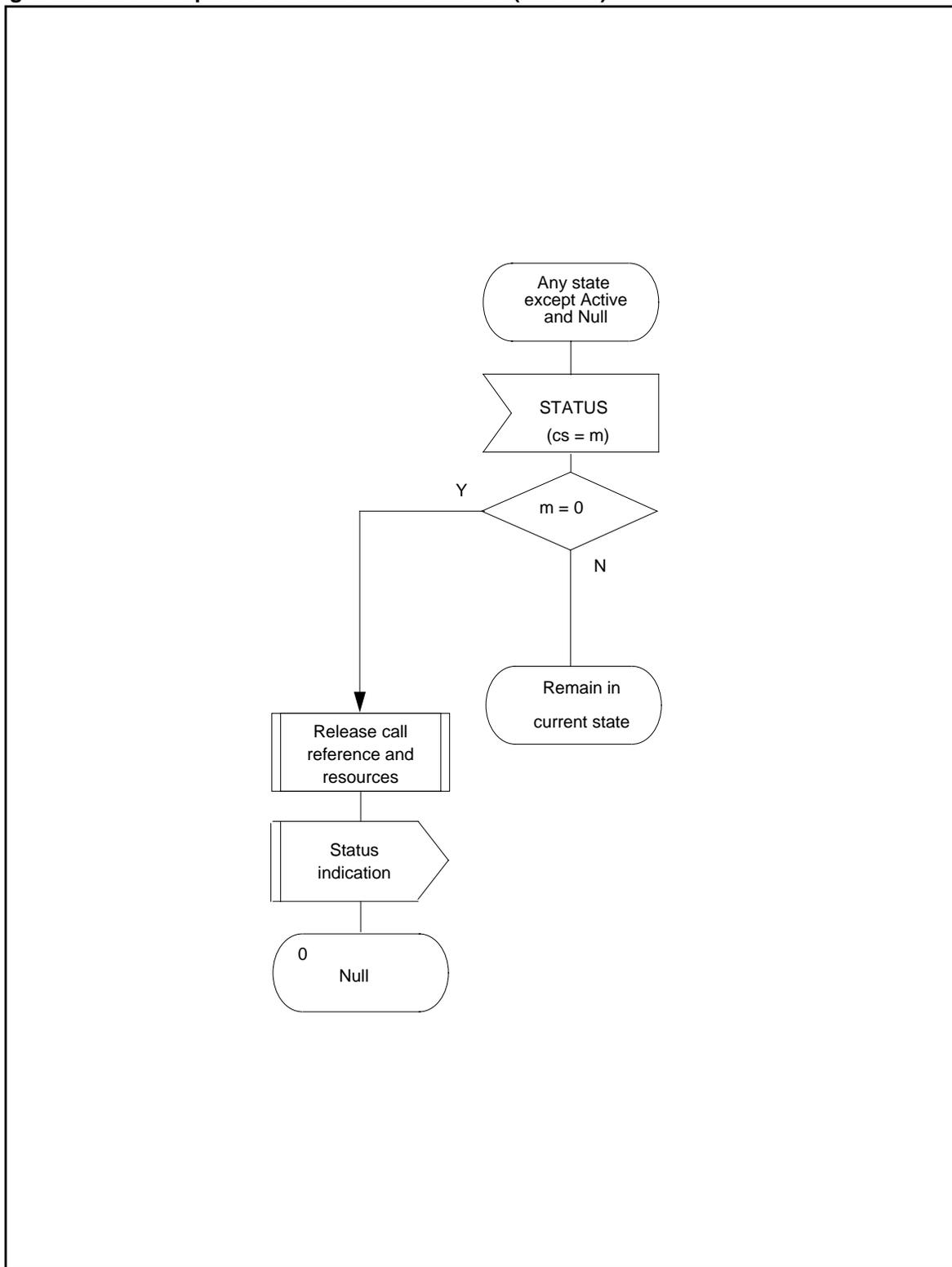
Figure 126 Detailed protocol control: network side (15 of 18)
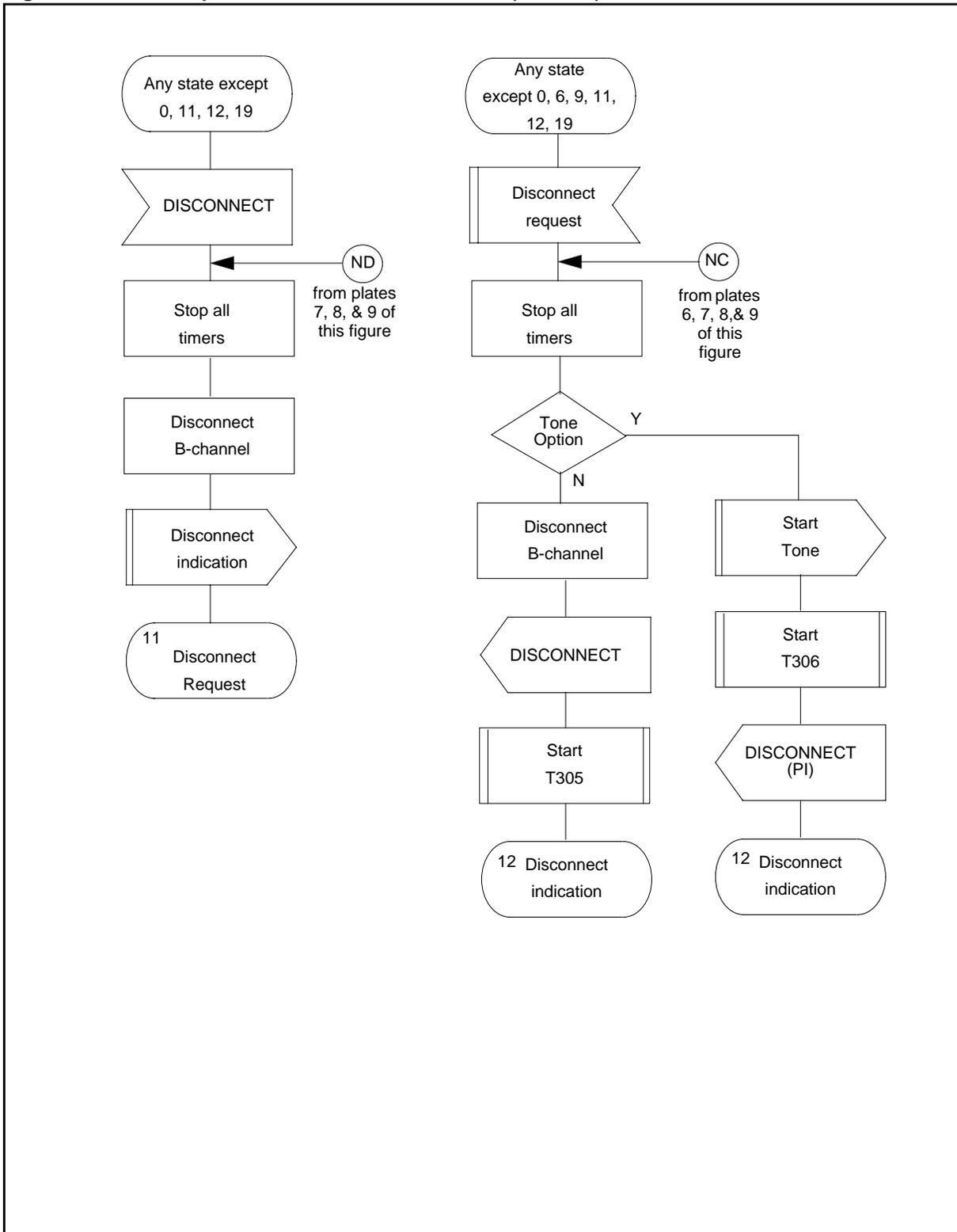
Figure 127 Detailed protocol control: network side (16 of 18)

Figure 128 Detailed protocol control: network side (17 of 18)
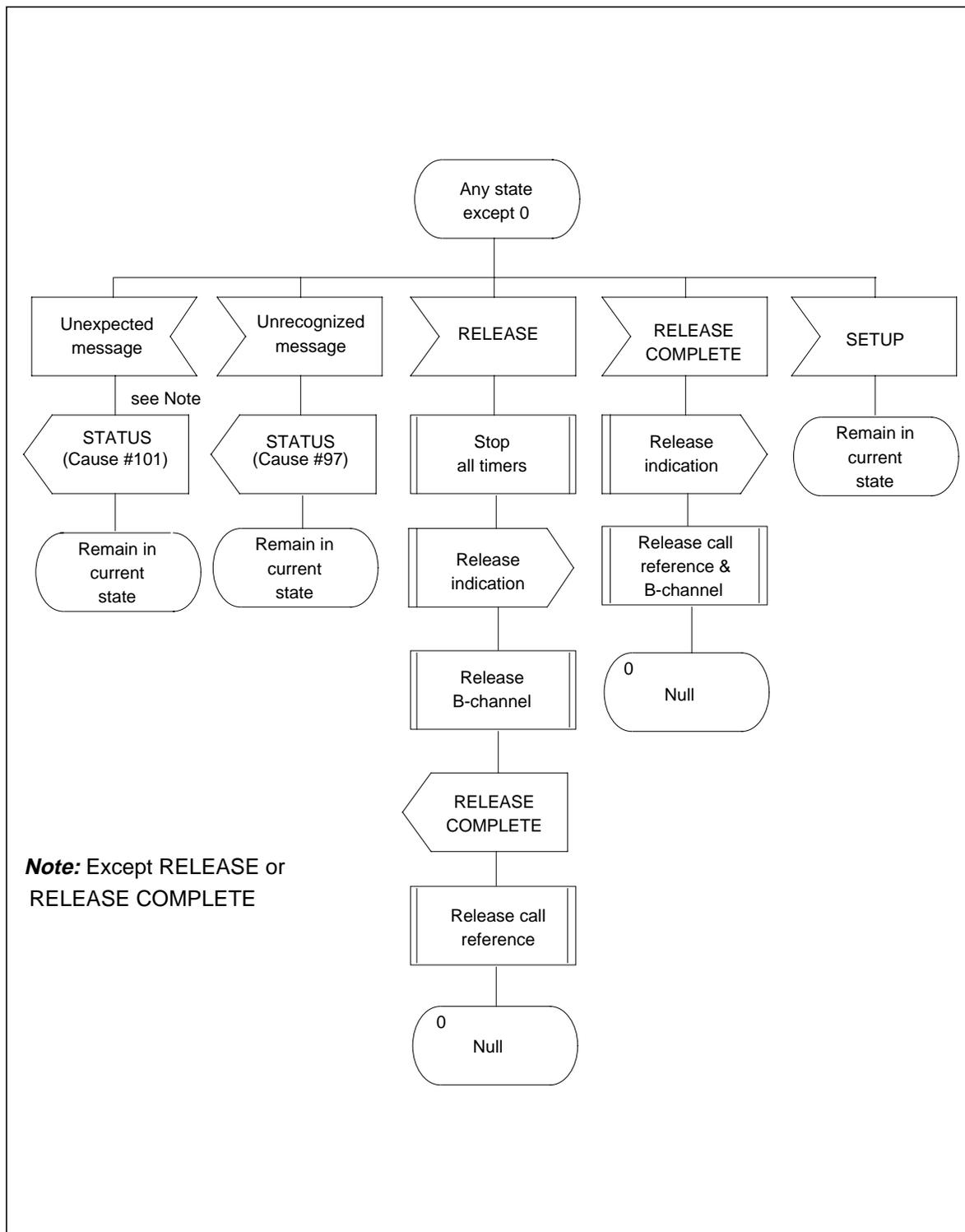
Figure 129 Detailed protocol control: network side (18 of 18)
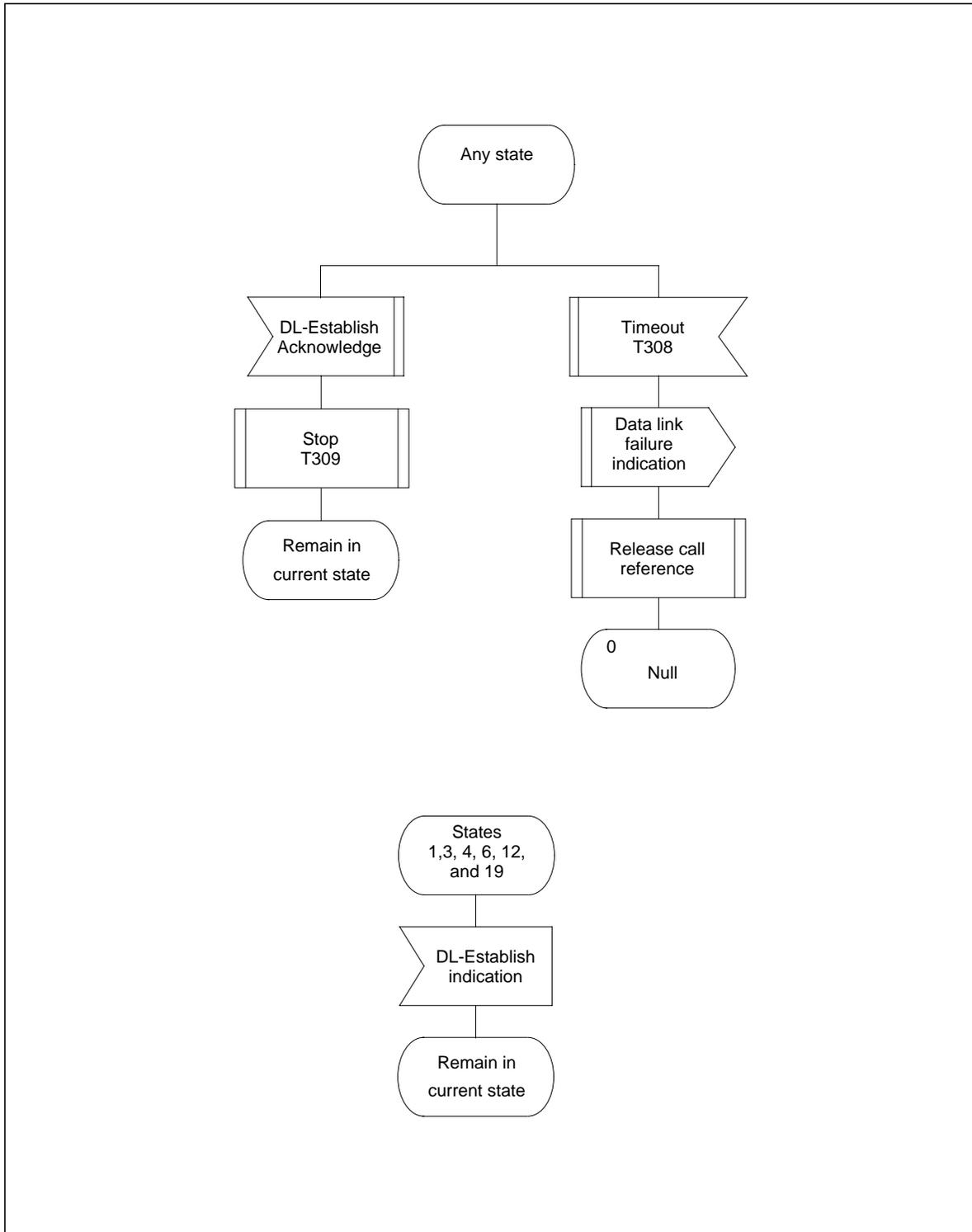
Part V: Supplementary services

Chapter 23: Supplementary services introduction

23.1 Introduction

The ISDN primary rate interface (PRI) supplementary services described in this section are those offered by a DMS-100 switch (the network) to a PRI user such as a private branch exchange (PBX).

The supplementary services offered with this specification are as follows:

- Calling line identification presentation/restriction (including calling line subaddress)
- Called party subaddress transmission
- Low and high layer compatibility
- Direct dial inward
- Hunt group
- Multiple interface per D-channel

The services offered are in accordance with *NTT INS NET 1500 Service Interface Volume 3 Primary rate user-network interface Layer 3 specification (Rev 1 1989)*

The call contol messages and associated information elements necessary to support the supplementary services are described in Section 4 of this specification.The message formats must be supported by the protocol in order that the service can be defined.

In the following chapters in this section, the service implementation is defined; there are a number of references to the messages and information elements in Section 4 should the reader require more information on the call control procedures.

Chapter 24: Supplementary services

24.1 Calling line identification presentation/restriction

The calling line identification presentation/restriction (CLIP/CLIR) supplementary service transmits the calling party number from the network to the terminating user. Calling line identification uses the *Calling party number* information element in the *Setup* message to transfer information from the calling terminal to the called terminal. The content of the *Calling party number* information element is subject to mandatory and subscription option controls.

In addition to the calling party number, the calling party subaddress is also transmitted to the called user if the *Calling party subaddress* information element is presented in the *Setup* message. The delivery of the subaddress information is not subject to the controls placed on the delivery of the calling party number. Note also that delivery of the subaddress is only available if the service provider has configured the network to permit the transmission of subaddress information.

The calling user may restrict presentation of their number on a per-call basis or for all calls.

The detailed SDL diagrams in Figure 130 and Figure 130 show the controls for the calling line identification presentation supplementary service. The *Calling party number* information element is described in Chapter 19: "Message formats", of this specification.

24.1.1 Mandatory controls at the originating interface

If the calling party number is not included in an incoming *Setup* message:

- the network provides the default calling party number from subscription data

- the screening indicator in the *Calling party number* information element is set to "Network provided".

If the calling party number is included in the incoming *Setup* message the network performs screening to determine whether a network-provided or user-provided calling party number is used to identify the calling user.

Figure 130 SDL diagram for calling line identification presentation/restriction at originating exchange
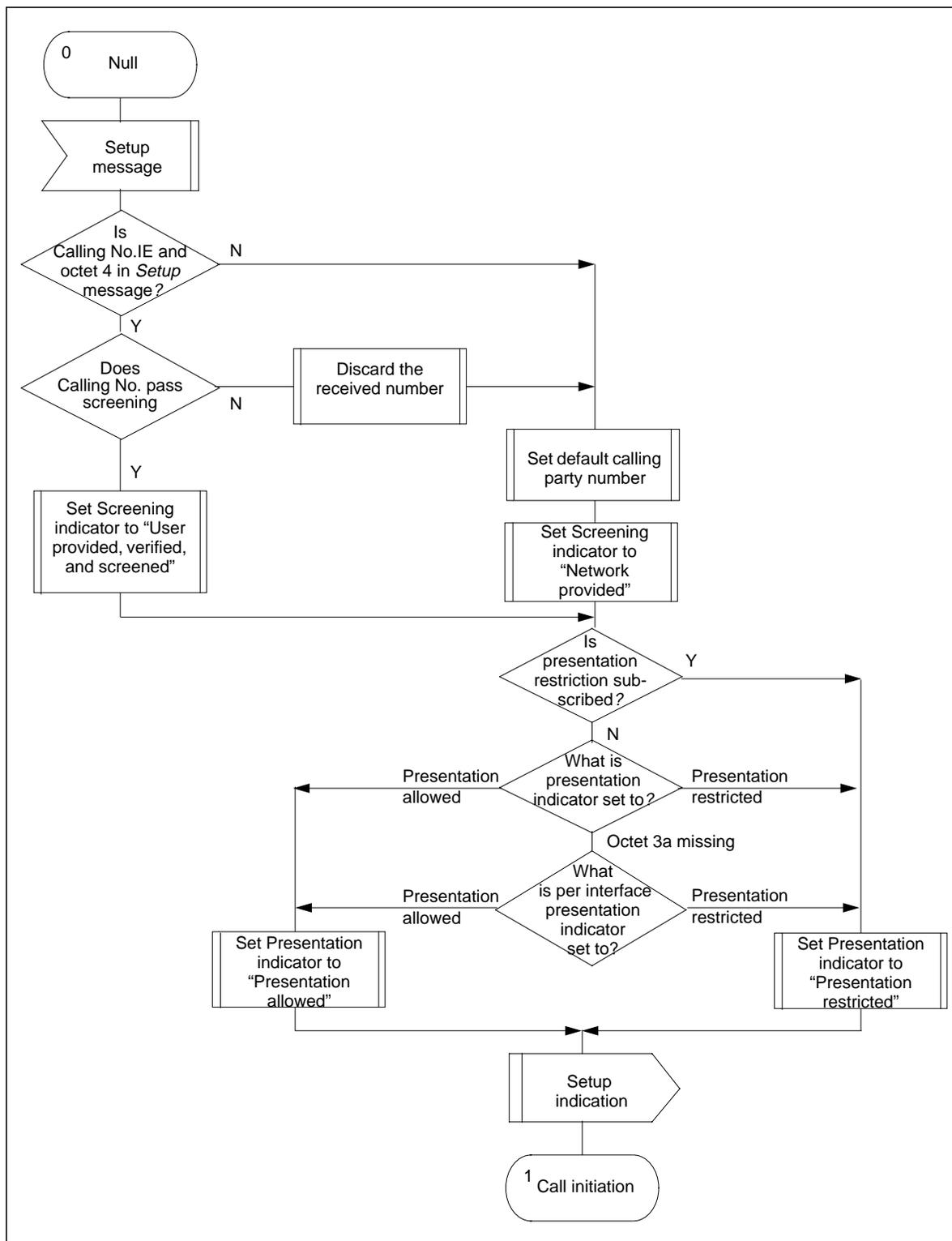
Figure 131 SDL diagram for calling line identification presentation/restriction at terminating exchange
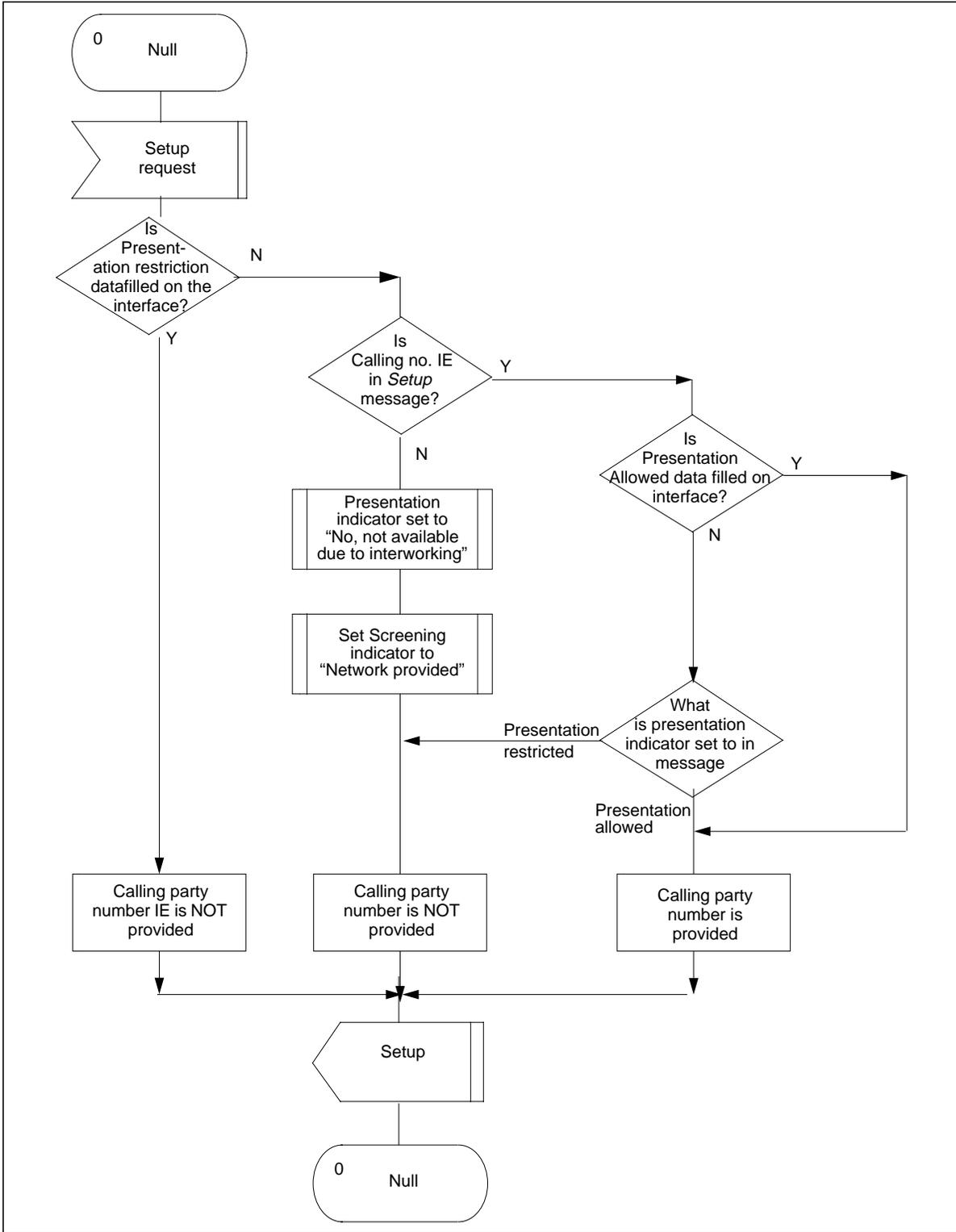
If the calling party number fails screening

- the network provides the default calling party number from subscription data

- the screening indicator in the *Calling party number* information element is set to "Network provided"

If the screening passes, the network sets the screening indicator to "User provided, verified and passed" and performs editing on the calling party number.

Editing is performed to convert a partial number delivered to the network interface at the calling end into a complete address that can be transmitted through the network to the called user. That is, if the number delivered by the calling party is of the form (*local office code + subscriber number*), it can be modified to a network number of the form (*0 + area code + local office code + subscriber number)* before transmission to the called party.

24.1.2 Optional controls at the originating interface

The user may select, as a subscription option, to have all calling party numbers marked as "Presentation restricted" by the *Calling party number* information element—in field *Presentation indicator.* Alternatively, the presentation indicator can be taken from the calling party number information provided by the user on a per-call basis.

If the presentation indicator is not included in an incoming *Setup* message, the network provides the default calling party number presentation indicator value from subscription data.

24.1.3 Controls at the terminating interface

The following paragraphs describe the controls for the delivery of the calling party number to the terminating user.

Interworking

If the *Calling party number* information element is not present, the presentation indicator is set to "Number not available due to interworking" and the screening indicator is set to "Network provided". No calling party number is passed to the terminating user.

Normal termination

If the presentation indicator is set to "Presentation allowed" the terminating exchange receives the calling party number.

If the presentation indicator is set to "Presentation restricted", no calling party number is sent to the terminating user, unless that user has subscribed to override the restriction.

24.1.4 Exception conditions

The service provider must configure the mandatory and optional controls, especially the default calling party number, to ensure that correct information is transmitted across the network.

If the network is unable to transmit the *Calling party subaddress* information element, a *Status* message containing *Cause* value #43 "Access information discarded" is returned to the user that sent the initial information element.

24.2 Called party subaddress transmission

The called party subaddress transmission supplementary service allows the transparent transport of called user subaddress information from the originating interface to the destination interface.

This service may be used to extend the addressing capacity beyond that supported by the network. For example, a PBX may only subscribe to one public ISDN number, but may allocate a unique subaddress (independent of the public ISDN numbering plan) to each of its terminals. This allows calls to be terminated on individual terminals in the PBX if the calling party specifies the private subaddress in addition to the public ISDN number of the PBX. Since the subaddress is tariffed as part of the basic call, this feature provides for an alternative tariff in comparison to the Direct dial inward service described in section 24.4 on page 332 of this chapter.

24.2.1 Description

A called party subaddress, if presented by a calling user, is delivered unchanged by the network to the called user. The called party subaddress may be used by the called user for terminal identification or for compatibility checking. The called user specifies the use of the subaddress.

This supplementary service does not include the transfer and delivery of the calling party subaddress information.

24.2.2 Operational requirements

The called party subaddress transmission supplementary service uses the incoming call and call offering procedures defined in Chapter 19: "Message formats".

If the calling user wants to transfer called party subaddress information to the called user, the calling user inserts the called party subaddress information in the *Called party subaddress* information element that is carried in the *Setup* message.

Similarly, at the destination interface, called party subaddress information is offered to the called user in the *Setup* message.

The called party subaddress transmission supplementary service is available to all users without prior arrangement or subscription between the user and the service provider.

24.2.3 Exception condition

If the *Called party subaddress* information element exceeds the maximum length (20 octets), it is truncated to that length.

The service is only available if the service provider has configured the network to permit transmission of the called party subaddress information.

If the network is unable to transmit the *Called party subaddress* information element, a *Status* message containing *Cause* value #43 "Access information discarded" is returned to the user that sent the original information element.

24.3 Lower and higher layer compatibility

This service allows the transparent transport of low layer compatibility (LLC) and high layer compatibility (HLC) information from the originating interface to the destination interface.

It may be used by the calling and called user for user-to-user compatibility checking and terminal identification. It allows calls to be terminated on a terminal that has the LLC and HLC compatibilities specified by the caller.

For example, a call offered on the destination interface with HLC encoded to *Group 4 Facsimile* is accepted only by a Group 4 facsimile terminal. In these situations, the destination interface can have one common ISDN address shared by voice, X.25, and facsimile terminals.

24.3.1 Description

This service allows the calling user to specify, and the called user to verify, the compatibility of their lower layer and higher layer protocols for communication on the bearer channel. The lower layer and higher layer compatibility information is not examined by the network; it is transferred unchanged through the network.

Lower layer compatibility is used to specify or check the compatibility at the lower protocol layers. That is, layers 1 through 3 in the NTT PRI. The higher layer compatibility is used to specify or check the higher protocol layers; typically layers 4 through 7 in the OSI model.

24.3.2 Operational requirements

The lower and higher layer compatibility services use the incoming call and call offering procedures defined in Chapter 19: "Message formats". The lower layer compatibility information is encoded in the *Lower layer compatibility* information element that is carried in the *Setup* and *Connect* messages. The

higher layer compatibility information is encoded in the *Higher layer compatibility* information element that is carried in the *Setup* message only.

The calling user may transfer either the lower or the higher layer compatibility information (or both) to the called user by inserting the relevant information elements in the *Setup* message as part of the basic call procedures. For lower layer compatibility, the *Connect* message may be used also.

Similarly, at the destination interface, the lower or higher layer (or both) compatibility information is offered to the called user in the *Setup* message. For lower layer compatibility, the *Connect* message may be used also.

The HLC and LLC feature is available to all users without prior arrangement or subscription between the user and the service provider.

24.3.3 Lower layer compatibility negotiation

The lower layer compatibility negotiation service allows the network to the *Lower layer compatibility* information element transparently in the *Connect* message. This allows the called and calling users to negotiate, out of band, one or more of the lower layer level attributes prior to call set up.

24.3.4 Exception conditions

The Lower and higher layer compatibility service is only available if the service provider has configured the network to permit transmission of these two information elements.

If the network is unable to transmit the *Lower level compatibility* or *Higher layer compatibility* information elements, a *Status* message containing *Cause* value #43 "Access information discarded" is returned to the user that sent the original information element.

24.4 Direct dial inward

The Direct dial inward supplementary service allows the called party number to be delivered to the called user interface. That is, on a PBX, this service allows the call to be set up directly to the terminal of the called user without intervention by an attendant.

24.4.1 Description

When the Direct dial inward supplementary service is provided, the destination local exchange delivers called party number information to the called user as part of the call set up procedures.

This service does not include the subaddress supplementary feature, though this may be combined with this service.

The number of digits delivered, the types of number, and the numbering plans that are supported are detailed in Chapter 19: "Message formats".

24.4.2 Operational requirements

The Direct dial inward supplementary service uses the incoming call and call offering procedures defined in Chapter 19: "Message formats". The called party number is encoded in the *Called party number* information element that is carried in the *Setup* message.

The Direct dial inward supplementary service requires prior arrangement or a subscription arrangement between the user and the service provider.

24.5 Hunt group

The hunting supplementary service is provided in the DMS-100 PRI trunk group selection mechanism.

24.5.1 Description

The hunting supplementary service allows the user to select the order that the B-channels are selected on the PRI interface. Six channel selection algorithms are available:

- Ascending sequential (ASEQ)
- Descending sequential (DSEQ)
- Clockwise circular trunk hunt (CWCTH)
- Counter clockwise circular trunk hunt (CCWCTH)
- Most idle (MIDL)
- Least idle (LIDL)

In the *ascending and descending search* sequence, shown in Figure 132, the selection order and the selection starting point are fixed. In general, the administrator should set the beginning of the list on the network side as the end of the list on the user side, and to select one side to use the ascending search and the other to use the descending search.

An example of a typical setup is shown in the statement thatFigure 132 "Ascending and descending hunting search"

If a *circular search* sequence is selected, the B-channel is selected by referencing the previous channel that was used and then picking the next free channel that is available—either clockwise or counter-clockwise (see Figure 133).

Note that the trunk should be set up so that the user and network side use different direction searches so that the incidence of glare is reduced.

If a *most idle and least idle channe search* sequence is selected, the channels are selected depending on the length of time that they have been idle. One switching group selects a channel that has been idle for the longest period of time. The opposite end selects a channel that has been idle for the shortest possible time. This ensures that the selection order of trunks is never fixed or predictable.

In all cases, the search is carried out on all B-channels associated with a trunk group. Therefore, as indicated in the introduction to the specification, a total of 479 B-channels may be associated with a single D-channel. All channels associated with that D-channel form the trunk group.

Figure 132 Ascending and descending hunting search
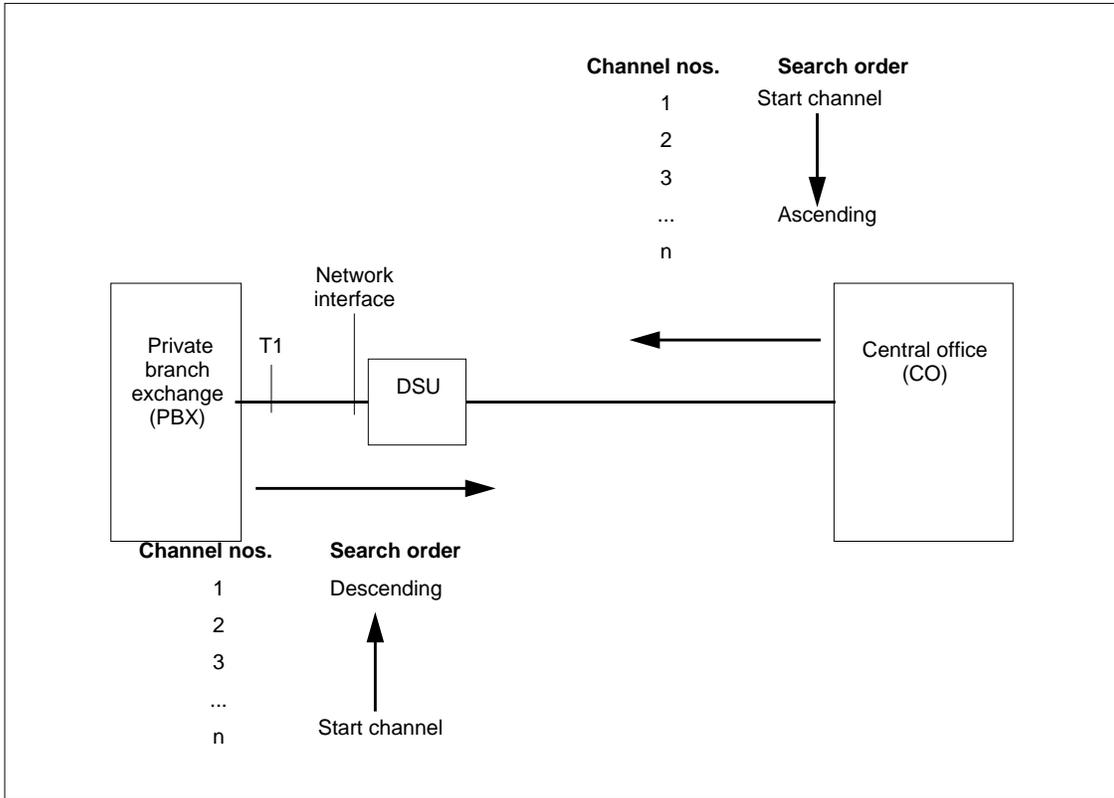
24.5.2 Operational requirements

For this supplementary service to operate efficiently, both sides of the network interface must have an agreement on the search method and the direction of search that each uses.

Figure 133 Circular hunting search
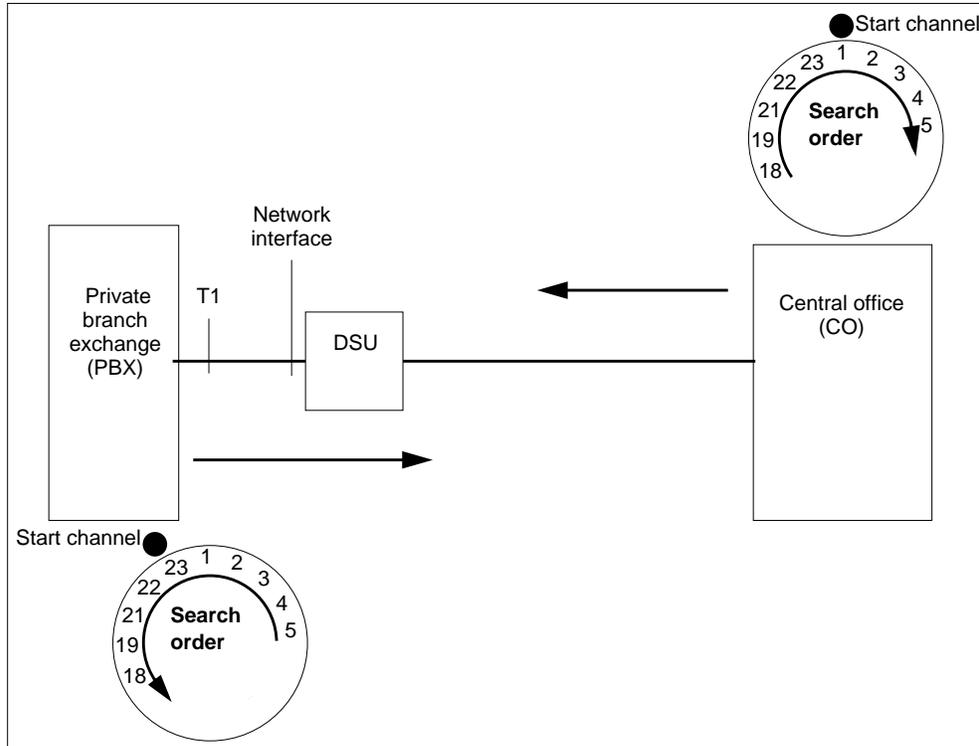
24.6 Multiple interface per D-channel

The multiple interface per D-channel (or non-associated signalling, as it is sometimes called) supplementary service enables a D-channel signal entity to assign calls on more than one interface (including the one containing the D-channel).

24.6.1 Description

The multiple interface per D-channel supplementary service provides support for nB + D channels on a single interface, where n is greater than 23. The number n is limited by the number of available interfaces on the DTCI. This is 20 on the DMS-100.Therefore, the maximum number of B-channels that can be supported by a single D-channel on a DMS-100 is 479. This number may be reduced in normal operation depending on the D-channel traffic capacity.

24.6.2 **Operational requirements**

This supplementary service requires explicit identifiers in the *Channel identification* information element as defined in Chapter 19: "Message formats".

Whenever the *Channel identification* information element is used in the call procedures, an interface identifier must be included in the information element if the channel is on an interface other than the one containing the D-channel. identifier (octet 3.1).

The value of the *Interface identifier* information element is in the range 0 to 31(binary coded). The length of the *Interface identifier* information element is always 1 octet. It is assigned to the interface at subscription time. Note that although the value is in the range 0 to 31, the maximum number allowable is 20.

List of terms

alarm indication signal (AIS)

A signal transmitted in lieu of the normal signal to maintain transmission continuity, and to indicate to the receiving terminal that there is a transmission fault which is located either at the transmitting terminal or upstream of the transmitting terminal. AIS is commonly called the Blue Alarm signal.

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

bipolar (alternate mark inversion) signal

A pseudo-ternary signal, conveying binary digits, in which successive "ones" (marks, pulses) are of alternating, positive (+) and negative (-) polarity, equal in amplitude, and in which a "zero" (space, no pulse) is of zero amplitude.

B8ZS (bipolar with 8-zero substitution)

A code where eight consecutive "zeros" are replaced with the sequence if the preceding pulse was +1, and with the sequence if the preceding pulse was -1, where +1 represents a positive pulse, -1 represents a negative pulse and 0 represents no pulse.

BCD

Binary coded decimal

bipolar violation

In a bipolar signal, a one (mark, pulse) which has the same polarity as its predecessor.

C/R

Command/Response field bit

carrier

An organization that provides telecommunications services to the public.

CCS7

    Common channel signaling system no. 7

CDN

    Called party number

CEI

    Connection endpoint identifier

CES

    Connection endpoint suffix

clear channel capability

    A characteristic of a transmission path in which the bit positions allocated for customer data may represent any combination of zeros and ones. For the DS-1 rate, the bits allocated for customer data are the last 192 bits of each frame.

CO

    Central office

CGN

    Calling party number

customer installation (CI)

    Consists of equipment and facilities at the customer' s location on the customer side of the network interface.

cyclical redundancy check (CRC)

    A method of checking the integrity of received data, where the check uses a polynomial algorithm based on the content of the data.

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.

DDI

    Direct dialing inward

DISC

    Disconnect

DL

    Communication between layer 3 and data link layer

DLCI

    Data link connection identifier

DM

Disconnect mode

DN

Directory number

DDO

Direct dialing outward

DS-1 (digital signal level 1)

A digital signal transmitted at the nominal transmission rate of 1.544 Mbit/s.

EA

Extended address field bit

embedded operation channel (EOC)

An embedded operation channel (EOC) is provided on telecommunications facilities to support administration and maintenance. For the primary rate interface, the EOC is the extended superframe data link.

ET

Exchange termination

extended superframe (ESF) terminal

The extended superframe (ESF) terminal is the source and sink of ESF framing, cyclical redundancy check (CRC 6) bits, and performance report messages (PRMs). The extended superframe terminal may be in a network terminal 2 (NT2) or terminal equipment (TE) functional group, or in equipment located within the network.

FCS

Frame check sequence

FRMR

Frame reject

I

Information

Ia

Ia is the 4 wire (2 pair) bi-directional primary rate interface point on the network side of the termination equipment (that is, NT1, NT2, TA, and TE) including the equipment connecting cord or equivalent on the user side of the interface cable.

IA5

International alphabet No. 5

Ib

Ib is the 4 wire (2 pair) bi-directional primary rate interface point on the user side of the termination equipment (that is, NT and NT2) including the equipment connecting cord or equivalent on the network side of the interface cable.

ID

Identification

IE

Information element

information network system 1500 (INS1500)

INS1500 is an ISDN primary rate interface signaling protocol variant based on the 1989 INS-NET Service Interface Technical Reference.

INS1500

See information network system 1500.

integrated services digital network (ISDN)

A network in general, evolving from an existing telephony network which provides end-to-end digital connectivity to support a wide range of both voice and non-voice services. User access to an ISDN is by way of a limited set of standard multipurpose interfaces.

IRQ

Information request

ISDN primary rate user-network interface specification

A collection of transmission and switching facilities used by a carrier to establish communication channels between various customer interfaces (CIs).

ISDN

Integrated services digital network

ISO

International organization for standardization

isolated pulse

An isolated pulse is a pulse that is free from the effects of the other pulses in the same signal. (A suitable testing signal is a repetitive pattern of a single "one" pulse followed by seven "zero" pulses, {100000001000000010000000...}.)

ISUP

ISDN user part

jitter

Jitter is a measurement of the short term variation of the significant instants of a digital signal from their ideal positions with respect to time. Short term implies that these variations are high frequency (greater than 10 Hz). (Compare with wander.)

keep-alive signal

A keep-alive signal is a signal that is transmitted instead of the normal signal to maintain transmission continuity on a particular channel.

L1

Layer 1

L2

Layer 2

L3

Layer 3

LAPB

Link access procedure -balanced

LAPD

Link access procedure on the D-channel

LDN

Listed directory number

loopback

A loopback is a state of the transmission facility in which the received signal is returned towards the sender.

M

Modifier function bit

MCO

Message class of service

MDL

Communication between management entity and data link layer

MF

Multiple frequency (analog) signaling

multiplexer

A multiplexer is a piece of equipment that is used for combining (multiplexing) two or more tributary signals into a single composite signal. In general, the multiplexer is

also used to de-multiplex the composite signal. That is, to separate the composite signal into its component tributary signals.

N(R)

Receive sequence number

N(S)

Send sequence number

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.

network interface (NI)

The network interface (NI) is the point of demarcation between the network and the customer interface (CI).

NPI

Numbering plan identification

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).

P/F

Poll/Final bit

payload

Payload is a term that is used to indicate the information data in a frame. For instance, the payload of a DS-1 frame consists of the 192 information data bits.

PBX

Private branch exchange

performance report messages (PRM)

An autonomous report initiated by an ISDN primary rate interface terminal (ET or NT/TE) that provides an objective measurement of the quality of transmission incoming to the terminal.

phase transient

An event which causes movement of the phase of the signal with respect to absolute time (for example, clock rearrangement).

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 1.536 Mbit/s payload.

PTS

           Per trunk signaling

pulse density

           A measure of the number of "ones" (marks, pulses) as a percentage of the total number of digital time slots transmitted.

receive signal

           The signal received across an interface Ia or Ib by the associated equipment.

receiver

           The sink or terminator of any signal in a transmission medium.

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.

regenerator

           Equipment that reconstructs and retransmits a received pulse train.

REJ

           REJect

remote alarm indication (RAI)

           A remote alarm indication (RAI) signal is transmitted in the outgoing direction when a terminal determines that it has lost the incoming signal. The RAI is commonly called the Yellow Alarm signal.

Ri

           Reference number

RNR

           Receive not ready

RR

      Receive ready

S

      Supervisory

S1

      Supervisory function bit

SABME

      Set asynchronous balanced mode extended

SAP

      Service access point

SAPI

      Service access point identifier

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.

TE

      Terminal equipment

TEI

      Terminal endpoint identifier

terminal equipment (TE)

      Terminal equipment (TE) is a functional group that provides the operation of user access protocols. (Digital telephones, data terminal equipment, and integrated work stations are examples of equipment that provide the functions associated with TEs).)

TNS

      Transit network selection

TON

      Type of number

transmit signal

      The signal sent across an interface Ia or Ib from the associated equipment.

transmitter

The source or generator of any signal in a transmission medium.

U

Unnumbered

UA

Unnumbered acknowledgment

UI

Unnumbered information

unit interval (UI)

The nominal difference in time between consecutive significant instants of an isochronous signal. In wave theory, this is referred to as the period of a wave.

V(A)

Acknowledged state variable

V(M)

Recovery state variable

V(R)

Receive state variable

V(S)

Send state variable

wander

Wander is a measurement of the long term variations of the significant instants of a digital signal from their ideal positions with respect to time. Long term implies that these variations are low frequency (less than 10 Hz). (Compare with jitter.)

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NØRTEL

NORTHERN TELECOM