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Lucent Technologies
Bell Labs Innovations

5ESS® Switch ISDN Primary Rate Interface Specification

5E12 and Later Software Releases

235-900-342
Issue 6.06
July 2000

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ISDN Primary Rate Interface Specification

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1. INTRODUCTION

1.1 PURPOSE

This document contains specifications for the physical interface and message-oriented signaling procedures of the *5ESS*® switch ISDN primary rate interface (PRI). It is published as a guide for the designers, manufacturers, suppliers, and operators of equipment that meets the *5ESS* switch PRI specifications.

Because of its multipurpose nature, this ISDN PRI is used in a range of applications including:

- The connection of customer premises equipment (CPE), either a private branch exchange (PBX) or other PRI-terminating equipment, to the *5ESS* switch central office (CO)
- The connection of a *5ESS* switch (either a PBX or a CO) to another *5ESS* switch, or to a switch compatible with the *5ESS* switch PRI
- The connection of a *5ESS* switch to a *4ESS*™ switch toll office or to other toll switches.

The *5ESS* switch ISDN PRI is a high-speed, multiplexed digital interface based on both international standards and Bellcore technical references. The PRI uses a 1.544-Mbps (DS1) digital interface, structured to contain bearer channels for the transport of end-user information (for example, voice, user data, video) and a message-oriented, out-of-band signaling channel for control of the bearer channels. This message-oriented signaling channel follows a layered protocol structure, based on ITU-T Recommendation Q.921 (I.441) for Layer 2 and ITU-T Recommendation Q.931 (I.451) for Layer 3.

Note: The Layers 2 and 3 recommendations are also called Q.921 and Q.931, respectively. The Q-Series Recommendations are identical to the respective I-Series Recommendations.

This interface specification is expected to change as requirements and standards evolve. Therefore, Lucent Technologies reserves the right to change or delete any portions of the document, or to add information in future issues.

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1.2 UPDATE INFORMATION

1.2.1 NEW IN THIS ISSUE

The following elements of this document reflect support of the feature II/OLI Delivery for National ISDN PRI as a software update for 5E14 Feature Release 3:

- Section 4.1.1.4, “5E14 Software Release,” has been changed.
- Table 4.2-13, “SETUP Message,” has been changed.
- Table 4.3-5, “Information Elements,” has been changed.
- Section 4.3.3.2, “Codesets,” has been changed.
- Section 4.3.3.12, “Generic Digits,” has been added, including:
  — Table 4.3-28, “Generic Digits Information Element Layout.”

— Table 4.3-29, “Example Encodings of Generic Digits IE.”

- Section 12, “Cross-References to Sections of Bellcore SR-4287,” has been changed.

Where technical content has been changed, vertical bars in the outer margin mark the affected pages.

1.2.2 SUPPORTED SOFTWARE RELEASES

In accordance with the *5ESS* Switch Software Support Plan, the 5E11 software release was rated Discontinued Availability (DA) as of November 13, 1999. The information supporting 5E11 and earlier is being removed over time, instead of concurrently, from all documentation.

If you are supporting offices that use a software release prior to 5E11 and have a need for the information that is being removed, retain the associated pages as they are removed from the paper documents, or retain the earlier copy of the CD-ROM.

1.2.3 TERMINOLOGY

This *5ESS* switch document may contain references to the *5ESS* switch, the 5ESS-2000 switch, and the 5ESS AnyMedia Switch. The official name of the product has been changed back to the *5ESS* switch. The documentation will not be totally reissued to change these references. Instead, the changes will be made over time, as technical changes to the document are required. In the interim, assume that any reference to the 5ESS-2000 switch or the 5ESS AnyMedia Switch is also applicable to the *5ESS* switch. It should be noted that this name change may not have been carried forward into software-influenced items such as input and output messages, master control center screens, and recent change/verify screens.

As of March 18, 1999, Bellcore officially changed its name to Telcordia Technologies. Not all pages of this document are being reissued to reflect this change; instead, the pages will be reissued over time, as technical and other changes are required. Customers on standing order for this document may see that, on previous-issue pages, the Bellcore name is still exclusively used.

Customers receiving new orders for this document will see the Telcordia Technologies name used as appropriate throughout the document, and the Bellcore name used only to identify items that were produced under the Bellcore name. Exceptions may exist in software-influenced elements such as input/output messages, master control center screens, and recent change/verify screens. These elements will not be changed in this document until such time as they are changed in the software code. Document updates will not be made specifically to remove historical references to Bellcore.

1.3 ORGANIZATION

The content of this interface specification is organized along the broad lines of the open systems interconnection protocol layers as follows:

- “Layer 1: The PRI Physical Layer,” Section 2, describes the PRI physical layer, including a summary of the electrical characteristics, the frame structure, and the line code on the T1 facilities carrying the PRI.

- “Layer 2: The PRI Data Link Layer,” Section 3, summarizes the PRI Data Link [link access protocol – D-channel (LAPD)], including a brief note on the differences between the National ISDN PRI and the Custom PRI at Layer 2. PRI data link procedures and link layer SDL diagrams are included.

- "Layer 3: The PRI Network Interface Layer," Section 4, specifies in detail the structure and coding for the Layer 3 messages flowing over the PRI, and the information elements (IEs) that are carried in these messages.
- "Call Control Procedures," Section 5, includes call control procedures such as normal call progression through the Layer 3 call states, error handling procedures, timer specifications, and other topics related to call control.
- "User Side Protocol Control SDL Diagrams," Section 6, "Network Side Protocol Control SDL Diagrams," Section 7, and "Symmetrical User SDL Diagrams," Section 8, present representations of the PRI for Layer 3 call control from the user side, the network side, and the symmetrical user side, respectively.
- "Maintenance Capabilities and Procedures," Section 9, specifies the maintenance messages and procedures for the PRI including separate discussions for the Custom PRI and the National ISDN PRI, and SDL diagrams for these procedures.
- "Non-Facility Associated Signaling and D-channel Backup," Section 10, describes procedures for non-facility associated signaling and for D-channel backup, two capabilities offered on the *5ESS* switch National ISDN PRI.

  Note: Neither of these capabilities is supported on the Custom PRI.
- "PRI Service-Specific Information," Section 11, gives individual descriptions of the features offered on the PRI and points to other documents for greater detail on these features.
- "Cross-References to Sections of Bellcore SR-4287," Section 12, provides a cross-reference between the specifications in this Lucent Technologies document and those in Bellcore SR-4287. Because of the close dependence between these two documents, this section has been included as an aid to the reader.

1.4 USER FEEDBACK

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Customers who are not represented by a documentation coordinator and employees of Lucent Technologies should order *5ESS* switch IPs directly from CIC.

To order, call the following telephone number:

- **1-888-LUCENT8 (1-888-582-3688)** or fax to **1-800-566-9568** (from inside the continental United States)
- **1-317-322-6847** or fax to **1-317-322-6699** (from outside the continental United States).

1.6 TECHNICAL ASSISTANCE

For initial technical assistance, call the North American Regional Technical Assistance Center (NARTAC) at **1-800-225-RTAC (1-800-225-7822)**.

For further assistance, call the Customer Technical Assistance Management (CTAM) center at the following number:

- **1-800-225-4672** (from inside the continental United States)
- **1-630-224-4672** (from outside the continental United States).

Both centers are staffed 24 hours a day, 7 days a week.

1.7 REFERENCES

1.7.1 OTHER *5ESS* SWITCH CUSTOMER DOCUMENTS

Document 235-190-104, **5ESS** *Switch ISDN Feature Descriptions* provides information on ISDN PRI feature and service operation, assignment, and implementation. Document 235-190-115, **5ESS** *Switch Local and Toll System Features* provides information about accessing inter-exchange carriers, including feature Group B and feature Group D access to carriers.

1.7.2 RELATIONSHIP TO BELLCORE DOCUMENTATION

The reader should be aware of the information contained in the following Bellcore documents:

1. Bellcore, *1998 Version of National ISDN Primary Rate Interface Customer Premises Equipment Generic Guidelines* (SR-4287)—the specifications for CPE to ensure compatibility with a PRI built to Bellcore technical references. CPE built to these specifications will be compatible with the *5ESS* switch National ISDN PRI.

2. Bellcore, *ISDN Primary Rate Interface Call Control Switching and Signaling Generic Requirements for Class II Equipment* (TR-NWT-001268)—the TR for the underlying PRI protocol and procedures, including NFAS and DCBU; compatible

with the National ISDN PRI. We note the following areas in which the *5ESS* switch National ISDN PRI differs from Bellcore requirements:

- The operator system access (OSA) IE is not supported. See “Dialed Sequences and Coding of SETUP Messages,” Section 5.2.14, for the rules for coding IEs for operator access.
- The calling party and called party subaddress IEs are not supported.
- Certain call-by-call services are available that are not specified by Bellcore TR-NWT-001268. See “PRI Service-Specific Information,” Section 11.
- Procedures to select the carrier for the call differ from the Bellcore procedures. See “Transit Network Selection,” Section 5.2.12, “Network Specific Facility Selection,” Section 5.2.13, and “Dialed Sequences and Coding of SETUP Messages,” Section 5.2.14.
- Certain limitations exist in the transmittal of user-supplied data. See “User-to-User Signaling Service,” Section 11.6, for user-to-user signaling service.
- On-demand packet-mode call setup procedures are not available on the *5ESS* switch PRI. See “Data Services,” Section 11.10, for available provisioned B-channel packet mode.
- Restart procedures differ from Bellcore procedures. One difference to note is that the *5ESS* switch accepts but does not send a RESTART message specifying restart of an entire interface. See “Maintenance Capabilities and Procedures,” Section 9.

3. Bellcore, *Generic Requirements for ISDN Call-by-Call Service Selection for Non-ISDN Foreign Exchange Facilities, Non-ISDN Tie Trunks, OUTWATS, and INWATS* (TR-NWT-001270)—the specifications for call-by-call services on the PRI, including the *5ESS* switch feature, Call-by-Call Service Selection for FX and tie, are described in this document.
4. Bellcore, *ISDN Calling Number Identification Services for Primary Rate Interfaces* (TR-NWT-001187)—the TR for calling number identification services (CNIS). The *5ESS* switch version of CNIS specified in this document is functionally equivalent to Bellcore TR-NWT-001187, but there are numerous differences in the protocol and procedures. As in other cases, the description in this *5ESS* switch document has precedence over the Bellcore document in cases of conflict.
5. Bellcore, *Generic Requirements for the Switched DS1/Switched Fractional DS1 Service Capability from an ISDN Interface (SWF-DS1/ISDN)* (TR-NWT-001203)—the TR for switched fractional-DS1 (NxDS0 switching). The document uses the protocol and procedures of Bellcore TR-NWT-001268 as a foundation and adds to those requirements to specify the capability. The switched fractional-DS1 capability offered on the National ISDN PRI is compatible with this document.
6. Bellcore, *ISDN Primary Rate Access Transport System Requirements* (TR-TSY-000754)—the *5ESS* switch PRI is compatible with the Layer 1 specified in this document.

7. Bellcore, *ISDN D-channel Exchange Access Signaling and Switching Requirements (Layer 2)* (TR-TSY-000793)—the *5ESS* switch PRI is compatible with the Layer 2 specified in this document.

8. Bellcore, *Switching System Operations Generic Requirements for ISDN* (GR-892-CORE).

9. Bellcore, *Advanced Intelligent Network (AIN) 0.2 Switch Intelligent Peripheral Interface (IPI) Generic Requirements* (GR-1129-CORE)—the facility IE and components are specified in this document.

10. Bellcore, *Advanced Intelligent Network (AIN) Switch-Service Control Point (SCP)/Adjunct Interface Generic Requirements* (GR-1299-CORE).

11. Bellcore, *Common Element Procedures for Service Control* (TR-NWT-000864)—the FACILITY message is specified in this document.

12. Bellcore, *Generic Requirements for ISDN PRI Call-by-Call Hotel/Motel and Selective Class of Call Screening (SCOCS) Service Selections* (TR-NWT-001397).

13. Bellcore, *PRI Common Element Procedures and Service Information Transport Generic Requirements* (GR-2823-CORE).

14. Bellcore, *Generic Requirements for ISDN Calling Name Identification Services for Primary Rate Interfaces* (GR-1367-CORE).

15. Bellcore, *Generic Requirements for ISDN PRI Two B-channel Transfer* (GR-2865-CORE)—Two B-channel Transfer (also known as Enhanced Explicit Call Transfer supplementary service) is defined in this document.

16. Bellcore, *Generic Requirements for Uniform Cause Code Values on National ISDN Primary Rate Interfaces* (SR-3138). This document defines the use of cause codes and location values.

1.7.3 ADDITIONAL RECOMMENDED DOCUMENTS

The following additional documents are recommended for use with this document:

- Bellcore, *Switching System Operations Generic Requirements for ISDN*, Issue 1, November 1994 (GR-892-CORE).
- Bellcore, *Switching System Operations Generic Requirements for ISDN*, Issue 2, December 1995 (GR-892-CORE).
- Bellcore, *Switching System Operations Generic Requirements for ISDN*, Issues List Report (ILR) 2B, December 1996 (GR-892-CORE).
- Bellcore, *Advanced Intelligent Network (AIN) 0.2 Switch Intelligent Peripheral Interface (IPI) Generic Requirements*, Issue 1, November 1993 (GR-1129-CORE).
- Bellcore, *Advanced Intelligent Network (AIN) Switch-Service Control Point (SCP)/ Adjunct Interface Generic Requirements*, Issue 2, December 1994 (GR-1299-CORE).
- Bellcore, *Common Element Procedures for Service Control*, Technical Reference, Issue 1, March 1991 (TR-NWT-000864).
- Bellcore, *PRI Generic Requirements for ISDN Call-By-Call Hotel/Motel and Selective Class of Call Screening (SCOCS) Service Selections*, Issue 1 and Issue 1, Revision 1 (TR-NWT-001397).

- Bellcore, *Generic Requirements for ISDN PRI Call-By-Call Service Selection for Non-ISDN Foreign Exchange Facilities, Non-ISDN Tie Trunks, OUTWATS, and INWATS,* Technical Reference, Issue 1, May 1992 (TR-NWT-001270).
- Bellcore, *Generic Requirements for ISDN Calling Name Identification Services for Primary Rate Interface,* Issue 1, July 1994 (GR-1367-CORE).
- Bellcore, *Generic Requirements for the Switched DS1/Switched Fractional DS1 Service Capability from an ISDN Interface (SWF-DS1/ISDN),* Technical Reference, Issue 1, December 1991 (TR-NWT-001203).
- Bellcore, *ISDN Calling Number Identification Services for Primary Rate Interfaces,* Technical Reference, Issue 1, March 1992 (TR-NWT-001187).
- Bellcore, *ISDN D-channel Exchange Access Signaling and Switching Requirements (Layer 2),* Technical Reference, Issue 1, October 1988 (TR-TSY-000793).
- Bellcore, *ISDN Primary Rate Access Transport System Requirements*, Technical Reference, Issue 1, July 1990 (TR-TSY-000754).
- Bellcore, *ISDN Primary Rate Interface Call Control Switching and Signaling Generic Requirements for Class II Equipment,* Technical Reference, Issue 1, Revision 1, December 1992 (TR-NWT-001268).
- Bellcore, *ISDN Primary Rate Interface Call Control Switching and Signaling Generic Requirements for Class II Equipment*, Technical Reference, Issue 1, Revision 2, March 1994 (TR-NWT-001268).
- Bellcore, *ISDN Primary Rate Interface Call Control Switching and Signaling Generic Requirements for Class II Equipment,* Technical Reference, Issue 1, Revision 3, May 1997 (TR-NWT-001268).
- Bellcore, *Generic Requirements for Uniform Cause Code Values on National ISDN Primary Rate Interfaces*, Issue 1, September 1994 (SR-3138).
- Bellcore, *1998 Version of National ISDN Primary Rate Interface Customer Premises Equipment Generic Guidelines*, Issue 1, December 1997 (SR-4287).
- Bellcore, *1997 Version of National ISDN Primary Rate Interface Customer Premises Equipment Generic Guidelines*, Issue 1, November 1996 (SR-3887).
- Bellcore, *1996 Version of National ISDN Primary Rate Interface Customer Premises Equipment Generic Guidelines*, Issue 1, September 1995 (SR-3338).
- Bellcore, *National ISDN-2,* Special Report, Issue 1, May 1992 (SR-NWT-002120).
- Bellcore, *PRI Common Element Procedures and Service Information Transport Generic Requirements,* Issue 1, October 1994 (GR-2823-CORE).
- Bellcore, *Generic Requirements for ISDN PRI Two B-channel Transfer,* Issue 2, April 1997 (GR-2865-CORE).
- Bellcore, *Generic Requirements for ISDN PRI Two B-channel Call Transfer Issues List Report,* Issue 1B, December 1996 (GR-2865-ILR).
- ISO/IEC, *Information Technology—Data Communications—X.25 Packet Level Protocol for Data Terminal Equipment*, 1990 (ISO/IEC 8208).

- International Telecommunication Union—Telecommunication Standardization Bureau, *Pulse Code Modulation (PCM) of Voice Frequencies* (ITU-T Recommendation G.711).
- International Telecommunication Union—Telecommunication Standardization Bureau, *Bearer Services Supported by an ISDN* (ITU-T Recommendation I.211).
- International Telecommunication Union—Telecommunication Standardization Bureau, *Circuit-Mode Bearer Capabilities* (ITU-T Recommendation I.231).
- International Telecommunication Union—Telecommunication Standardization Bureau, *ISDN User-Network Interfaces: Interface Structures and Access Capabilities* (ITU-T Recommendation I.412).
- International Telecommunication Union—Telecommunication Standardization Bureau, *ISDN User-Network Interfaces: Layer 1 Recommendations* (ITU-T I.43X Series Recommendations).
- International Telecommunication Union—Telecommunication Standardization Bureau, *Basic User-Network Interface—Layer 1 Specification* (ITU-T Recommendation I.430).
- International Telecommunication Union—Telecommunication Standardization Bureau, *Primary Rate User-Network Interface—Layer 1 Specification* (ITU-T Recommendation I.431).
- International Telecommunication Union—Telecommunication Standardization Bureau, *Multiplexing, Rate Adaption, and Support of Existing Interfaces for Restricted 64-kb/s Transfer Capability* (ITU-T Recommendation I.464).
- International Telecommunication Union—Telecommunication Standardization Bureau, *ISDN User-Network Interface Data Link Layer—General Aspects* (ITU-T Recommendation Q.920/I.440).
- International Telecommunication Union—Telecommunication Standardization Bureau, *ISDN User-Network Interface Data Link Layer Specification* (ITU-T Recommendation Q.921/I.441).
- International Telecommunication Union—Telecommunication Standardization Bureau, *ISDN User-Network Interface Layer 3 Specification* (ITU-T Recommendation Q.931/I.451).
- International Telecommunication Union—Telecommunication Standardization Bureau, *Digital Subscriber Signalling System No. 1 Network Layer* (ITU-T Recommendation Q.932).
- International Telecommunication Union—Telecommunication Standardization Bureau, *Digital Subscriber Signalling System No. 1 (DSS1)— Supplementary Services Protocols, Structure and General Principles*, March 1993 (ITU-T Recommendation Q.950).
- International Telecommunication Union—Telecommunication Standardization Bureau, *Support of Data Terminal Equipments (DTEs) with V-Series Type Interfaces by an Integrated Services Digital Network (ISDN)*, (ITU-T Recommendation V.110/I.463).
- International Telecommunication Union—Telecommunication Standardization Bureau, *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 Circuits (ITU-T Recommendation X.25).

- International Telecommunication Union—Telecommunication Standardization Bureau, ITU-T Recommendation X.30.
- International Telecommunication Union—Telecommunication Standardization Bureau, *Remote Operations: Model Notation and Service Definition* (ITU-T Recommendation X.219).
- International Telecommunication Union—Telecommunication Standardization Bureau, *Remote Operations: Protocol Specification* (ITU-T Recommendation X.229).
- International Telecommunication Union—Telecommunication Standardization Bureau, Z-Series Recommendations

1.8 CUSTOM PRI VERSUS NATIONAL ISDN PRI: DEFINITIONS AND STRATEGY

Two versions of the PRI on the *5ESS* switch have been developed. These versions are not mutually compatible:

- Custom PRI, developed to be compatible with Lucent Technologies network specifications for communication with the *4ESS* switch
- National ISDN PRI, compatible with selected Bellcore TRs. The National ISDN PRI is intended to function with products designed according to Bellcore's National ISDN specifications.

The most notable protocol difference between the Custom PRI and the National ISDN PRI without PRI B-channel Availability Signaling (BCAS) Procedures provisioned is the use of the SERVICE message: the Custom PRI uses the SERVICE message for control of only the B-channel; Bellcore TR-NWT-001268 specifies the use of the SERVICE message for control of only the PRI D-channel. The use of the SERVICE message is described in detail in "Maintenance Capabilities and Procedures," Section 9.

Beginning with the 5E12 software release, B-channel Availability Signaling (BCAS) has been available. Although BCAS, as defined by Bellcore GR-892-CORE, provides many of the maintenance functions that are also available on the Custom PRI, the National ISDN protocol differs from the Custom protocol. For this reason, the National ISDN PRI and Custom PRI may not be compatible on all connections.

Lucent Technologies allows its customers the flexibility to choose the interface appropriate for their application on a PRI-by-PRI basis. Both the Custom PRI and the National ISDN PRI can be provisioned on the same *5ESS* switch SM, although clearly not on the same PRI. Furthermore, for the capabilities and features common to both types of PRIs, there is complete interworking between the two types of PRI. Any call originated on a *5ESS* switch Custom PRI can be terminated on a National ISDN PRI on the same *5ESS* switch, and any call originated on a National ISDN PRI can be terminated on a Custom PRI on the same *5ESS* switch.

In spite of the incompatibility between the National ISDN PRI and the Custom PRI, all features offered on the Custom PRI are available on the National ISDN PRI and operate with few changes. The feature set offered on the 5E11 National ISDN PRI comprises the entire Custom PRI feature set plus three features: non-facility associated signaling, D-channel backup, and switched fractional-DS1 service. These features are described in detail in this document.

The National ISDN PRI has been developed to be compatible with the Bellcore technical references listed in the Bellcore special report, *National ISDN-2*, Issue 1, May 1992 (SR-NWT-002120), also called the National ISDN-2 agreement. Some areas of the existing functionality were not adapted or augmented to conform to the Bellcore specifications because the *5ESS* switch National ISDN PRI has been developed from the existing Custom PRI.

Since Bellcore published this National ISDN-2 agreement, Bellcore special reports have provided a more accurate view of the portions of the Bellcore TRs to which the major switch manufacturers comply. The *5ESS* switch National ISDN PRI is compatible with the interfaces built to the requirements in the following Bellcore documents:

- *National ISDN-2*, Issue 1, May 1992 (SR-NWT-002120)
- *1996 Version of National ISDN Primary Rate Interface Customer Premises Equipment Generic Guidelines*, Issue 1, September 1995 (SR-3338)
- *1997 Version of National ISDN Primary Rate Interface Customer Premises Equipment Generic Guidelines*, Issue 1, November 1996 (SR-3887)
- *1998 Version of National ISDN Primary Rate Interface Customer Premises Equipment Generic Guidelines*, Issue 1, December 1997 (SR-4287).

Items identified as conditional requirements, future requirements, objectives, or options in Bellcore SR-4287 may or may not be supported by the *5ESS* switch National ISDN PRI. In case of any differences between this document and any of the Bellcore documents cited, the behavior of the *5ESS* switch should be inferred from this document.

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2. LAYER 1: THE PRI PHYSICAL LAYER

2.1 GENERAL

The physical layer provides for the transmission of bits over the physical medium (hardware). It receives the bits and passes them up to the data link layer (Layer 2). It can provide for multiplexing of several data links (B-channels) over a single physical link. The data unit at the physical layer is a bit.

The primary rate interface (PRI) physical interface is based on the use of a standard T1 Carrier interface [with Extended Superframe (ESF) or D4 framing] and on ITU-T Recommendations I.412 and I.431, and conforms to Lucent Technologies (formerly AT&T) Technical Reference 62411, "*ACCUNET*[1] T1.5 Service Description and Interface Specification." The following sections clarify the *5ESS*® switch implementation of the PRI physical layer. The PRI is supported on a synchronous optical network (SONET) interface, the digital networking unit – SONET (DNU-S).

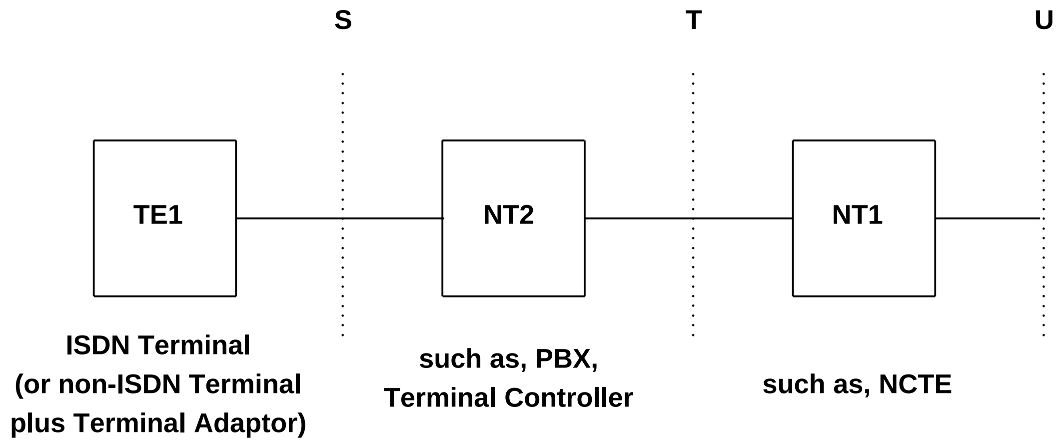
2.2 CUSTOM PRI VERSUS NATIONAL ISDN PRI

For the Custom PRI, only one DS1 interface (T1 Carrier or DNU-S) can be used. For the National ISDN PRI, up to 20 DS1 interfaces (T1 Carrier and/or DNU-S) can comprise a PRI using the Non-Facility Associated Signaling feature. The latter is termed a "PRI Group," which is a collection of B-channels and one or two signaling D-channels. See "Non-Facility Associated Signaling and D-channel Backup," Section 10, for more information. There is no other difference at the physical layer between the Custom PRI and the National ISDN PRI.

2.3 SUMMARY OF PHYSICAL LAYER SPECIFICATION

The physical layer specification is based on the use of standard DS-1 Interface with Extended Superframe (ESF) or D4 framing and on ITU-T Recommendations I.412, I.431 and I.211[2]. The specifications include requirements on electrical characteristics, channel structure, AMI and B8ZS line coding, pulse density, clear and restricted channels, and the use of bit-inverted HDLC on certain restricted channels.

1. Registered servicemark of AT&T.
2. CCITT Study Group XVIII, ITU-T Recommendation I.412, "ISDN User-Network Interfaces, Interface Structures and Access Capabilities;" ITU-T Recommendation I.431, "Primary Rate User-Network Interface –– Layer 1 Specification;" ITU-T Recommendation I.211, "Bearer Services Supported by an ISDN," October 1984.



Note: NT1, NT2, and TE1 are functional or logical units and are not necessarily physically discrete. The reference points S, T, and U are demarcation points among the functional units. Functions may be merged within equipment. For example, the NT1 function may be absorbed within a PBX in which case there may be no physical interface at T. Likewise, the Terminal Adaption function may be provided within a PBX in which case there may be no physical interface at S.

Figure 2-1 — Reference Configuration for ISDN Primary Rate Interfaces

The physical layer specifications are for DS-1 interfaces at ISDN reference points S, T, and U shown in Figure 2-1. In particular:

- The electrical specifications for the S/T and U reference points are based on the DSX-1 interface and the CPE-network interface, respectively.
- ESF and D4 framing as well as AMI and B8ZS line coding are allowed as customer/network options. The evolutionary goal is ESF framing and B8ZS line coding.
- The 4-kbps ESF data link is used for Yellow Alarm signals. Optional uses are discussed in PUB 54016.
- A customer access arrangement must have at least one D-channel. A D-channel, when present on a primary rate interface, must be in Time Slot 24.
- The interface allows a single H_{11} channel or any combination of B and H_0 channels. Time slots can be flexibly assigned to B and H_0 channels.
- Restricted channels are supported when B8ZS is not available.
- An encoding method is specified for restricted channels that use HDLC requiring processing by the network. The method requires bit inversion and suppression of all-zero octets. It is elementary and achieves full data throughput despite the restricted nature of the transfer capability.

2.4 ELECTRICAL INTERFACE

This section gives the electrical specifications for interfaces at reference points T, S, and U. The specification for the T and S reference points are identical except for “timing” considerations.

The material in this section is based on existing Lucent Technologies practices. The electrical specifications are, however, being actively debated in the various Subcommittees of T1 Committee (Telecommunications) of the Exchange Carriers Standards Association. As a consequence, the electrical standards might change, at least in the form if not in the details of the specifications. Future issues of this publication will track the changes in the standards arena.

2.4.1 INTERFACE AT REFERENCE POINT T

The electrical requirements for the interface at Reference Point T are based on specifications at a physical point located between the NT1 and NT2. This physical point is called the cross-connect point although no physical equipment such as a cross-connect frame or a connector is necessarily located there. The location of this point, if not specified, is assumed to be half way between the NT1 and NT2.

The electrical requirements are partly based on DSX-1 cross-connect specifications in Lucent Technologies (formerly AT&T) Technical Advisory No. 34, “Interconnection Specification for Digital Cross-connects, Issue 3,” March 1980, and are summarized in Table 2-1.

Table 2-1 — DSX-1 Interconnection Specification

SPECIFICATIONS	REQUIREMENTS
Line Rate	1.544 Mbps +/- 32 ppm (see the following text)
Line Code	Bipolar 8 Zero Substitution (B8ZS); or Alternate Mark Inversion (AMI) with minimum ones density (see the following text).
Test Load	100 ohms resistive
Pulse Shape	An isolated pulse shall fit the template, shown in Figure 3 of Technical Advisory No. 34, at the cross-connect point. The pulse amplitude shall be between 2.4 and 3.6 volts and may be scaled by a constant factor to fit the template.
Power Levels	For an all-ones transmitted pattern, the power in a 2-kHz band about 772 kHz shall be 12.6 to 17.9 dBm and the power in a 2-kHz band about 1544 kHz shall be at least 29 dB below that in a 2-kHz band about 772 kHz.
Pulse Imbalance	There shall be less than 0.5 dB difference between the total power of the positive pulses and that of the negative pulses.

For most applications of existing equipment, the maximum allowable loss between the cross-connect point and the NT2, and between the cross-connect point and the NT1, is 6 dB at 772 kHz. The corresponding maximum distance depends upon the physical medium.

The input port on each side of the reference point must be able to receive a digital signal with the previously mentioned characteristics modulated by jitter. The jitter specifications can be found in AT&T Communications Technical Reference, PUB 62411, “*ACCUNET* T1.5 Service Description and Interface Specification,” December 1990.

The 32-ppm tolerance on line rate is required for compatibility with Digital Synchronization Network Plan[3]. This tolerance applies to the receive capability on each side of the reference point. It also applies to the free running transmit capability of the NT2. This free running mode is relevant, for example, (i) if a loop-timed NT2 needs to send an alarm signal when there is a loss of the incoming signal from the NT1; (ii) if the NT2 uses a network service whose timing cannot be traced to a network clock.

If the NT2 uses a network service whose timing can be traced to a network clock, then the network will normally be the timing master with the NT2 transmit clock slaved to it. The NT2 may also operate plesiochronously based on a Stratum 1 clock. See Pub 60110 for more information. Such operation may be necessary when the NT2 is connected to more than one (public or private) synchronous network.

Further information on synchronization and timing can be found in AT&T Communications Technical Reference, Pub 60110. Also, additional requirements on synchronization can be found in PUB 62411.

2.4.2 INTERFACE AT REFERENCE POINT S

The electrical requirements for the interface at Reference Point S are the same as those for Reference Point T (see "Interface at Reference Point T," Section 2.4.1) with the possible exception of timing considerations. The primary rate ISDN terminal or Terminal Adaptor (TA) will typically derive its transmit clock by loop timing. The 32 ppm transmit tolerance applies to the ISDN terminal or TA if it is capable of sending a Yellow Alarm signal (see "Alarms," Section 2.9).

When the NT2 is absent, the S and T reference points coalesce. In this case, the ISDN terminal or TA is connected directly to the NT1 and all requirements for the T reference point given in the preceding subsection apply.

2.4.3 INTERFACE AT REFERENCE POINT U

The electrical requirements are specified in PUB 62411, *ACCUNET* T1.5 Service Description and Interface Specification. The jitter and frequency specification are the same as those specified for the T reference point in "Interface at Reference Point T," Section 2.4.1, and also as specified in PUB 62411. The transmit tolerance of 32 ppm does not apply to the NT1 unless it is determined that the NT1 has an alarming (see "Alarms," Section 2.9) function or other maintenance function that requires a free running clock.

2.5 FRAMING FORMAT

Both the D4 format and the Extended Superframe Format (ESF) are supported on the *5ESS* switch. The ESF is recommended for the Custom PRI and National ISDN PRI interface for D-channel and B-channel use; the D4 format should be used only when the ESF is not available. The ESF is the required framing format for use with wideband switching; the D4 format is not allowed for wideband switching calls. The proper DFI Mode must be provisioned on the *5ESS* switch for the desired framing format. Refer to document 235-190-104, **5ESS** *Switch ISDN Feature Descriptions*, for more details.

In the D4 format, each frame contains 24 consecutive 8-bit time slots preceded by the Framing (F) bit for a total of 193 bits per frame. Since each frame is transmitted at a

3. AT&T Communications Technical Reference, Pub 60110, "Digital Synchronization Network Plan," December 1983.

rate of 8000 times per second, the Framing bit is transmitted at a rate of 8 kbps. The ESF redefines the 8-kbps Framing bit into the following components (refer to Table 2-2):

1. A 2-kbps stream used as the Framing Pattern Sequence
2. A 4-kbps stream used as a Facility Data Link (message bits)
3. A 2-kbps stream used for error-checking using Cyclic Redundancy. Check

PUB 62411 provides further details about these formats.

The *5ESS* switch responds to only the receipt of a Yellow Alarm signal (1111111100000000) over the ESF Facility Data Link; receipt of the enhanced facility maintenance functions over the Facility Data Link (sometimes referred to as Embedded Operations Channel) will invoke no response by the *5ESS* switch. The *5ESS* switch is capable of transmitting only the following two signals over the Facility Data Link: the ESF Yellow Alarm signal (1111111100000000); and a pattern of continuous ones (11111111), which is transmitted when the Facility Data Link is idle.

The *5ESS* switch does not transmit the enhanced facility maintenance functions over the Facility Data Link.

Table 2-2 — Extended Superframe (ESF) Format

ESF Frame Number	ESF Bit Number	F-Bit Assignment		
		FPS[a]	FDL[b]	CRC[c]
1	0	-	m	-
2	193	-	-	CB1
3	386	-	m	-
4	579	0	-	-
5	772	-	m	-
6	965	-	-	CB2
7	1158	-	m	-
8	1351	0	-	-
9	1544	-	m	-
10	1737	-	-	CB3
11	1930	-	m	-
12	2123	1	-	-
13	2316	-	m	-
14	2509	-	-	CB4
15	2702	-	m	-
16	2895	0	-	-
17	3088	-	m	-
18	3281	-	-	CB5
19	3474	-	m	-
20	3667	1	-	-
21	3860	-	m	-
22	4053	-	-	CB6
23	4246	-	m	-
24	4439	1	-	-

Note(s):
a. FPS - Framing Pattern Sequence (...001011...)
b. FDL - 4-kbps Facility Data Link (Message Bits m)
c. CRC - CRC-6 Cyclic Redundancy Check (Check Bits CB1-CB6)

2.6 LINE CODING AND PULSE DENSITY

Customer equipment must comply with the line code supported by the access transport. The *5ESS* switch supports both Bipolar Eight Zero Substitution (B8ZS) line coding, and Alternate Mark Inversion (AMI) with Zero Code Suppression (ZCS) line coding. The use of B8ZS line coding is recommended when a choice of B8ZS access transport is available, in order to allow the support of both clear and restricted channel operation. B8ZS is the only line coding acceptable for use with the National ISDN PRI wideband switching; AMI with ZCS line coding is not allowed for wideband switching.

AMI with ZCS can support only restricted channel operation over the D-channel or the B-channel. When AMI with ZCS line coding is used, a time slot used for a D-channel or a B-channel must not contain the all-zero octet. No other restrictions apply. The proper line coding must be provisioned consistently end to end. Refer to document 235-190-104, **5ESS** *Switch ISDN Feature Descriptions*, for more details.

A sufficiently high pulse density must be maintained in order to ensure adequate timing recovery at digital regenerators. The pulse density is automatically sufficient when B8ZS line coding is used.

2.7 RESTRICTED AND CLEAR CHANNELS

A channel that cannot contain the all-zero octet is called a restricted channel. When the absence of any restriction is required or needs emphasis, the channel is called an unrestricted or clear channel. At Layer 1, the Custom PRI and the National ISDN PRI support 64-kbps Clear (64C), 64-kbps Restricted (64R), and 64-kbps Clear with 56-kbps rate adaption (56R). Refer to the definition of Bearer Capability in “Bearer Capability,” Section 4.3.3.4, for further details.

2.8 PULSE CODE MODULATION IDLE CODE

The physical layer idle code is the code transmitted across the interface when the physical layer *itself* is idle. It is not necessarily the code that would be transmitted when the physical layer is serving an entity (for example, voice encoder on a B-channel or Layer 2 on a D-channel) that is in an “idle” condition. For the *5ESS* switch specification, the physical layer idle code in both directions is identified by the pattern “0111 1111” in the Pulse Code Modulation (time slot) channels.

The idle code must be transmitted on:

- Every time slot not assigned to a channel (such as slots awaiting channel assignment on a per-call basis and residual slots on an interface that is not fully provisioned).
- Every channel that is not allocated to a call.

The physical layer idle code applies equally to restricted channels; that is, the bit pattern is *not* inverted prior to transmission.

The receiving side of an interface should deduce the Layer 1 idle status of a time slot or channel from the D-channel signaling messages or the customer subscription profile. The Layer 1 idle status should not be deduced from the incoming bit streams of the bearer channels.

The previously mentioned idle code does not apply when the interface or a portion thereof, such as a time slot, is being tested.

2.9 ALARMS

The discussion of alarms is facilitated by referring to the two sides of the interface as A and B.

The receiver on Side A may be unable to maintain frame synchronization either because of an internal failure or because of the nature of the received signal. Examples of received signals that the receiver cannot frame on are: loss of signal, severely errored signal, signal without a framing pattern (such as an all-ones signal) and signal with the wrong framing pattern. If the absence of frame synchronization persists for 2 to 3 seconds, Side A enters the Red Alarm state. Side A leaves this state when it re-acquires frame synchronization and maintains it for 10 to 20 seconds.

When in the Red Alarm state, Side A must transmit a Yellow Alarm signal to Side B. Side A must stop sending the Yellow Alarm signal when it leaves the Red Alarm state.

The *5ESS* switch has the capability to send the Yellow Alarm signal (Remote Alarm Indication) and the Red Alarm signal across the Custom/National ISDN PRI interface. The pattern of the Yellow Alarm signal is dependent on the framing format. If the D4 format is used, the second bit is forced to zero in all 24 time slots. If the ESF format is used, the 16-bit pattern of 8 bits of ones followed by 8 bits of zeros (1111111100000000) is transmitted continuously for a minimum of 1 second over the ESF Facility Data Link. The *5ESS* switch sends the Yellow Alarm signal when it detects a Red Alarm signal from the transmitting terminal or upstream of the transmitting terminal.

The pattern of all ones in the Pulse Code Modulation (time slot) channel bits and the F bit is transmitted to indicate a Red Alarm signal. The *5ESS* switch sends the Red Alarm signal when a PIDB clock loss is detected or when the DFI is out of service. The *5ESS* switch also sends the Red Alarm signal during diagnostics and system initialization prior to the establishment of a valid state.

Additionally, the *5ESS* switch Digital Facilities Interface measures errored-seconds (1 bit-error in a second). When 14 errored-seconds occur within 15 minutes, a Minor Alarm is reported on the read-only printer (ROP). When 75 errored-seconds occur within 15 minutes, a Major Alarm is reported on the ROP. Major Alarm and Minor Alarm messages due to errored-seconds are not transmitted across the PRI interface via the Facility Data Link. These measurements are performed in the DFI hardware for each T1 facility regardless of the type of traffic on the T1 (MF trunk, PRI, data). The default thresholds are defined in the DFI hardware (firmware), and are not adjustable via software. Additional information on Alarms and ROP messages can be found in document 235-105-220, *Corrective Maintenance Procedures*, document 235-600-700, **5ESS** *Switch Input Messages*, and document 235-600-750, **5ESS** *Switch Output Messages*.

Additional alarms related to SONET apply to the DNU-S facilities. These are not discussed here. Please refer to Bellcore TR-NWT-000253 and TR-TSY-000782 for further information.

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3. LAYER 2: THE PRI DATA LINK LAYER

The PRI data link layer provides for a relatively error-free path to higher layers across the primary rate user-to-network interface. It defines the data transmission units (frame) and performs an error and sequence check on the frames. The content of the information is not relevant. Acknowledgments from the receiver guarantee the transmitter that the frames are received. If the data frames are not acknowledged, the transmitter will retransmit the frames. Flow control is also provided at this layer. The data unit at the data link layer is a frame.

The PRI data link layer is based on ITU-T Recommendation Q.921 (I.441). The concepts, terminology, overview description of LAPD functions and procedures, and the relationship with other Recommendations are described in general terms in ITU-T Recommendation Q.920 (I.440).

"Graphical Representation of the Point-to-Point Procedures of the Data Link Layer," Section 3.7, contains the SDL diagrams that describe the protocol interactions in an overall manner.

The *5ESS*® switch supports both the "Network Side" and the "User Side" procedures at Layer 2. When two *5ESS* switches are connected directly using an Custom/National ISDN PRI, one end of the PRI must be assigned the "User Side" and the other end the "Network Side." The switch that is designated the "User Side" must respond to the TEI check request from the "Network Side," but must not initiate it.

Note: Setup Glare is resolved based on Layer 2 provisioning.

There are no separate Layer 2 procedures for D-channel backup.

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3.1 SUMMARY OF CAPABILITIES

- Acknowledged Multiple Frame mode of operation for only information transfer.
- Modulo-128 sequencing.
- The only fixed TEI Value supported is “0”.
- The only use for a broadcast TEI is a TEI check procedure. TEI check using UI frames (SAPI=63, TEI = Group TEI (127), Ai = 0)
- No support for Automatic TEI Assignment procedures.
- Link supervision with supervisory command frames RR/RNR, P=1.
- Default parameter values used:

```
N201 = 260 octets
T200 = 1 second
K    = 7 (National ISDN PRI)
K    = 1 (Custom PRI)
T203 = 30 seconds.
```

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3.2 CUSTOM PRI VERSUS NATIONAL ISDN PRI

The maximum number of outstanding I frames (k) is different for the National ISDN PRI from the Custom PRI. The Custom PRI value is “1” and the National ISDN PRI value is “7”. See “Send State Variable V(S),” Section 3.4.4.2.2. All other aspects of Layer 2 are the same for both the Custom PRI and the National ISDN PRI.

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3.3 FRAME STRUCTURE FOR PEER-TO-PEER COMMUNICATION

All data link layer peer-to-peer exchanges are in frames conforming to one of the formats shown in Figure 3.3-1. Two format types are shown in the figure: format A for frames where there is no information field and format B for frames containing an information field.

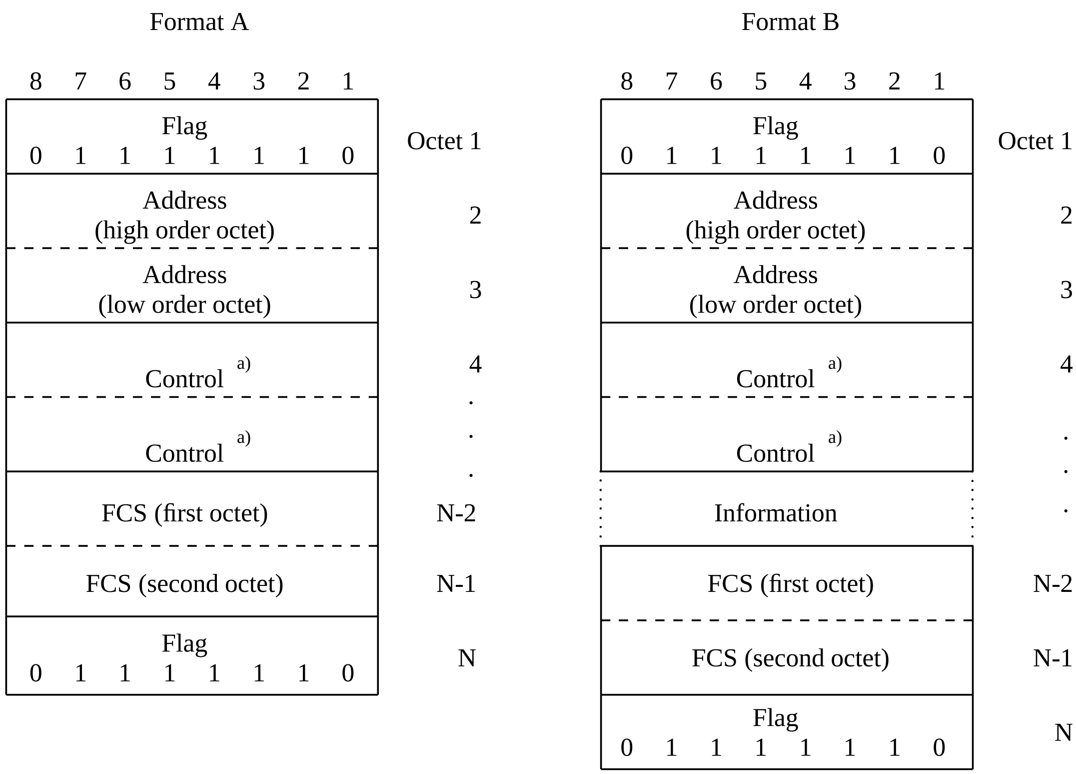
3.3.1 FLAG SEQUENCE

All frames shall start and end with the flag sequence consisting of one 0 bit followed by six contiguous 1 bits and one 0 bit. The flag preceding the address field is defined as the opening flag. The flag following the Frame Check Sequence (FCS) field is defined as the closing flag. The closing flag may also serve as the opening flag of the next frame, in some applications. However, all receivers must be able to accommodate receipt of one or more consecutive flags.

Note: Products should transmit consecutive flags that do not share “0”s. For compatibility purposes, it is suggested, but not required that products should be able to receive consecutive flags that share “0”s.

3.3.2 ADDRESS FIELD

The address field shall consist of two octets as illustrated in Figure 3.3-1. The address field identifies the intended receiver of a command frame and the transmitter of a response frame. The format of the address field is defined in “Address Field Format,” Section 3.4.1.



a) Unacknowledged operation - one octet

Multiple frame operation - two octets for frames with sequence numbers; one octet for frames without sequence numbers

Figure 3.3-1 — Frame Formats

3.3.3 CONTROL FIELD

The control field shall consist of one or two octets. Figure 3.3-1 illustrates the two frame formats (A and B), each with a control field of one or two octets, depending upon the type of frame.

The format of the control field is defined in "Control Field Formats," Section 3.4.3.

3.3.4 INFORMATION FIELD

The information field of a frame, when present, follows the control field (see "Control Field," Section 3.3.3) and precedes the frame check sequence (see "FCS Field," Section 3.3.6). The contents of the information field shall consist of an integer number of octets.

The maximum number of octets in the information field is defined in "Maximum number of octets in an information field (N201)," Section 3.6.8.3.

3.3.5 TRANSPARENCY

A transmitting data link layer entity shall examine the frame content between the opening and closing flag sequences, (address, control, information and FCS fields) and shall insert 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. A receiving data link layer entity shall examine the frame contents between the opening and closing flag sequences and shall discard any 0 bit that directly follows five contiguous 1 bits.

3.3.6 FCS FIELD

The FCS field shall be a 16-bit sequence. It shall be the ones complement of the sum (modulo 2) of:

a. 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, and

b. 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 1s and is then modified by division by the generator polynomial (as described previously) on the address, control, and information fields; the ones complement of the resulting remainder is transmitted as the sixteen-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 1s. The final remainder after multiplication by x^{16} and then division (modulo 2) by the generator polynomial $x^{16} + x^{12} + x^5 + 1$ of the serial incoming protected bits and the FCS, will be 0001 1101 0000 1111 (x^{15} through x^0, respectively) in the absence of transmission errors.

3.3.7 FORMAT CONVENTION

3.3.7.1 Numbering Convention

The basic convention used in this Recommendation is illustrated in Figure 3.3-2. The bits are grouped into octets. The bits of an octet are shown horizontally and are numbered from 1 to 8. Multiple octets are shown vertically and are numbered from 1 to n.

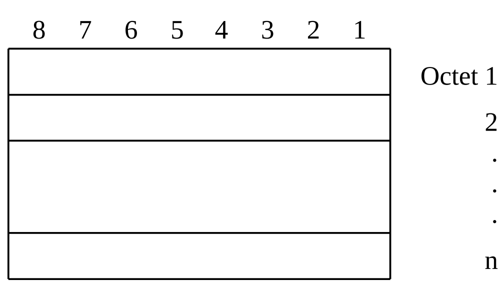


Figure 3.3-2 — Format Convention

3.3.7.2 Order of Bit Transmission

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

3.3.7.3 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 within each octet progressively decreases as the octet number increases. The lowest bit number associated with the field represents the lowest order value.

For example, a bit number can be identified as a couple (o,b) where o is the octet number and b is the relative bit number within the octet. Figure 3.3-3 illustrates 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).

8	7	6	5	4	3	2	1	
					2^4	2^3	2^2	1st octet of the field
2^1	2^0							2nd octet of the field

Figure 3.3-3 — Field Mapping Convention

An exception to the preceding field mapping convention is the data link layer 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 3.3-4).

8	7	6	5	4	3	2	1	
2^8							2^{15}	1st octet of the field
2^0							2^7	2nd octet of the field

Figure 3.3-4 — FCS Mapping Convention

3.3.8 INVALID FRAMES

An invalid frame is a frame that:

a. is not properly bounded by two flags, or

b. has fewer than six octets between flags of frames that contain sequence numbers and fewer than five octets between flags of frames that do not contain sequence numbers, or

c. does not consist of an integral number of octets prior to zero bit insertion or following zero bit extraction, or

d. contains a frame check sequence error, or

e. contains a service access point identifier (see “Service Access Point Identifier (SAPI),” Section 3.4.2.3) that is not supported by the receiver.

Invalid frames shall be discarded without notification to the sender. No action is taken as the result of that frame.

3.3.9 FRAME ABORT

Receipt of seven or more contiguous 1 bits shall be interpreted as an abort and the data link layer shall ignore the frame currently being received.

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3.4 ELEMENTS OF PROCEDURES AND FORMATS OF FIELDS FOR DATA LINK LAYER PEER-TO-PEER COMMUNICATION

The elements of procedures define the commands and responses that are used on the data link connections carried on the D-channel.

Procedures are derived from these elements of procedures and are described in “Definition of the Peer-to-Peer Procedures of the Data Link Layer,” Section 3.6).

3.4.1 ADDRESS FIELD FORMAT

The address field format shown in Figure 3.4-1 contains the address field extension bits, a command/response indication bit, a data link layer Service Access Point Identifier (SAPI) subfield, and a Terminal Endpoint Identifier (TEI) subfield.

8	7	6	5	4	3	2	1	
SAPI						C/R	EA 0	Octet 2
TEI							EA 1	3

EA = Address field extension bit

C/R = Command/response field bit

SAPI = Service access point identifier

TEI = Terminal endpoint identifier

Figure 3.4-1 — Address Field Format

3.4.2 ADDRESS FIELD VARIABLES

3.4.2.1 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 shall have Bit 1 of the first octet set to a 0 and Bit 1 of the second octet set to 1.

3.4.2.2 Command/Response Field Bit (C/R)

The C/R bit identifies a frame as either a command or a response. The user side shall send commands with the C/R bit set to 0, and responses with the C/R bit set to 1. The network side shall do 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 Table 3.4-1.

In conformance with HDLC rules, commands use the address of the peer data link layer entity and responses use the address of their own data link layer entity. According to these rules, both peer entities on a point-to-point data link connection use the same Data Link Connection Identifier (DLCI) composed of a SAPI-TEI where SAPI and TEI conform to the definitions contained in “Service Access Point Identifier (SAPI),” Section 3.4.2.3, and “Terminal Endpoint Identifier (TEI),” Section 3.4.2.4, and define the data link connection as described in ITU-T Recommendation Q.920 (I.440), Section 3.4.1.

Table 3.4-1 — C/R Field Bit Usage

Command/Response	Direction	C/R value
Command	Network side ––> User side	1
	User side ––> Network side	0
Response	Network side ––> User Side	0
	User side ––> Network side	1

3.4.2.3 Service Access Point Identifier (SAPI)

The SAPI identifies a point 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 specifies a Layer 3 or management entity that is to receive information carried by the data link layer frame. The SAPI allows 64 service access points to be specified, where Bit 3 of the address field octet containing the SAPI is the least significant binary digit and Bit 8 is the most significant. The SAPI values are allocated as shown in Table 3.4-2.

Table 3.4-2 — Allocation of SAPI Values

SAPI[a] value	Related Layer 3 or management entity
0	Call control procedures
63	Layer management procedures[b]
All others	Reserved for future standardization

Note(s):
a. The reservation of SAPI values for experimental purpose is for further study.
b. Implementation of SAPI 63 is optional.

3.4.2.4 Terminal Endpoint Identifier (TEI)

The TEI for a point-to-point data link connection may be associated with a single Terminal Equipment (TE). A TE may contain one or more TEIs used for point-to-point data transfer. The TEI for a broadcast data link connection is associated with all user side data link layer entities containing the same SAPI. The TEI subfield allows 128 values 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 following conventions shall apply in the assignment of these values.

3.4.2.4.1 TEI for Broadcast Data Link Connection

The TEI subfield bit pattern 111 1111 (=127) is defined as the group TEI. The group TEI is assigned to the broadcast data link connection associated with the addressed Service Access Point (SAP).
Note: The implementation of TEI 127 is optional.

3.4.2.4.2 TEI for Point-to-Point Connection

The TEI subfield bit pattern 000 0000 (=0) will be used for the point-to-point data link connections associated with the addressed SAP. This value shall be assigned at subscription time.

3.4.3 CONTROL FIELD FORMATS

The control field identifies the type of frame, which will be either a command or a response. The control field will contain sequence numbers, where applicable.

Three types of control field formats are specified; numbered information transfer (I format), supervisory functions (S format), and unnumbered information transfers and control functions (U format). The control field formats are shown in Table 3.4-3.

Table 3.4-3 — Control Field Formats

Control field bits (modulo 128)	8	7	6	5	4	3	2	1	Octet
I format	N(S)[a]							0	Octet 4
	N(R)[b]							P	Octet 5
S format	X[c]	X[c]	X[c]	X[c]	S[e]	S[e]	0	1	Octet 4
	N(R)[b]							P/F[f]	Octet 5
U format	M[d]	M[d]	M[d]	P/F[f]	M[d]	M[d]	1	1	Octet 4

Note(s):
a. Transmitter send sequence number
b. Transmitter receive sequence number
c. Reserved and set to 0
d. Modifier function bit
e. Supervisory function bit
f. Poll bit when issued as a command, final bit when issued as a response

3.4.3.1 Information Transfer (I) Format

The I format shall be used to perform an information transfer between Layer 3 entities. The functions of N(S), N(R) and P (defined in “Control Field Parameters and Associated State Variables,” Section 3.4.4) are independent; that is, each I frame has an N(S) sequence number, an N(R) sequence number that may or may not acknowledge additional I frames received by the data link layer entity, and a P bit that may be set to 0 or 1.

The use of N(S), N(R), and P is defined in “Control Field Parameters and Associated State Variables,” Section 3.4.4.

3.4.3.2 Supervisory (S) Format

The S format shall be used to perform data link supervisory control functions such as acknowledgments of I frames, requests for retransmission of I frames, and requests for temporary suspension of transmission of I frames. The functions of N(R) and P/F are independent, that is, each supervisory frame has an N(R) sequence number that may or may not acknowledge additional I frames received by the data link layer entity, and a P/F bit that may be set to 0 or 1.

3.4.3.3 Unnumbered (U) Format

The U format shall be used to provide additional data link control functions and unnumbered information transfers for unacknowledged information transfer. This format does not contain sequence numbers. It does include a P/F bit that may be set to 0 or 1.

3.4.4 CONTROL FIELD PARAMETERS AND ASSOCIATED STATE VARIABLES

The various parameters associated with the control field formats are described in this section. The coding of the bits within these parameters is such that the lowest numbered bit within the parameter field is the least significant bit.

3.4.4.1 Poll/Final (P/F) Bit

All frames contain the Poll/Final (P/F) bit. The P/F bit serves a function in both command frames and response frames. In command frames the P/F bit is referred to as the P bit. In response frames it is referred to as the F bit. The P bit set to 1 is used by a data link layer entity to solicit (poll) a response frame from the peer data link layer entity. The F bit set to 1 is used by a data link layer entity to indicate the response frame transmitted as a result of a soliciting (poll) command.

The use of the P/F bit is described in “Procedure for the Use of the P/F Bit,” Section 3.6.1.

3.4.4.2 Multiple Frame Operation—Variables and Sequence Numbers

3.4.4.2.1 Modulus

Each I frame is sequentially numbered and may have the value 0 through (n – 1), where n is the modulus of the sequence numbers. The modulus equals 128 and the sequence numbers cycle through the entire range, 0 through 127.

Note: All arithmetic operations on state variables and sequence numbers contained in this Recommendation are affected by the modulus operation.

3.4.4.2.2 Send State Variable V(S)

Each point-to-point data link connection endpoint shall have an associated V(S) when using I frame commands. V(S) denotes the sequence number of the next I frame to be transmitted. The V(S) can take on the value 0 through (n – 1). The value of V(S) shall be incremented by 1 with each successive I frame transmission, and shall not exceed V(A) by more than the maximum number of outstanding I frames, k. The value of k may be in the range of \$1 ≤ k ≤ 127 \$. For the Custom PRI, the implemented value for k is 1; for the National ISDN PRI, the implemented value for k is 7.

3.4.4.2.3 Acknowledge State Variable V(A)

Each point-to-point data link connection endpoint shall have an associated V(A) when using I frame commands and supervisory frame commands/responses. V(A) identifies the last frame that has been acknowledged by its peer [V(A)-1 equals the N(S) of the last acknowledged I frame]. V(A) can take on the value 0 through (n – 1). The value of V(A) shall be updated by the valid N(R) values received from its peer (see “Receive State Variable V(R),” Section 3.4.4.2.5). valid N(R) value is one that is in the range $V(A) \le N(R) \le V(S)$.

3.4.4.2.4 Send Sequence Number N(S)

Only I frames contain N(S), the send sequence number of transmitted I frames. At the time that an in-sequence I frame is designated for transmission, the value of N(S) is set equal to V(S).

3.4.4.2.5 Receive State Variable V(R)

Each point-to-point data link connection endpoint shall have an associated V(R) when using I frame commands and supervisory frame commands/responses. V(R) denotes the sequence number of the next in-sequence I frame expected to be received. V(R) can take on the value 0 through (n – 1). The value of V(R) shall be incremented by one with the receipt of an error-free, in-sequence I frame whose N(S) equals V(R).

3.4.4.2.6 Receive Sequence Number N(R)

All I frames and supervisory frames contain N(R), the expected send sequence number of the next received I frame. At the time that one frame of the previously mentioned types is designated for transmission, the value of N(R) is set equal to V(R). N(R) indicates that the data link layer entity transmitting the N(R) has correctly received all I frames numbered up to and including N(R) – 1.

3.4.4.3 Unacknowledged Operation—Variables and Parameters

No variables are defined. One parameter is defined, N201 (see “Maximum number of octets in an information field (N201),” Section 3.6.8.3).

3.4.5 FRAME TYPES

3.4.5.1 Commands and Responses

The following commands and responses are used by either the user or the network data link layer entities and are represented in Table 3.4-4. Each data link connection shall support the full set of commands and responses for each application implemented. The frame types associated with each of the two applications are identified in Table 3.4-4.

Frame types associated with an application not implemented shall be discarded and no action shall be taken as a result of that frame.

For purposes of the LAPD procedures in each application, those frame types not identified in Table 3.4-4 are identified as undefined command and/or response control fields. The actions to be taken are specified in “Frame Rejection Condition,” Section 3.6.7.5.

The commands and responses in Table 3.4-4 are defined in “Information (I) Command,” Section 3.4.5.2, “Frame reject (FRMR) response,” Section 3.4.5.11, and “Exchange identification (XID) command/response,” Section 3.4.5.12.

Table 3.4-4 — Commands and Responses—Modulo 128

Application	Format	Commands	Responses	Encoding 8	7	6	5	4	3	2	1	Octet
Unacknowledged and multiple frame acknowledgment information transfer	Information transfer	I (information)		N(S)							0	4
				N(S)							P	5
	Supervisory	RR (receive ready)	RR (receive ready)	0	0	0	0	0	0	0	1	4
				N(R)							P/F	5
		RNR (receive not ready)	RNR (receive not ready)	0	0	0	0	0	1	0	1	4
				N(R)							P/F	5
		REJ (reject)	REJ (reject)	0	0	0	0	1	0	0	1	4
				N(R)							P/F	5
	Unnumbered	SABME (set asynchronous balanced mode extended)		0	1	1	P	1	1	1	1	4
			DM (disconnected mode)	0	0	0	F	1	1	1	1	4
		UI (unnumbered information		0	0	0	P	0	0	1	1	4
		DISC (disconnect)		0	1	0	P	0	0	1	1	4
			UA (unnumbered acknowledgment)	0	1	1	F	0	0	1	1	4
			FRMR (frame reject)	1	0	0	F	0	1	1	1	4
Connection management		XID (exchange identification)[a]	XID (exchange identification)[a]	1	0	1	P/F	1	1	1	1	4

Note(s):

a. Use of the XID frame other than for parameter negotiation procedures is for further study. No procedures use XID frames in PRI applications. PRI applications treat XID frames as invalid frames.

3.4.5.2 Information (I) Command

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

3.4.5.3 Set Asynchronous Balanced Mode Extended (SABME) Command

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

No information field is permitted with the SABME command. A data link layer entity confirms acceptance of an SABME command by the transmission at the first opportunity of a UA response. Upon acceptance of this command, the data link layer entity's V(S), V(A), V(R), and retransmission count are set to 0. The transmission of an SABME command indicates the clearance of all exception conditions.

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

3.4.5.4 Disconnect (DISC) Command

The DISC unnumbered command is used to terminate the multiple frame operation.

No information field is permitted with the DISC command. The data link layer entity receiving the DISC command confirms the acceptance of a DISC command by the transmission of a UA response. The data link layer entity sending the DISC command terminates the multiple frame operation when it receives the acknowledging UA or DM response.

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

3.4.5.5 Unnumbered Information (UI) Command

When a Layer 3 or management entity requests unacknowledged information transfer, the UI unnumbered command is used to send information to its peer without affecting data link layer variables. UI command frames do not carry a sequence number and therefore, the UI frame may be lost without notification.

3.4.5.6 Receive Ready (RR) Command/Response

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

a. indicate it is ready to receive an I frame;

b. acknowledge previously received I frames numbered up to and including N(R)-1 (as defined in “Definition of the Peer-to-Peer Procedures of the Data Link Layer,” Section 3.6); and

c. 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 may be used by the data link layer entity to ask for the status of its peer data link layer entity.

3.4.5.7 Reject (REJ) Command/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 I frames numbered up to and including N(R)-1. New I frames pending initial transmission shall be 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 cleared (reset) upon the receipt of an I frame with an N(S) equal to the N(R) of the REJ frame.

The transmission of a REJ frame shall also indicate the clearance of any busy condition within the sending data link layer entity that was reported 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 REJ 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.

3.4.5.8 Receive Not Ready (RNR) Command/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 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 ask for the status of its peer data link layer entity.

3.4.5.9 Unnumbered Acknowledgment (UA) Response

The UA unnumbered 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. No information field is permitted with the UA response. The transmission of the UA response indicates the clearance of any busy condition that was reported by the earlier transmission of an RNR frame by that same data link layer entity.

3.4.5.10 Disconnected Mode (DM) Response

The DM unnumbered 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. No information field is permitted with the DM response.

3.4.5.11 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. the receipt of a command or response control field that is undefined or not implemented;

b. the receipt of a frame with an information field that is not permitted or the receipt of a supervisory or unnumbered frame with incorrect length;

c. the receipt of an invalid N(R); or

d. the receipt of an I frame with an information field that exceeds the maximum established length.

An undefined control field is any of the control field encodings not identified in Table 3.4-4.

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

If the frame being rejected has an undefined control field or if it is a response with an invalid N(R) field, then the final bit of the FRMR should be set to “0”. Otherwise, the final bit of the FRMR should be set to the value of the poll bit of the rejected frame.

An information field that immediately follows the control field and consists of five octets (modulo 128 operation) is returned with this response and provides the reason for the FRMR response. This information field format is given in Figure 3.4-2.

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

Figure 3.4-2 — FRMR Information Field Format—Extended (Modulo 128) Operation

For Figure 3.4-2:

- Rejected frame control field is the control field of the received frame that caused the frame reject. When the rejected frame is an unnumbered frame, the control field of the rejected frame is positioned in Octet 5, with Octet 6 set to 0000 0000.
- V(S) is the current send state variable value on the user side or network side reporting the rejection condition.
- C/R is set to 1 if the frame rejected was a response, or is set to 0 if the frame rejected was a command.
- V(R) is the current receive state variable value on the user side or network side reporting the rejection condition.
- W set to 1 indicates that the control field received and returned in Octets 5 and 6 was undefined or not implemented.
- 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 that is not permitted with this frame or is a supervisory or unnumbered frame with incorrect length. Bit W must be set to 1 in conjunction with this bit.
- 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.
- Z set to 1 indicates that the control field received and returned in Octets 5 and 6 contained an invalid N(R).
- Bit 1 of Octet 7, and Bits 5 through 8 of Octet 9, shall be set to 0.

3.4.5.12 Exchange Identification (XID) Command/Response

Reserved for future use.

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3.5 ELEMENTS FOR LAYER-TO-LAYER COMMUNICATION

3.5.1 GENERAL

Communications between layers and, for ITU-T Recommendation Q.920 (I.440), between the data link layer and the layer management are accomplished by means of primitives.

Primitives represent, in an abstract way, the logical exchange of information and control between the data link 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:

XX—Generic name—Type: Parameters

where XX designates the interface across which the primitive flows. For ITU-T Recommendation Q.920 (I.440), XX is:

- DL for communication between Layer 3 and the data link layer;
- PH for communication between the data link layer and the physical layer;
- MDL for communication between the layer management and the data link layer; or
- MPH for communication between the management entity and the physical layer.

3.5.1.1 Generic Names

The generic name specifies the activity that should be performed. Table 3.5-1 illustrates the primitives defined in ITU-T Recommendation Q.920 (I.440). Note that not all primitives have associated parameters.

Table 3.5-1 — Primitives Associated with ITU-T Recommendation Q.921 (I.441)

Generic name	Type				Parameters		Message unit contents
	Request	Indication	Response	Confirm	Priority indicator	Message unit	
L3 <-> L2[a]							
DL-ESTABLISH	X	X	—	X	—	—	
DL-RELEASE	X	X	—	X	—	—	
DL-DATA	X	X	—	—	—	X	Layer 3 peer-to-peer message
DL-UNIT DATA	X	X	—	—	—	X	Layer 3 peer-to-peer message
M <-> L2[c]							
MDL-ERROR	—	X	X	—	—	X	Reason for error message
MDL-UNIT DATA	X	X	—	—	—	X	Management function peer-to-peer message
L2 <-> L1[b]							
PH-DATA	X	X	—	—	X	X	Data link layer peer-to-peer message

Note(s):
a. L3 <-> L2: Layer 3/data link layer boundary
b. L2 <-> L1: Data link layer/physical layer boundary
c. M <-> L2: Management entity/data link layer boundary

The primitive generic names that are defined in this Recommendation are:

3.5.1.1.1 DL-ESTABLISH

The DL-ESTABLISH primitives are used to request, indicate, and confirm the outcome of the procedures for establishing multiple frame operation.

3.5.1.1.2 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, or for reporting an unsuccessful establishment attempt.

3.5.1.1.3 DL DATA

The DL DATA primitives are used to request and indicate Layer 3 messages that are to be transmitted, or have been received, by the data link layer using the acknowledged information transfer service.

3.5.1.1.4 DL UNIT DATA

The DL UNIT DATA primitives are used to request and indicate Layer 3 messages that are to be transmitted, or have been received, by the data link layer using the unacknowledged information transfer service.

3.5.1.1.5 MDL-ASSIGN

Reserved for future use.

3.5.1.1.6 MDL REMOVE

Reserved for future use.

3.5.1.1.7 MDL ERROR

The MDL ERROR primitives are used to indicate to the connection management entity that an error has occurred, associated with a previous management function request or detected as a result of communication with the data link layer peer entity. The layer management entity may respond with an MDL ERROR primitive if the layer management entity cannot obtain a TEI value.

3.5.1.1.8 MDL UNIT DATA

The MDL UNIT DATA primitives are used to request and indicate layer management entity messages that are to be transmitted, or have been received, by the data link layer using the unacknowledged information transfer service.

3.5.1.1.9 MDL-XID

Reserved for future use.

3.5.1.1.10 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.

3.5.1.1.11 PH ACTIVATE

Reserved for future use.

3.5.1.1.12 PH DEACTIVATE

Reserved for future use.

3.5.1.1.13 MPH ACTIVATE

Reserved for future use.

3.5.1.1.14 MPH DEACTIVATE

Reserved for future use.

3.5.1.1.15 MPH INFORMATION

Reserved for future use.

3.5.1.1.16 DL DM RLS

Reserved for future use.

3.5.1.2 Primitive Types

The primitive types defined in ITU-T Recommendation Q.920 (I.440) are REQUEST, INDICATION, RESPONSE, and CONFIRM.

3.5.1.2.1 REQUEST

The REQUEST primitive type is used when a higher layer or layer management is requesting a service from the lower layer.

3.5.1.2.2 INDICATION

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

3.5.1.2.3 RESPONSE

The RESPONSE primitive type is used by layer management as a consequence of the INDICATION primitive type.

3.5.1.2.4 CONFIRM

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

Figure 3.5-1 illustrates the relationship of the primitive types to Layer 3 and the data link layer.

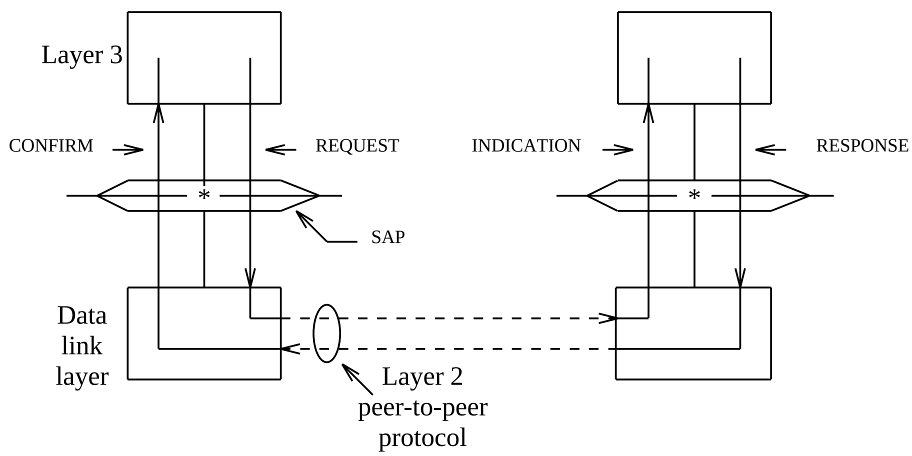


Figure 3.5-1 — Relationship of the Primitive Types to Layer 3 and the Data Link Layer

3.5.1.3 Parameter Definition

3.5.1.3.1 Priority Indicator

Since several SAPs may exist on the network side or user side, protocol message units sent by one SAP may contend with those of other service access points for the physical resources available for message transfer. The priority indicator is used to determine which message unit will have greater priority when contention exists. The priority indicator is needed only at the user side for distinguishing message units sent by the SAP with a SAPI value of 0 from all other message units.

3.5.1.3.2 Message Unit

The message unit contains additional layer-to-layer information concerning actions and results associated with requests. In the case of the 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 layer frame.

Note: The operations across the data link layer/Layer 3 boundary shall be such that the layer sending the DL DATA or DL UNIT DATA primitive can assume a temporal order of the bits within the message unit and that the layer receiving the primitive can reconstruct the message with its assumed temporal order.

3.5.2 PRIMITIVE PROCEDURES

3.5.2.1 General

Primitive procedures specify the interactions between adjacent layers to invoke and provide a service. The service primitives represent the elements of the procedures.

In the scope of ITU-T Recommendation Q.920 (I.440) the interactions between Layer 3 and the data link layer are specified.

3.5.2.2 Layer 3—Data Link Layer Interactions

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.

Data link connection endpoint states are defined as follows:

a. Broadcast data link connection endpoint:
   - Reserved for future use.

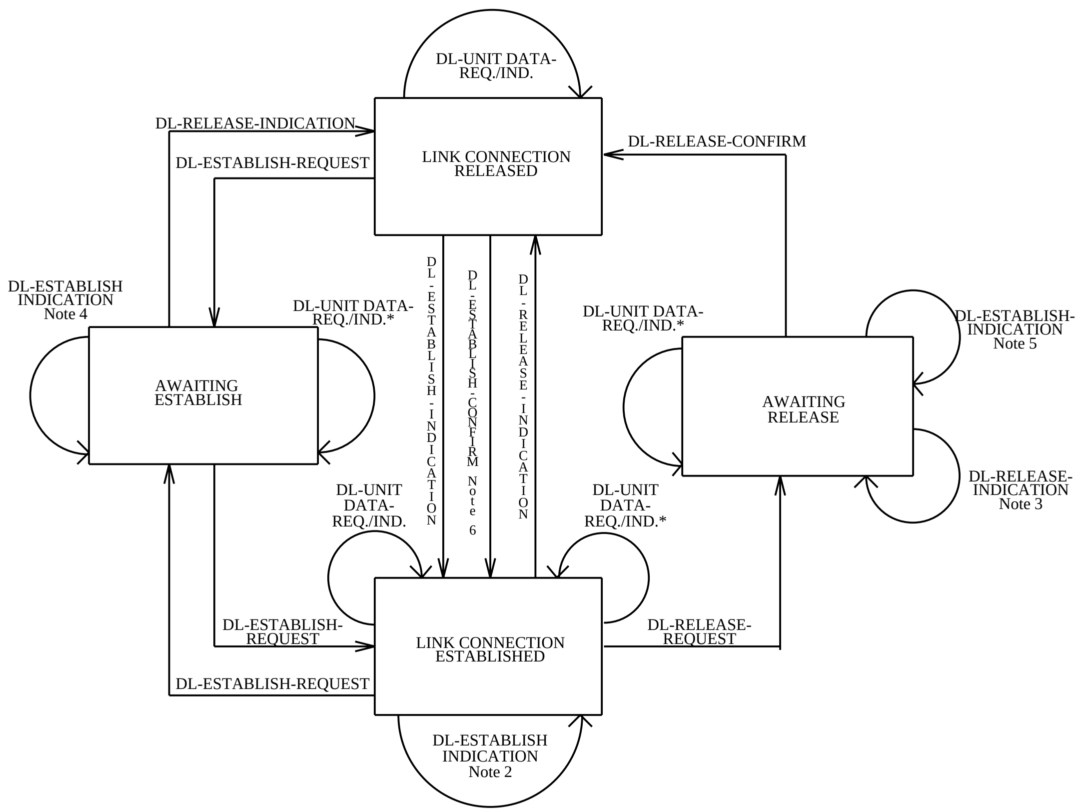
b. Point-to-point data link connection endpoint:
   - *link connection released* state
   - *awaiting establish* state
   - *awaiting release* state
   - *link connection established* state

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

This section defines the constraints on the sequences in which the primitives may occur. The sequences are related to the states at one point-to-point data link connection endpoint.

The possible overall sequences of primitives at a point-to-point data link connection endpoint are defined in the state transition diagram, Figure 3.5-2. The *link connection released* and *link connection established* states are stable states; the *awaiting establish* and *awaiting release* states are transition states.

The model illustrates the behavior of Layer 2 as seen by Layer 3. This model assumes that the primitives passed between layers is implemented by a first in, first out queue. In this model, “collisions” of REQUEST and INDICATION primitives can occur thereby illustrating actions that seem to be in conflict with the actual Layer 2 protocol description. In some implementations, these collisions could occur.



Notes to Figure 3.5-2:

Note 1: If the data link layer entity issues a DL ESTABLISH INDICATION (this applies to the case of data link layer-initiated or peer system-initiated re-establishment), DL RELEASE CONFIRM or DL RELEASE INDICATION, this indicates the discard of all the data link service data units representing DL DATA REQUESTS.

Note 2: This primitive notifies Layer 3 of link re-establishment.

Note 3: This primitive will occur if a DL RELEASE REQUEST collides with a DL RELEASE INDICATION.

Note 4: This primitive will occur if a DL ESTABLISH REQUEST collides with a DL ESTABLISH INDICATION.

Note 5: This primitive will occur if a DL RELEASE REQUEST collides with a DL ESTABLISH INDICATION.

Note 6: This primitive will occur if a DL ESTABLISH REQUEST (this applies to the case of Layer 3 initiated re-establishment) collides with a DL RELEASE INDICATION. Since this DL RELEASE INDICATION is not related to the DL ESTABLISH REQUEST, the data link layer will establish the link and issue a DL ESTABLISH CONFIRM.

Figure 3.5-2 — State Transition Diagram for Sequences of Primitives at a Point-to-Point Data Link Connection as seen by Layer 3 (Note 1)

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3.6 DEFINITION OF THE PEER-TO-PEER PROCEDURES OF THE DATA LINK LAYER

The procedures for use by the data link layer are specified in the following sections.

The elements of procedure (frame types) that apply are:

a. for unacknowledged information transfer (see “Procedures for Unacknowledged Information Transfer,” Section 3.6.2):

   UI-command

b. for multiple frame acknowledged information transfer (see “Procedures for Establishment and Release of Multiple Frame Operation,” Sections 3.6.4, “Procedures for Information Transfer in Multiple Frame Operation,” Section 3.6.5, “Re-Establishment of Multiple Frame Operation,” Section 3.6.6, and “Exception Condition Reporting and Recovery,” Section 3.6.7):

   SABME-command

   UA-response

   DM-response

   DISC-command

   RR-command/response

   RNR-command/response

   REJ-command/response

   I-command

   FRMR-response

3.6.1 PROCEDURE FOR THE USE OF THE P/F BIT

3.6.1.1 Unacknowledged Information Transfer

For unacknowledged information transfer the P/F bit is not used and shall be set to 0.

3.6.1.2 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, shall set the F bit to 1 in the next response frame it transmits, as defined in Table 3.6-1.

Table 3.6-1 — 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

3.6.2 PROCEDURES FOR UNACKNOWLEDGED INFORMATION TRANSFER

3.6.2.1 General

The procedures that apply to the transmission of information in unacknowledged operation are defined below.

No data link layer error recovery procedures are defined for unacknowledged operation.

3.6.2.2 Transmission of Unacknowledged Information

Note: The term "transmission of a UI frame" refers to the delivery of a UI frame by the data link layer to the physical layer.

Unacknowledged information is passed to the data link layer by Layer 3 or management entities using the primitives DL UNIT DATA REQUEST or MDL UNIT DATA REQUEST, respectively. The Layer 3 or management message unit shall be transmitted in a UI command frame.

For broadcast operation, the TEI value in the UI command address field shall be set to 127 (binary 111 1111, the group value).

For point-to-point operation, the TEI value "0" shall be used.

The P bit shall be set to 0.

3.6.2.3 Receipt of Unacknowledged Information

On receipt of a UI command frame with a SAPI and TEI that are supported by the receiver, the contents of the information field shall be passed to the Layer 3 or management entity using the data link layer to Layer 3 primitive DL UNIT DATA INDICATION or the data link layer to management primitive MDL UNIT DATA INDICATION, respectively. Otherwise, the UI command frame shall be discarded.

3.6.3 TERMINAL ENDPOINT IDENTIFIER (TEI) MANAGEMENT PROCEDURES

TEI management, as implemented by the *5ESS*® switch, consists of the following:

- Performing an internal loopback test
- Entering the TEI Assigned state with a TEI value of "0"
- Transitioning to the TEI Assigned state, using TEI Removal Procedures, when a hard failure occurs on the data link.

For the primary rate interface, a TEI value of "0" is assumed to be assigned at subscription time. Automatic TEI assignment procedures are *not* supported. Conceptually, the Management Entity delivers the TEI value of "0" to the data link layer entity, causing it to enter the TEI Assigned State. Before entering the TEI Assigned state, the *5ESS* switch initiates an internal loopback test to verify path integrity.

Upon a loss of power, a protocol handler hard-switch, or a similar condition, the management entity instructs the data link layer entity to remove the TEI value "0" by using the TEI Removal Procedure to cause the data link layer to enter the TEI Unassigned state. Then the *5ESS* switch initiates an internal loopback test and, if success is indicated, enters the TEI Assigned state.

Both the internal loopback test (described in Section 3.6.3.1, "Internal Loopback Test") and the TEI Removal Procedures (described in Section 3.6.3.2, "Format of TEI Removal Procedure") use a SAPI value of "63." As indicated in Table 3.4-2, "Allocation of SAPI Values," implementation of SAPI value "63" is optional. If this value is not supported, messages concerning the internal loopback test or the TEI Removal Procedure should be ignored.

3.6.3.1 Internal Loopback Test

Before entering the TEI Assigned state, the *5ESS* switch verifies the internal path integrity through an internal loopback test, initiated by a message passed over the data link.

Note: Far-end equipment may ignore this message.

This message has the following format:

SAPI	63
TEI	126
UNNUMBERED FORMAT	
Control Field	U format
Poll/Final Bit	1
Cmnd/Resp Bit	1
LAYER MGMT FRAME	
Management Entity ID	0
HEX CODING OF MSG	FE FD 03

3.6.3.2 Format of TEI Removal Procedure

All messages used for TEI management procedures are carried in the information field of UI command frames with a SAPI value set to “63” (binary 11 1111) and TEI value set to “127” (binary 111 1111). These messages have the structure shown in Figure 3.6-1, where E is the Action indicator field extension bit. The Action indicator field is described in Section 3.6.3.2.4, “Action indicator (Ai).”

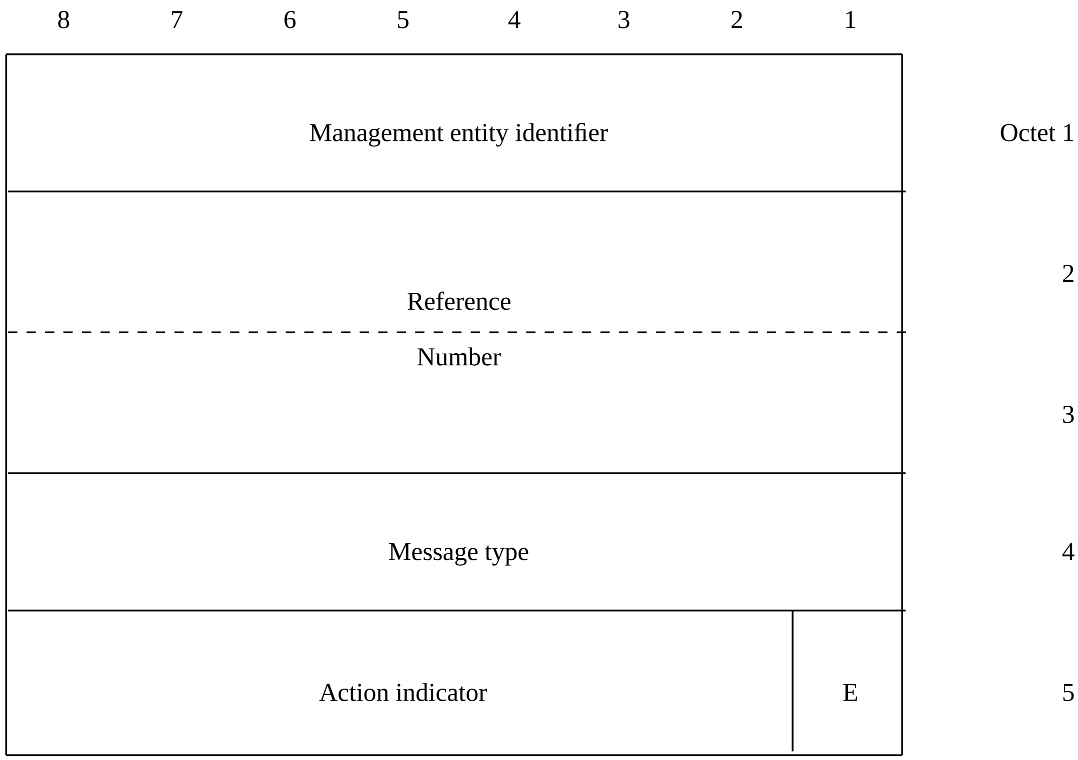

Figure 3.6-1 — Message Structure for TEI Management Procedures

Any field not used in a given message should be coded with all zeros and not processed by either side. The coding of each field of the Identity Remove Request message is shown in Table 3.6-2.

Table 3.6-2 — Coding of the Identity Remove Request Message

MESSAGE NAME	MANAGEMENT ENTITY IDENTIFIER	REFERENCE NUMBER (Ri)	MESSAGE TYPE	ACTION INDICATOR (Ai)
Identity Remove Request	0000 1111	Not used 0000 0000	0000 0110	Ai=127. Remove all TEIs.

3.6.3.2.1 Layer Management Entity Identifier

For TEI administration procedures, the layer management entity identifier octet is 0000 1111. Other values are reserved for further standardization.

3.6.3.2.2 Reference Number (Ri)

Octets 2 and 3 contain Ri. When used, it can assume any value between 0 and 65535.

3.6.3.2.3 Message Type

The message type identifies the function of the message being sent. Octet 4 contains the message type.

3.6.3.2.4 Action Indicator (Ai)

The Action indicator identifies the TEI value(s). The Ai field is extended by reserving the first transmitted bit of the Ai field octets to indicate the final octet of the Ai field. Ai variables in the Ai field are coded as follows:

a. Bit 1 is the extension bit and is set to 1.

b. Bits 2 through 8 contain the Action indicator.

3.6.4 PROCEDURES FOR ESTABLISHMENT AND RELEASE OF MULTIPLE FRAME OPERATION

3.6.4.1 Establishment of Multiple Frame Operation

The provision of extended multiple frame operation (modulo 128 sequencing) is required.

3.6.4.1.1 General

These procedures shall be used to establish multiple frame operation between the network and a designated user entity.

Layer 3 will request establishment of the multiple frame operation by the use of the DL ESTABLISH REQUEST primitive. Re-establishment may be initiated as a result of the data link layer procedures defined in “Re-Establishment of Multiple Frame Operation,” Section 3.6.6. All frames other than unnumbered frame formats received during the establishment procedures shall be ignored.

3.6.4.1.2 Establishment Procedures

A data link layer entity shall initiate a request for the multiple frame operation to be set by transmitting the SABME command. All existing exception conditions shall be cleared, the retransmission counter shall be reset, and Timer T200 shall then be started (Timer T200 is defined in “Timer T200,” Section 3.6.8.1). All mode setting commands shall be transmitted with the P bit set to 1.

Layer 3 initiated establishment procedures imply the discard of all outstanding DL DATA REQUEST primitives and all I frames in queue.

A data link layer entity receiving an SABME command, if it is able to enter the *multiple-frame-established* state, shall:

- respond with an UA response with the F bit set to the same binary value as the P bit in the received SABME command;
- set V(S), V(R) and V(A) to 0;
- enter the *multiple-frame-established* state and inform Layer 3 using the DL ESTABLISH INDICATION primitive;
- clear all existing exception conditions;
- clear any existing peer receiver busy condition;
- start Timer T203 (Timer T203 is defined in “Timer T203,” Section 3.6.8.8); and
- Reset the transmission counter.

If the data link layer entity is unable to enter the *multiple-frame-established* state, it shall respond to the SABME command with a DM response with the F bit set to the same binary value as the P bit in the received SABME command.

Upon reception of the UA response with the F bit set to 1, the originator of the SABME command shall:

- reset Timer T200;
- start Timer T203;
- set V(S), V(R), and V(A) to 0; and
- enter the *multiple-frame-established* state and inform Layer 3 using the DL ESTABLISH CONFIRM primitive.

Upon reception of a DM response with the F bit set to 1, the originator of the SABME command shall indicate this to Layer 3 by means of the DL RELEASE INDICATION primitive, and reset Timer T200. It shall then enter the *TEI-assigned* state. DM responses with the F bit set to 0 shall be ignored in the TEI Assigned state.

A DL RELEASE REQUEST primitive received during data link layer-initiated re-establishment shall be serviced on completion of the establishment mode-setting operation.

3.6.4.1.3 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 shall:

- retransmit the SABME command as previously mentioned;
- restart Timer T200; and
- increment the retransmission counter.

After retransmission of the SABME command N200 times, the data link layer entity shall indicate this to Layer 3 and the connection management entity by means of the DL RELEASE INDICATION and MDL ERROR INDICATION primitives, respectively, and enter the *TEI-assigned* state, after discarding all outstanding DL DATA REQUEST primitives and all I frames in queue.

The value of N200 is defined in “Maximum Number of Retransmissions (N200),” Section 3.6.8.2.

3.6.4.2 Information Transfer

After either the UA response to a received SABME command has been transmitted or the UA response to a transmitted SABME command has been received, I frames and supervisory frames shall be transmitted and received according to the procedures described in “Procedures for Information Transfer in Multiple Frame Operation,” Section 3.6.5.

If an SABME command is received while in the *multiple-frame-established* state, the data link layer entity shall conform to the re-establishment procedure described in “Re-Establishment of Multiple Frame Operation,” Section 3.6.6.

On receipt of a UI command, the procedures defined in “Procedures for Unacknowledged Information Transfer,” Section 3.6.2, shall be followed.

3.6.4.3 Termination of Multiple Frame Operation

3.6.4.3.1 General

These procedures shall be used to terminate the multiple frame operation between the network and a designated user entity.

Layer 3 will request termination of the multiple frame operation by use of the DL RELEASE REQUEST primitive.

All frames other than unnumbered frames received during the release procedures shall be ignored.

All outstanding DL DATA REQUEST primitives and all I frames in queue shall be discarded.

3.6.4.3.2 Release Procedure

A data link layer entity shall 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 shall then be started and the retransmission counter reset.

A data link layer entity receiving a DISC command while in the *multiple-frame-established* or *timer recovery* state shall transmit a UA response with the F bit set to the same binary value as the P bit in the received DISC command. A DL RELEASE INDICATION primitive shall be passed to Layer 3, and the *TEI-assigned* state shall be entered.

If the originator of the DISC command receives either:

- a UA response with the F bit set to 1; or
- 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,

it shall enter the *TEI-assigned* state and reset Timer T200.

The data link layer entity that issued the DISC command is now in the *TEI-assigned* state and will notify Layer 3 by means of the DL RELEASE CONFIRM primitive. The conditions relating to this state are defined in “TEI Assigned state,” Section 3.6.4.4.

3.6.4.3.3 Procedure on Expiry of Timer T200

If Timer T200 expires before a UA or DM response with the F bit set to 1 is received, the originator of the DISC command shall:

- retransmit the DISC command as defined in “Release Procedure,” Section 3.6.4.3.2;
- restart Timer T200; and
- increment the retransmission counter.

If the data link layer entity has not received the correct response as defined in “Release Procedure,” Section 3.6.4.3.2, after N200 attempts to recover, the data link layer entity shall indicate this to the connection management entity by means of the MDL ERROR INDICATION primitive, enter the *TEI-assigned* state and notify Layer 3 by means of the DL RELEASE CONFIRM primitive.

3.6.4.4 TEI Assigned State

While in the *TEI-assigned* state:

- the receipt of a DISC command shall result in the transmission of a DM response with F bit set to the value of the received P bit;
- on receipt of an SABME command, the procedures defined in “Establishment of Multiple Frame Operation,” Section 3.6.4.1, shall be followed;

- on receipt of an unsolicited DM response with the F bit set to 0, the DM shall be ignored;
- on receipt of UI commands, the procedures defined in “Procedures for Unacknowledged Information Transfer,” Section 3.6.2, shall be followed;
- on receipt of any unsolicited UA response or a DM with F bit set to 1, an MDL ERROR INDICATION primitive indicating a possible double assignment of a TEI value shall be issued; and
- all other frame types shall be discarded.

Note: The receipt of an I frame or supervisory frame with the P bit set to “1” may result in the transmission of a DM response with the F bit set to “1” (as defined in “Procedure for the use of the P/F Bit,” Section 3.6.1).

3.6.4.5 Collision of Unnumbered Commands and Responses

3.6.4.5.1 Identical Transmitted and Received Commands

If the transmitted and received unnumbered commands (SABME or DISC) are the same, the data link layer entities shall send the UA response at the earliest possible opportunity. The indicated state shall be entered after receiving the UA response. The data link layer entity shall notify Layer 3 by means of the appropriate confirm primitive.

3.6.4.5.2 Different Transmitted and Received Commands

If the transmitted and received unnumbered commands (SABME or DISC) are different, the data link layer entities shall issue a DM response at the earliest possible opportunity. Upon receipt of a DM response with the F bit set to “1,” the data link layer shall enter the *TEI-assigned* state and notify Layer 3 by means of the appropriate primitive. The entity receiving the DISC command will issue a DL RELEASE INDICATION primitive, while the other entity will issue a DL RELEASE CONFIRM primitive.

3.6.4.6 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 typically caused by a user equipment applying a protocol procedure according to X.25 LAPB to ask for a mode-setting command.

In order to avoid misinterpretation of the DM response received, a data link layer entity shall always send its SABME or DISC command with the P bit set to 1.

A DM response with the F bit set to 0 colliding with an SABME or DISC command shall be ignored.

3.6.5 PROCEDURES FOR INFORMATION TRANSFER IN MULTIPLE FRAME OPERATION

The procedures that apply to the transmission of I frames are defined below.

Note: The term “transmission of an I frame” refers to the delivery of an I frame by the data link layer to the physical layer.

3.6.5.1 Transmitting I Frames

Information received by the data link layer entity from Layer 3 by means of a DL DATA REQUEST primitive shall be transmitted in an I frame. The control field parameters N(S) and N(R) shall be assigned the values V(S) and V(R), respectively. V(S) shall be incremented by 1 at the end of the transmission of the I frame.

If Timer T200 is not running at the time of transmission of an I frame, it shall be started. If Timer T200 expires, the procedures defined in “Waiting Acknowledgment,” Section 3.6.5.7, shall be followed.

If V(S) is equal to V(A) plus *k* (where *k* is the maximum number of outstanding I frames – see “Maximum Number of Outstanding I Frames (k),” Section 3.6.8.5), the data link layer entity shall not transmit any new I frames, but may retransmit an I frame as a result of the error recovery procedures as described in “Receiving REJ Frames,” Section 3.6.5.4, and “Waiting Acknowledgment,” Section 3.6.5.7.

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 condition does not exist.

When the network side or user side is in the frame rejection condition, it shall stop transmitting I frames.

3.6.5.2 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 N(S) is equal to the current V(R), the data link layer entity shall:

- pass the information field of this frame to Layer 3 using the DL DATA INDICATION primitive;
- increment by 1 its V(R), and act as indicated below.

3.6.5.2.1 P Bit Set to 1

If the P bit of the received I frame was set to 1, the data link layer entity shall respond 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 shall send an RR response with the F bit set to 1;
- if the data link layer entity receiving the I frame enters the own receiver busy condition upon receipt of the I frame, it shall send an RNR response with the F bit set to 1.

3.6.5.2.2 P Bit Set to 0

If the P bit of the received I frame was set to 0 and:

a. 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 shall transmit an RR response with the F bit set to 0; or
   - if an I frame is available for transmission and no peer receiver busy condition exists, the data link layer entity shall transmit the I frame with the value of N(R) set to the current value of V(R) as defined in “Transmitting I Frames,” Section 3.6.5.1; or

b. if, on receipt of this I frame, the data link layer entity is now in an own receiver busy condition, it shall transmit an RNR response with the F bit set to 0.

When the data link layer entity is in an own receiver busy condition, it shall process any received I frame according to “Data Link Layer Own Receiver Busy Condition,” Section 3.6.5.6.

3.6.5.3 Sending and Receiving Acknowledgments

3.6.5.3.1 Sending Acknowledgments

Whenever a data link layer entity transmits an I frame or a supervisory frame, N(R) shall be set equal to V(R).

3.6.5.3.2 Receiving Acknowledgments

On receipt of a valid I frame or supervisory frame (RR, RNR, or REJ), even in the own receiver busy, or timer recovery conditions, the data link layer entity shall treat the N(R) contained in this frame as an acknowledgment for all the I frames it has transmitted with an N(S) up to and including the received N(R) – 1. V(A) shall be set to N(R). The data link layer entity shall reset the Timer T200 on receipt of a valid I frame or supervisory frame with the N(R) higher than V(A) (actually acknowledging some I frames), or an REJ frame with an N(R) equal to V(A).

Note 1: If a supervisory frame with the P bit set to 1 has been transmitted and not acknowledged, Timer T200 shall not be reset.

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

If Timer T200 has been reset by the receipt of an I, RR, or RNR frame, and if outstanding I frames remain unacknowledged, the data link layer entity shall restart Timer T200. If Timer T200 then expires, the data link layer entity shall follow the recovery procedure as defined in “Waiting Acknowledgment,” Section 3.6.5.7, with respect to the unacknowledged I frames.

If Timer T200 has been reset by the receipt of an REJ frame, the data link layer entity shall follow the retransmission procedures in “Receiving REJ Frames,” Section 3.6.5.4.

3.6.5.4 Receiving REJ Frames

On receipt of a valid REJ frame, the data link layer entity shall act as follows:

a. if it is not in the timer recovery condition:

- clear an existing peer receiver busy condition;
- set its V(S) and its V(A) to the value of the N(R) contained in the REJ frame control field;
- stop Timer T200;
- start Timer T203 if implemented;
- transmit the corresponding I frame as soon as possible, as defined in “Transmitting I Frames,” Section 3.6.5.1, taking into account the Items 1 through 4 below and the paragraph following Items 1 through 4; and
- notify a protocol violation to the connection management entity by means of the MDL ERROR INDICATION primitive, if it was an REJ response frame with the F bit set to 1.

Note: See "Procedures for Information Transfer in Multiple Frame Operation," Section 3.6.5.

b. if it is in the timer recovery condition and it was an REJ response frame with the F bit set to 1:

- clear an existing peer receiver busy condition;
- set its V(S) and its V(A) to the value N(R) contained in the REJ frame control field;
- stop Timer T200;
- start Timer T203 if implemented;
- enter the multiple-frame-established state; and
- transmit the corresponding I frame as soon as possible, as defined in "Transmitting I Frames," Section 3.6.5.1, taking into account the Items 1 through 3 below and the paragraph following Items 1 through 3.

c. if it is in the timer recovery condition and it was an REJ frame other than an REJ response frame with the F bit set to 1:

- clear an existing peer receiver busy condition;
- set its V(A) to the value of the N(R) contained in the REJ frame control field; and
- if it was an REJ command frame with the P bit set to 1, transmit an appropriate supervisory response frame with the F bit set to 1 (see Note 2 in "Receiving RNR Frames," Section 3.6.5.5).

Transmission of I frames shall take account of the following:

1. if the data link layer entity is transmitting a supervisory frame when it receives the REJ frame, it shall complete that transmission before commencing transmission of the requested I frame;
2. if the data link layer entity is transmitting a SABME command, a DISC command, a UA, DM, or FRMR response when it receives the REJ frame, it shall ignore the request for retransmission; and
3. if the data link layer entity is not transmitting a frame when the REJ is received, it shall immediately commence transmission of the requested I frame.
4. it may terminate the I frame so long as it does not cause an FRMR condition at the receiver.

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

3.6.5.5 Receiving RNR Frames

After receiving a valid RNR command or response, if the data link layer entity is not engaged in a mode-setting operation, it shall set a peer receiver busy condition and then:

- if it was an RNR command with the P bit set to 1, it shall respond with an RR response with the F bit set to 1 if the data link layer entity is not in an own receiver busy condition, and shall respond with an RNR response with the F bit set to 1 if the data link layer entity is in an own receiver busy condition; and

- if it was an RNR response with the F bit set to 1, an existing timer recovery condition shall be cleared and the N(R) contained in this RNR response shall be used to update V(S).

The data link layer entity shall take note of the peer receiver busy condition and not transmit any I frames to the peer that has indicated the busy condition.

Note: The N(R) in any RR or RNR command frame (with the P bit set to 1) will not be used to update the send state variable V(S).

The data link layer entity shall then:

- treat the 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], and set its V(A) to the value of the N(R) contained in the RNR frame; and
- restart 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 shall:

- if it is not yet in a timer recovery condition, enter the timer recovery condition and reset the retransmission count variable; or
- if it is already in a timer recovery condition or status inquiry add one to its retransmission count variable.

The data link layer entity shall then:

a. if the value of the retransmission count variable is less than N200:
   - transmit an appropriate supervisory command (see Note 2) with a P bit set to 1;
   - restart Timer T200; and

b. if the value of the retransmission count variable is equal to N200, initiate a re-establishment procedure as defined in “Re-Establishment of Multiple Frame Operation,” Section 3.6.6, and indicate this by means of the MDL ERROR INDICATION primitive to the connection management entity.

The data link layer entity receiving the supervisory frame with the P bit set to 1 shall respond, at the earliest opportunity, with a supervisory response frame (see Note 2) with the F bit set to 1, to indicate whether its own receiver busy condition still exists.

Upon receipt of the supervisory response with the F bit set to 1, the data link layer entity shall reset Timer T200, and:

- if the response is an RR or REJ response, the peer receiver busy condition is cleared and the data link layer entity may transmit new I frames or retransmit I frames as defined in “Transmitting I Frames,” Section 3.6.5.1, or “Receiving REJ Frames,” Section 3.6.5.4, respectively; or
- if the response is an RNR response, the data link layer entity receiving the response shall proceed according to this “Receiving RNR Frames,” Section 3.6.5.5, first paragraph.

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 shall:

- 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, clear the peer receiver busy condition and if the supervisory frame received was a command with the P bit set to 1, transmit the appropriate supervisory response frame (see Note 2) with the F bit set to 1. However, the transmission or retransmission of I frames shall not be undertaken until the appropriate supervisory response frame with the F bit set to 1 is received; or
- if the supervisory frame is an RNR command frame or an RNR response frame with the F bit set to 0, retain the peer receiver busy condition and if the supervisory frame received was an RNR command with P bit set to 1, transmit the appropriate supervisory response frame (see Note 2) with the F bit set to 1. The inquiry of the peer status shall be repeated following the expiry of Timer T200, or after expiry of Timer T200 following the receipt of the RNR response with the F bit set to “1”.

Upon receipt of an SABME command, the data link layer entity shall clear the peer receiver busy condition.

Note: 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 an 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 an 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.

3.6.5.6 Data Link Layer Own Receiver Busy Condition

When the data link layer entity enters an own receiver busy condition, it shall transmit an RNR frame at the earliest opportunity.

The RNR frame may be:

- an RNR response with the F bit set to 0; or
- if this condition is entered on receiving a command frame with the P bit set to 1, an RNR response with the F bit set to 1; or
- if this condition is entered on expiry of Timer T200, an RNR command with the P bit set to 1.

All received I frames with the P bit set to 0 shall be discarded, after updating V(A).

All received supervisory frames with the P/F bit set to 0 shall be processed, including updating V(A).

All received I frames with the P bit set to 1 shall be discarded, after updating V(A). However, an RNR response frame with the F bit set to 1 shall be transmitted.

All received supervisory frames with the P bit set to 1 shall be processed including updating V(A). An RNR response with the F bit set to 1 shall be transmitted.

To indicate to the peer data link layer entity the clearance of the own receiver busy condition, the data link layer entity shall transmit an RR frame or, if a previously detected N(S) sequence error has not yet been reported, an REJ frame with the N(R) set to the current value of 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 the clearance of the own receiver busy condition.

3.6.5.7 Waiting Acknowledgment

The data link layer entity shall maintain an internal retransmission count variable.

If Timer T200 expires, the data link layer entity shall:

- if it is not yet in the timer recovery condition, enter the timer recovery condition and reset the retransmission count variable; or
- if it is already in the timer recovery condition, add one to its retransmission count variable.

The data link layer entity shall then:

a. if the value of the retransmission count variable is less than N200:
   - restart Timer T200; and either
   - transmit an appropriate supervisory command (see Note 2 in “Receiving RNR Frames,” Section 3.6.5.5) with the P bit set to 1; or
   - retransmit the last transmitted I frame [V(S) – 1] with the P bit set to 1; or

b. if the value of the retransmission count variable is equal to N200, initiate a re-establishment procedure as defined in “Re-Establishment of Multiple Frame Operation,” Section 3.6.6, and indicate this by means of the MDL ERROR INDICATION primitive to the connection management entity.

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 received supervisory frame N(R) is within the range from its current V(A) to its current V(S) inclusive, it shall set its V(S) to the value of the received N(R). Timer T200 shall be reset if the received supervisory frame response is an RR or REJ response, and then the data link layer entity shall resume with I frame transmission or retransmission, as appropriate. Timer T200 shall be reset and restarted if the received supervisory response is an RNR response, to proceed with the enquiry process according to “Receiving RNR Frames,” Section 3.6.5.5.

3.6.6 RE-ESTABLISHMENT OF MULTIPLE FRAME OPERATION

3.6.6.1 Criteria for Re-Establishment

The criteria for re-establishing the multiple frame mode of operation are defined in this section by the following conditions:

- the receipt, while in the multiple-frame mode of operation, of an SABME;
- the receipt of a DL ESTABLISH REQUEST primitive from Layer 3 (see “General,” Section 3.6.4.1.1);

- the receipt, while in the multiple-frame mode of operation, of an unsolicited UA or DM (F=1) response; (this is an implementation option)
- the occurrence of N200 retransmission failures while in the timer recovery condition (see “Waiting Acknowledgment,” Section 3.6.5.7);
- the occurrence of a frame rejection condition as identified in “Frame Rejection Condition,” Section 3.6.7.5;
- the receipt, while in the multiple-frame mode of operation, of an FRMR response frame (see “Receipt of an FRMR Response Frame,” Section 3.6.7.6);
- the receipt, while in the multiple-frame mode of operation, of an unsolicited DM response with the F bit set to “0” (see “Unsolicited Response Frames,” Section 3.6.7.7);
- the receipt, while in the timer-recovery condition, of a DM response with the F bit set to 1.

3.6.6.2 Procedures

In all re-establishment situations, the data link layer entity shall follow the procedures defined in “Establishment of Multiple Frame Operation,” Section 3.6.4.1. All locally generated conditions for re-establishment will cause the transmission of the SABME.

In the case of data link layer, the data link layer entity shall:

- issue an MDL ERROR INDICATION primitive to the connection management entity; and discard all queues.
- After successful establishment, issue a DL ESTABLISH INDICATION primitive to Layer 3, and discard all I queues.

In case of Layer 3 initiated re-establishment, or if a DL ESTABLISH REQUEST primitive occurs pending re-establishment, the DL ESTABLISH CONFIRM primitive shall be used.

3.6.7 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 that are available to effect recovery following the detection of an exception condition at the data link layer are defined in this section.

3.6.7.1 N(S) Sequence Error

An N(S) sequence error exception condition occurs in the receiver when a valid I frame is received that contains an N(S) value not equal to the V(R) at the receiver. The information field of all I frames whose N(S) does not equal the V(R) shall be discarded.

The receiver shall not acknowledge [or increment its V(R)] the I frame causing the sequence error, or any I frames that follow, until an I frame with the correct N(S) is received.

A data link layer entity that receives one or more I frames having sequence errors but otherwise error-free, or subsequent supervisory frames (RR, RNR, and REJ), shall use the control field information contained in the N(R) field and the P or F bit to perform data link control functions; for example, to receive acknowledgment of previously transmitted I frames and to cause 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 therefore different from, the ones 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 shall be established at a time.

A data link layer entity receiving an REJ command or response shall initiate sequential transmission (retransmission) of 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.

3.6.7.2 N(R) Sequence Error

An N(R) sequence error exception condition occurs in the transmitter when a valid supervisory frame or I frame that contains an invalid N(R) value is received.

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

The information field contained in an I frame that is correct in sequence and format may be delivered to Layer 3 by means of the DL DATA INDICATION primitive.

The data link layer entity shall inform the connection management entity of this exception condition by means of the MDL ERROR INDICATION primitive, and initiate re-establishment according to "Procedures," Section 3.6.6.2.

3.6.7.3 Timer Recovery Condition

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

The data link layer entity that transmitted the unacknowledged I frame(s) shall, on the expiry of Timer T200, take appropriate recovery action as defined in "Waiting Acknowledgment," Section 3.6.5.7, to determine at which I frame retransmission must begin.

3.6.7.4 Invalid Frame Condition

Any frame received that is invalid (as defined in "Invalid Frames," Section 3.3.8, and "Frame Types," Section 3.4.5) shall be discarded, and no action shall be taken as a result of that frame.

3.6.7.5 Frame Rejection Condition

A frame rejection condition results from one of the conditions described in "Commands and Responses," Section 3.4.5.1, third paragraph, or "Frame Reject (FRMR) Response," Section 3.4.5.11, Items b, c, and d.

At either side, this frame rejection condition may optionally be indicated by transmission of FRMR response for appropriate action by the other side, followed by the transmission of a SABME or DISC command. A SABME is recommended.

Once the frame rejection condition has been established, no additional I frames or supervisory frames shall be processed (except for examination of the P bit) until the condition is reset.

Alternatively, the data link layer entity may initiate re-establishment directly by transmitting an SABME.

3.6.7.6 Receipt of an FRMR Response Frame

Upon receipt of an FRMR response frame in the multiple-frame mode of operation, the data link layer entity shall:

- issue an MDL ERROR INDICATION primitive; and
- initiate re-establishment (see "Procedures," Section 3.6.6.2).

3.6.7.7 Unsolicited Response Frames

The action to be taken on the receipt of an unsolicited response frame is defined in Table 3.6-3.

The data link layer entity shall assume possible multiple TEI assignment on the receipt of an unsolicited UA response and shall inform the layer management.

Table 3.6-3 — Actions Taken on Receipt of Unsolicited Response Frames

Unsolicited response frame	TEI Assigned	Awaiting Establishment	Awaiting Release	Multiple frame modes of operation	
				Established mode	Timer recovery condition
UA response, F=1	MDL-ERROR-INDICATION	Solicited	Solicited	MDL-ERROR-INDICATION	MDL-ERROR-INDICATION
UA response, F=0	MDL-ERROR-INDICATION	MDL-ERROR-INDICATION	MDL-ERROR-INDICATION	MDL-ERROR-INDICATION	
DM response, F=1	[a]Ignore or MDL-ERROR-INDICATION	Solicited	Solicited	Re-establish and/or MDL-ERROR-INDICATION	[a]Re-establish and MDL-ERROR-INDICATION, or Solicited
DM response, F=0	Ignore	Ignore	Ignore	Re-establish MDL-ERROR-INDICATION	Re-establish MDL-ERROR-INDICATION
Supervisory response, F=1	Ignore	Ignore	Ignore	MDL-ERROR-INDICATION	Solicited
Supervisory response, F=0	Ignore	Ignore	Ignore	Solicited	Solicited

Note(s):
a. IMPLEMENTATION OPTION

3.6.7.8 Multiple Assignment of a TEI Value

Reserved for future use.

3.6.8 LIST OF SYSTEM PARAMETERS

The system parameters listed below are associated with each individual SAP.

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

3.6.8.1 Timer T200

The default value for Timer T200, at the end of which transmission of a frame may be initiated according to the procedures described in "Procedures for Information Transfer in Multiple Frame Operation," Section 3.6.5, shall be one second.

Note: The proper operation of the procedure requires that Timer T200 be greater than the maximum time between transmission of command frames and the reception of their corresponding response or acknowledgment frames.

3.6.8.2 Maximum Number of Retransmissions (N200)

The maximum number of retransmissions of a frame (N200) is a system parameter. The default value of N200 shall be 3.

3.6.8.3 Maximum Number of Octets in an Information Field (N201)

The maximum number of octets in an information field (N201) is a system parameter. (See also “Information Field,” Section 3.3.4.) The default value shall be 260 octets.

3.6.8.4 Maximum Number of Transmissions of the TEI Identity Request Message (N202)

Reserved for future use.

3.6.8.5 Maximum Number of Outstanding I Frames (k)

The *5ESS* switch supports a fixed value for the maximum number of outstanding (that is, unacknowledged) sequentially numbered I frames (k). For the Custom PRI, k has the value of 1. For the National ISDN PRI, k has the value of 7.

3.6.8.6 Timer T201

The minimum time between retransmissions of the TEI Identity check messages (T201) is a system parameter that shall be set to T200 seconds.

3.6.8.7 Timer T202

Reserved for future use.

3.6.8.8 Timer T203

Timer T203 represents the maximum time allowed without frames being exchanged. The *5ESS* switch supports a fixed value for Timer T203. Timer T203 has a value of 30 seconds for both the Custom PRI and the National ISDN PRI.

3.6.9 DATA LINK LAYER MONITOR FUNCTION

3.6.9.1 General

The procedural elements defined in “Definition of the Peer-to-Peer Procedures of the Data Link Layer,” Section 3.6, allow for the supervision of the data link layer resource. This section describes procedures that may be used to provide this supervision function.

3.6.9.2 Data Link Layer Supervision in the Multiple-Frame-Established State

The procedures specified herein propose a solution identified in the HDLC classes of procedures. The connection verification is a service provided by 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 Timer T203, and operates in the *multiple-frame-established* state as follows.

If no frames (new or outstanding I frames, or supervisory frames with a P bit set to 1) are being exchanged on the data link connection, a faulty data link connection condition or an unplugged user equipment cannot be detected. Timer T203 represents the maximum time allowed during which no frames are exchanged.

If Timer T203 expires, a supervisory command with a P bit set to 1 is transmitted to start a status enquiry. Such a procedure is protected against transmission errors by making use of the normal Timer T200 procedure including retransmission count and N200 attempts.

3.6.9.3 Connection Verification Procedures

3.6.9.3.1 Start Timer T203

The Timer T203 is started:

- when the *multiple-frame-established* state is entered; and
- in the *multiple-frame-established* state whenever Timer T200 is stopped. (See note in “Stop Timer T203,” Section 3.6.9.3.2.)

Upon receiving an I or supervisory frame, Timer T203 will be restarted if Timer T200 is not to be started.

3.6.9.3.2 Stop Timer T203

The Timer T203 is stopped

- when, in the *multiple-frame-established* state, the Timer T200 is started (see Note); and
- upon leaving the *multiple-frame-established* state.

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

3.6.9.3.3 Expiry of Timer T203

If Timer T203 expires, the data link layer entity will act as follows (note that Timer T200 is neither running nor expired):

a. set the retransmission count variable to 0;

b. enter *timer recovery* state;

c. transmit a supervisory command with the P bit set to 1 as follows:
   - if there is not a receiver busy condition (own receiver not busy), transmit an RR command; or
   - if there is a receiver busy condition (own receiver busy), transmit an RNR command; and

d. start Timer T200; and

e. send MDL ERROR INDICATION primitive to connection management after N200 retransmissions, and a DL RELEASE INDICATION to the Layer 3 entity;

f. retransmit the supervisory command (p bit = 1) up to N200 times.

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3.7 GRAPHICAL REPRESENTATION OF THE POINT-TO-POINT PROCEDURES OF THE DATA LINK LAYER

The purpose of this section is to provide a graphical representation of the point-to-point procedures of the data link layer, to assist in the understanding of this Specification. This graphical representation does not describe all of the possible actions of the data link layer entity, as a non-partitioned representation was selected in order to minimize its complexity. The graphical representation does not therefore constrain implementations from exploiting the full scope of the procedures as presented within the text of this Specification. The text description of the procedures is definitive.

3.7.1 OVERVIEW OF THE STATES OF THE POINT-TO-POINT DATA LINK LAYER ENTITY

This representation of the point-to-point procedures is based on an expansion of the three basic states identified in Figure 3.7-1 to the following eight states:

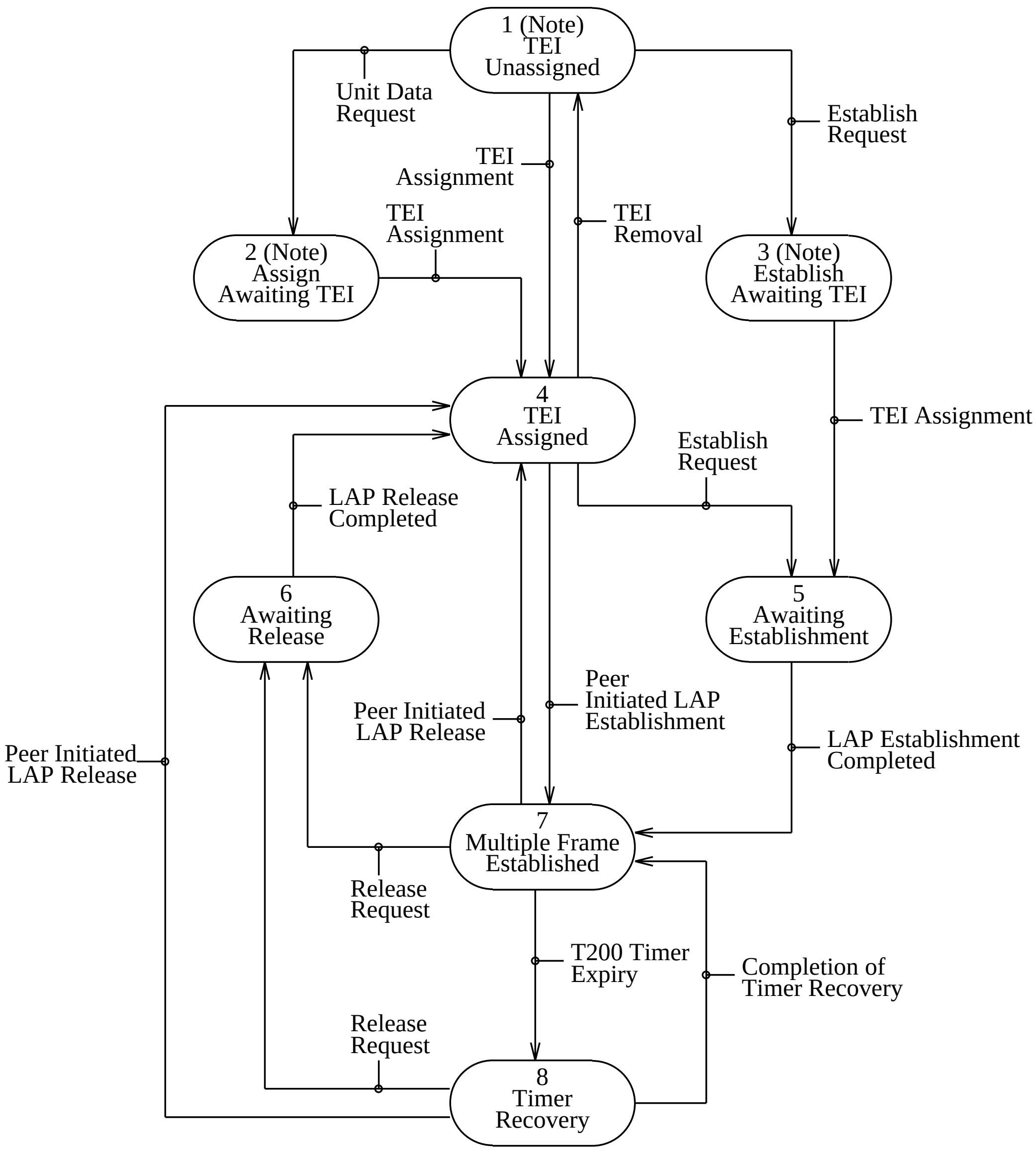
1. TEI Unassigned
2. Assign Awaiting TEI
3. Establish Awaiting TEI
4. TEI Assigned
5. Awaiting Establishment
6. Awaiting Release
7. Multiple Frame Established
8. Timer Recovery.

For the primary rate interface, State 1 (TEI Unassigned) is relevant due to the reasons described in “Terminal Endpoint Identifier (TEI) Management Procedures,” Section 3.6.3. On power-up, it is assumed that the management entity issues an MDL ASSIGN REQ primitive to the data link layer entity with the TEI value of “0,” thus causing the data link layer entity to enter the TEI Assigned state. Since automatic TEI assignment procedures are not supported for the primary rate interface, States 2 and 3 are not relevant to this interface. The receipt of an establish request in the TEI Assigned state (State 4) will cause the initiation of the establishment procedures and the transition to the Awaiting Establishment state (State 5). Completion of the LAP establishment procedures takes the data link layer entity into the Multiple-Frame-Established state (State 7). Peer initiated establishment causes a direct transition from the TEI Assigned state (State 4) to the Multiple-Frame-Established state (State 7). In the Multiple-Frame-Established state (State 7), acknowledged data transfer requests can be serviced directly subject to the restrictions of the procedures. Expiry of the Timer T200, which is used in both the flow control and data transfer aspects of the data link layer entity’s procedures initiates the transition to the Timer Recovery state (State 8). Completion of the timer recovery procedures will return the data link layer entity to the Multiple-Frame-Established state (State 7). In States 7 and 8 of the SDL representation, the following conditions identified within the specification are observed:

1. Peer receiver busy
2. Reject exception

3. Own receiver busy

In addition other conditions are used in order to avoid identification of additional states. The complete combination of both of these categories of conditions with the eight states of the SDL representation, is the basis for the state transition table description of the data link layer entity. A peer initiated LAP release will take the data link layer entity directly into the TEI Assigned state (State 4), while a release request will be using the Awaiting Release state (State 6). TEI removal will cause a transition to the TEI Unassigned state (State 1). See Figure 3.7-1.



Note: States 1, 2, and 3 are not relevant to the primary interface because the TEI assignment procedures are not supported.

Figure 3.7-1 — Link Layer State Transition

3.7.2 SDL REPRESENTATION OF LINK LAYER PROCEDURES

SDL diagrams for States 4 to 8 are given in the following figures:

- Figure 3.7-3
- Figure 3.7-4
- Figure 3.7-5
- Figure 3.7-6
- Figure 3.7-7

These diagrams show actions taken, procedures called, and signals generated when events occur in those states. In Figure 3.7-8, the SDL diagrams that apply to more than one state, the relevant states, are indicated. Figure 3.7-9 shows the definitions of the procedures that are invoked in the SDL diagrams.

3.7.3 SYMBOLS USED IN SDL DIAGRAMS

The symbols used within this description are described in Figure 3.7-2. A full description of their meanings and applications can be found in the ITU-T Z-Series Recommendations.

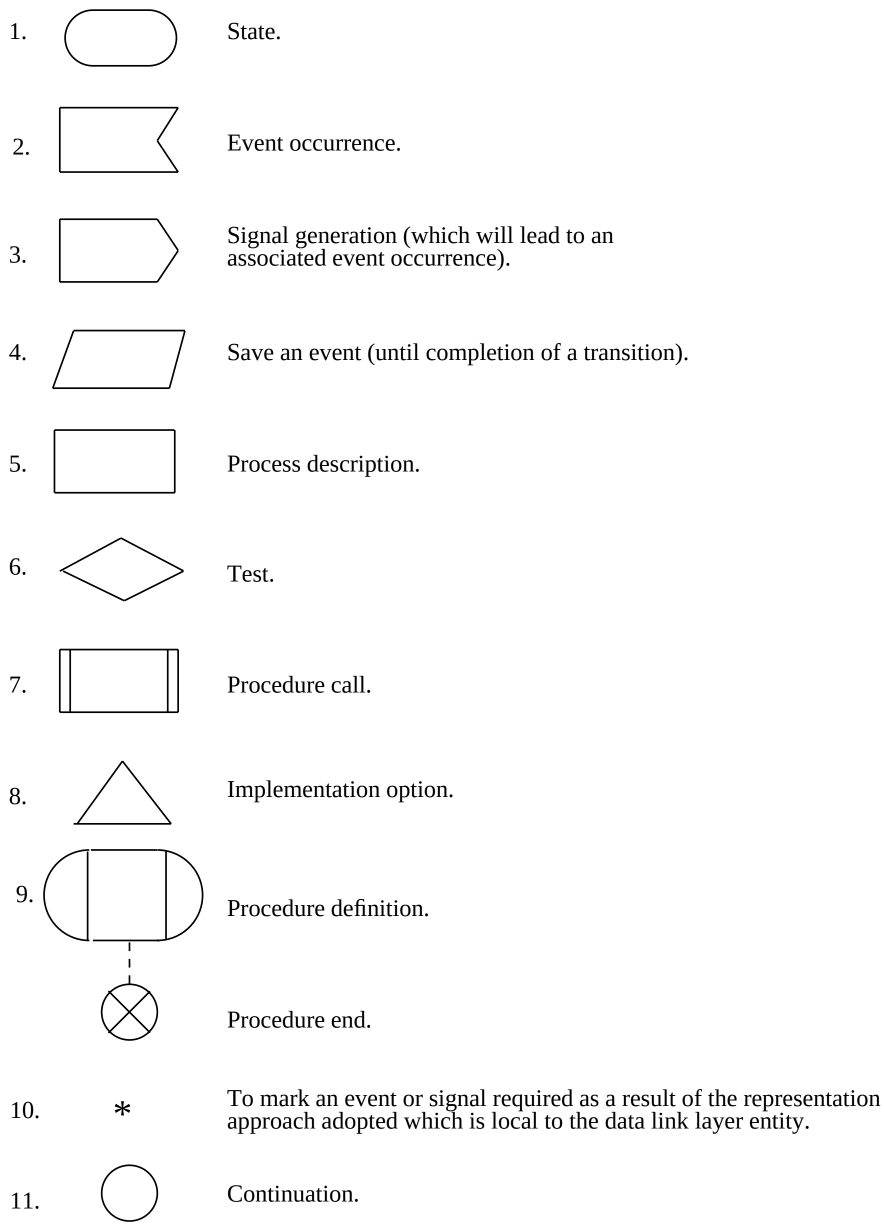


Figure 3.7-2 — Legend for Link Layer SDL Diagrams

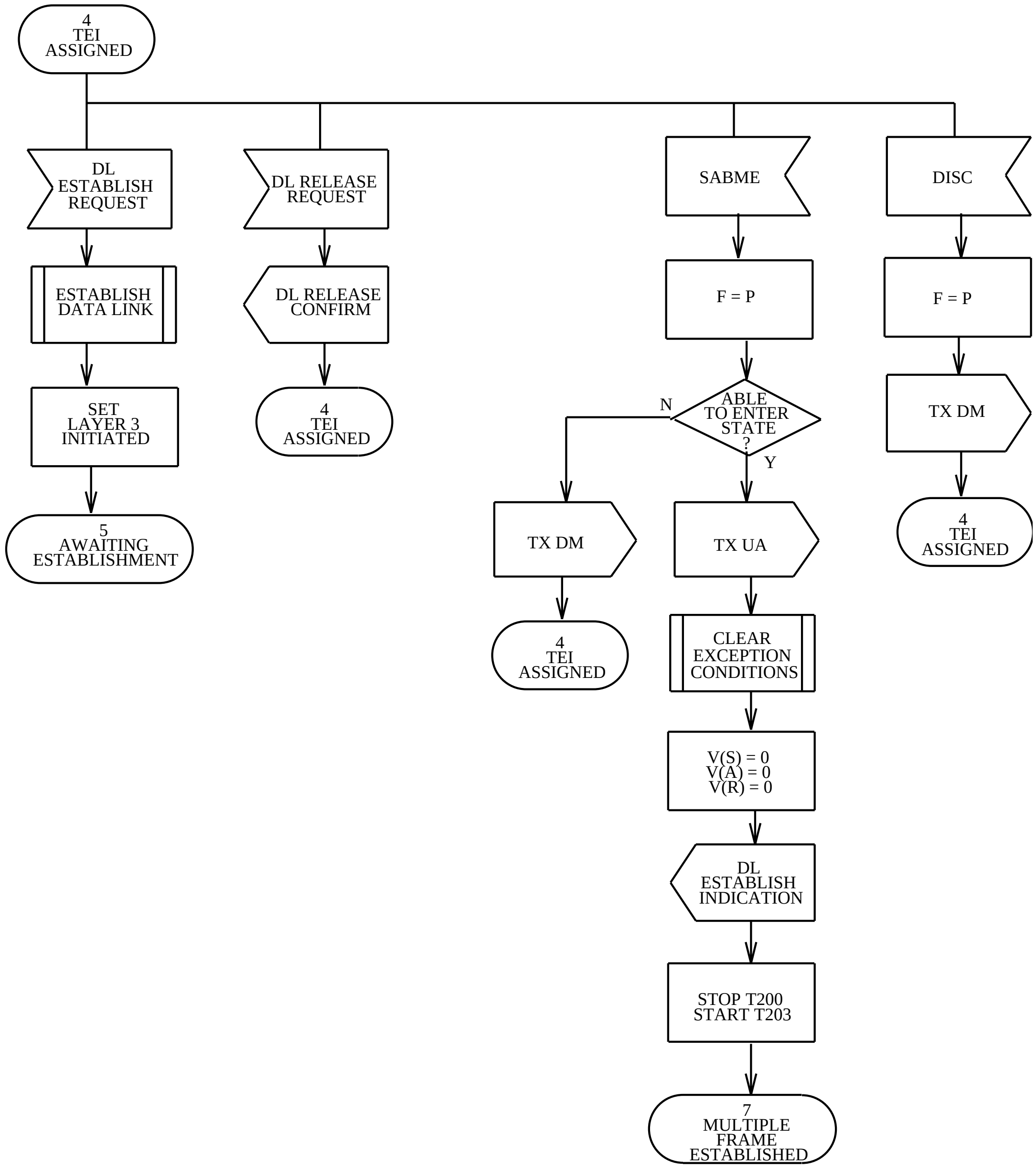


Figure 3.7-3 — Link Layer Point-to-Point: State 4, TEI Assigned (1 of 2)

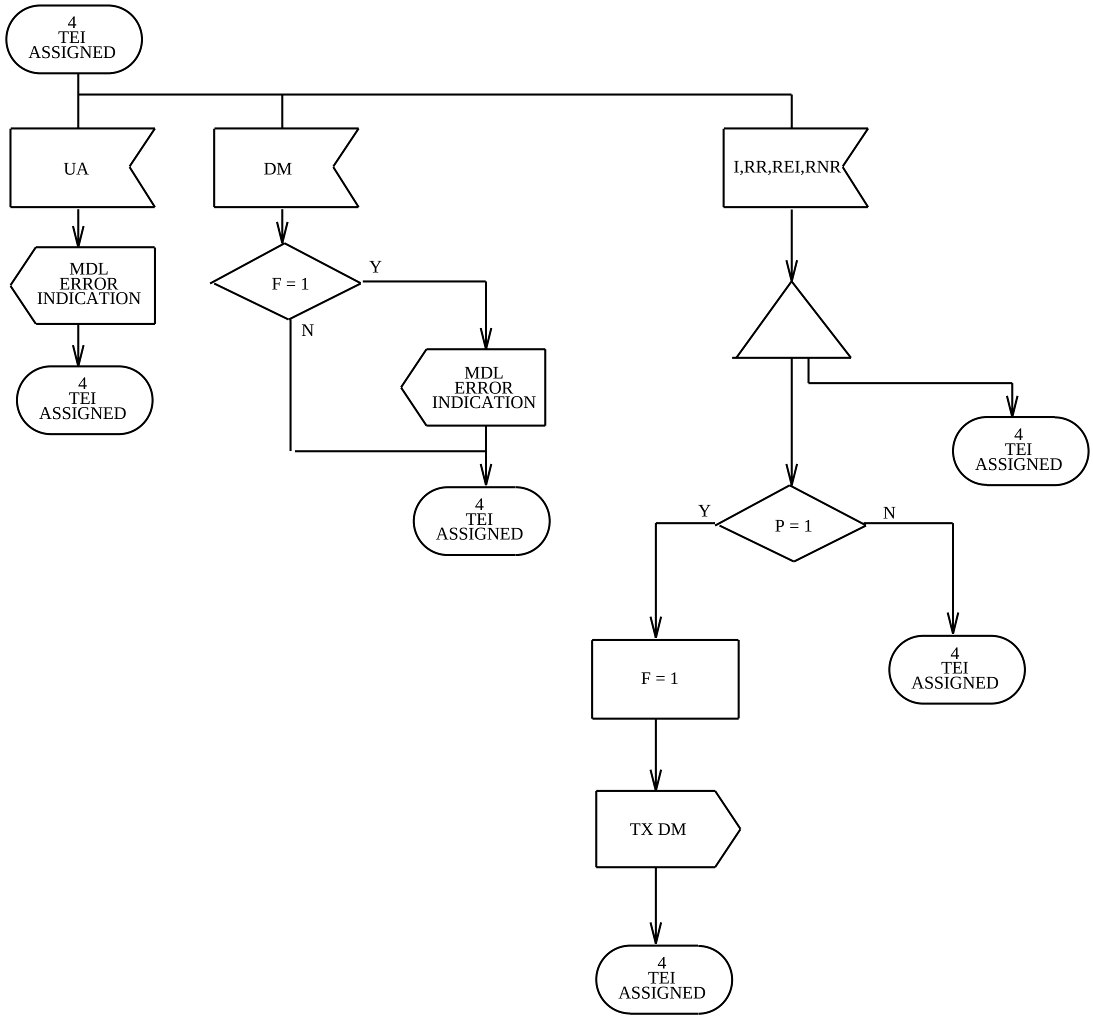


Figure 3.7-3 — Link Layer Point-to-Point: State 4, TEI Assigned (2 of 2)

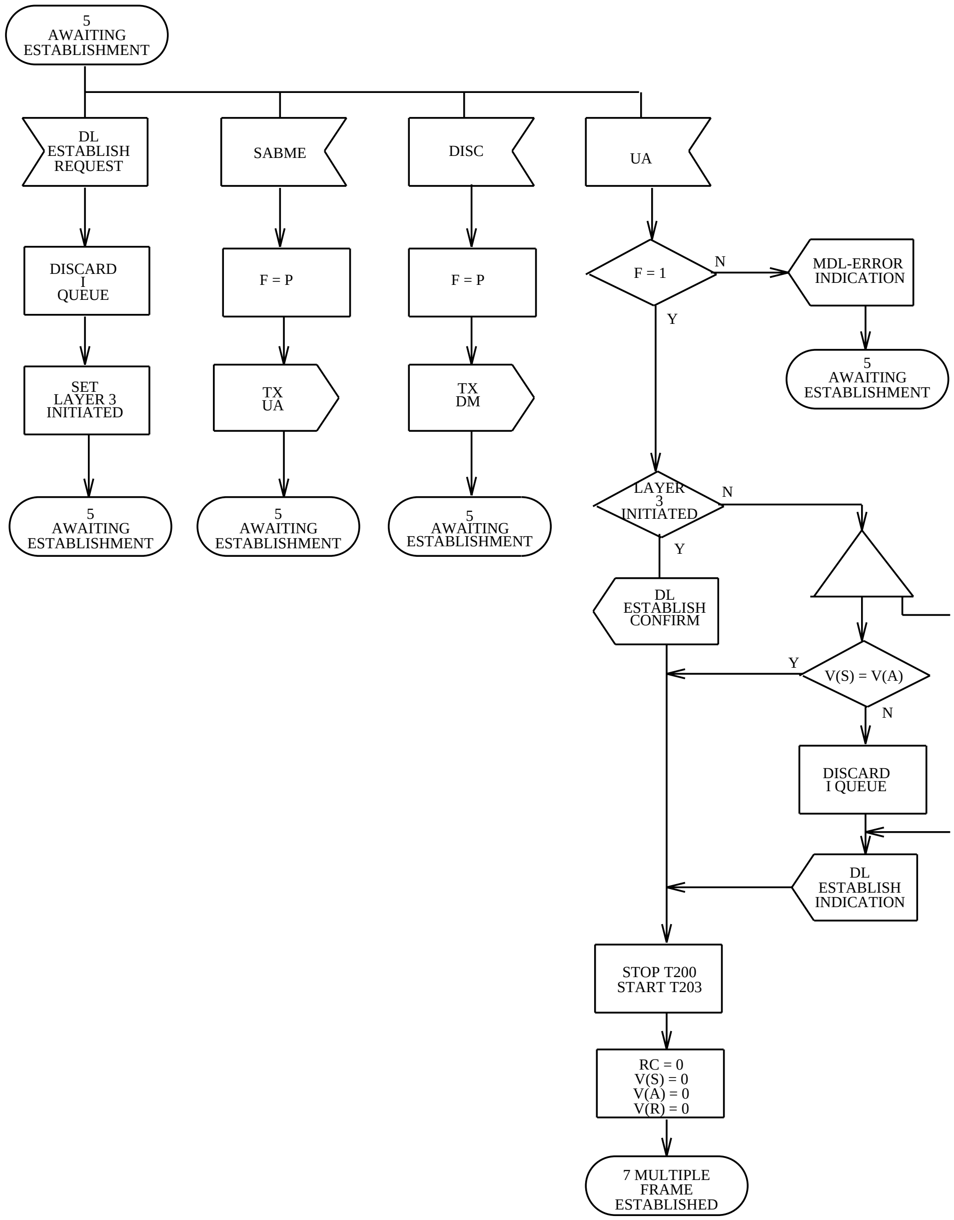


Figure 3.7-4 — Link Layer Point-to-Point: State 5, Awaiting Establishment (1 of 2)

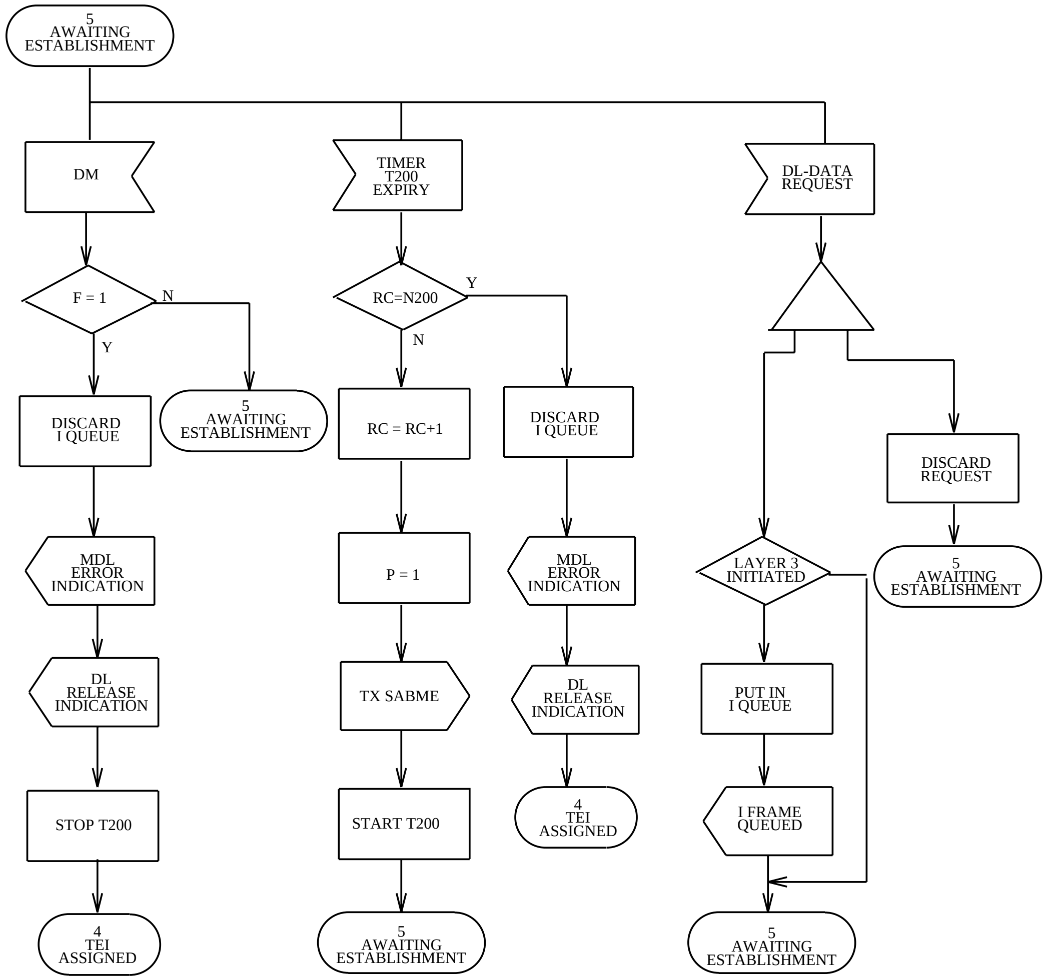


Figure 3.7-4 — Link Layer Point-to-Point: State 5, Awaiting Establishment (2 of 2)

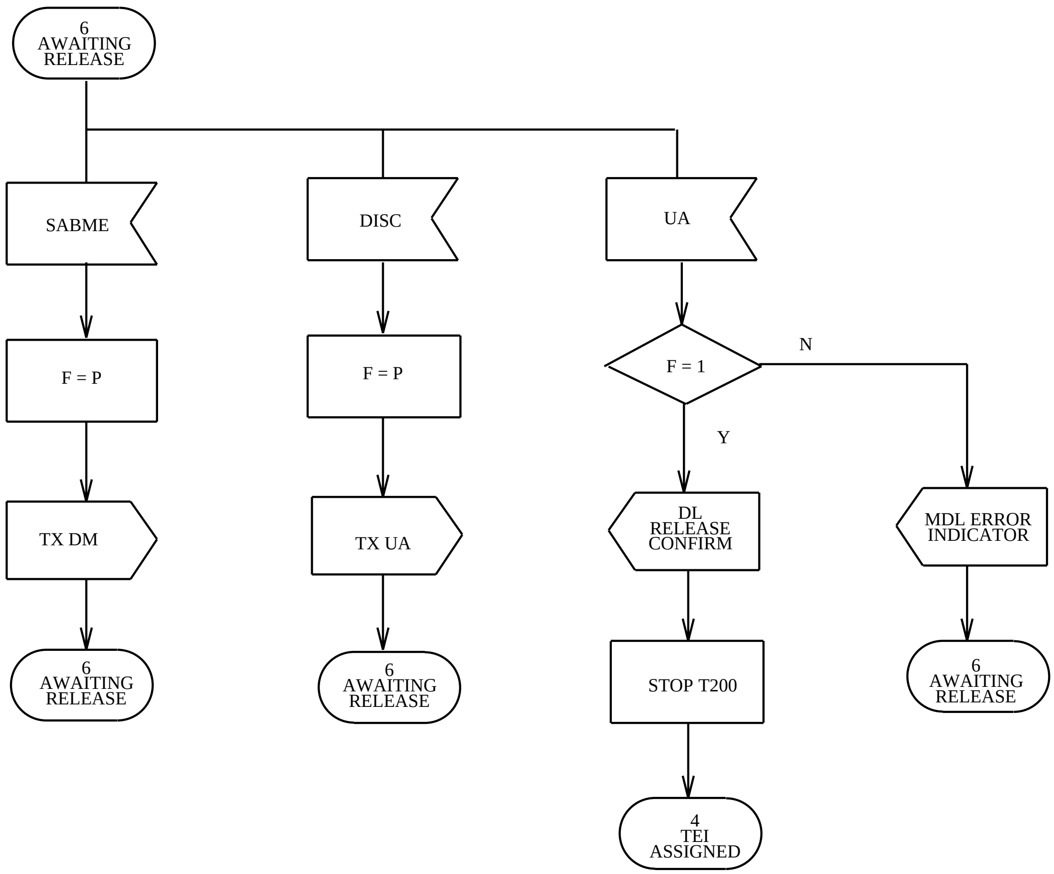


Figure 3.7-5 — Link Layer Point-to-Point: State 6, Awaiting Release (1 of 2)

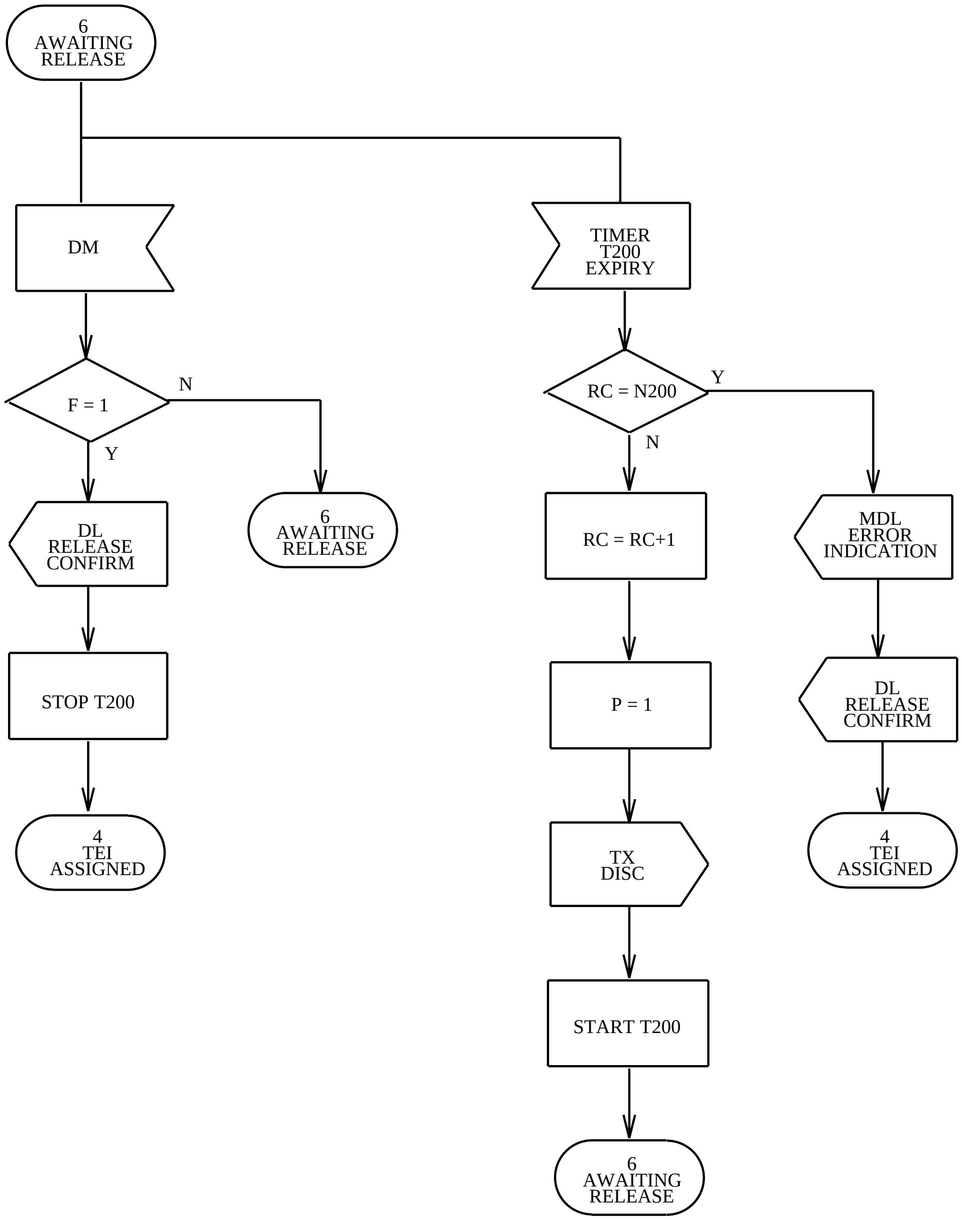


Figure 3.7-5 — Link Layer Point-to-Point: State 6, Awaiting Release (2 of 2)

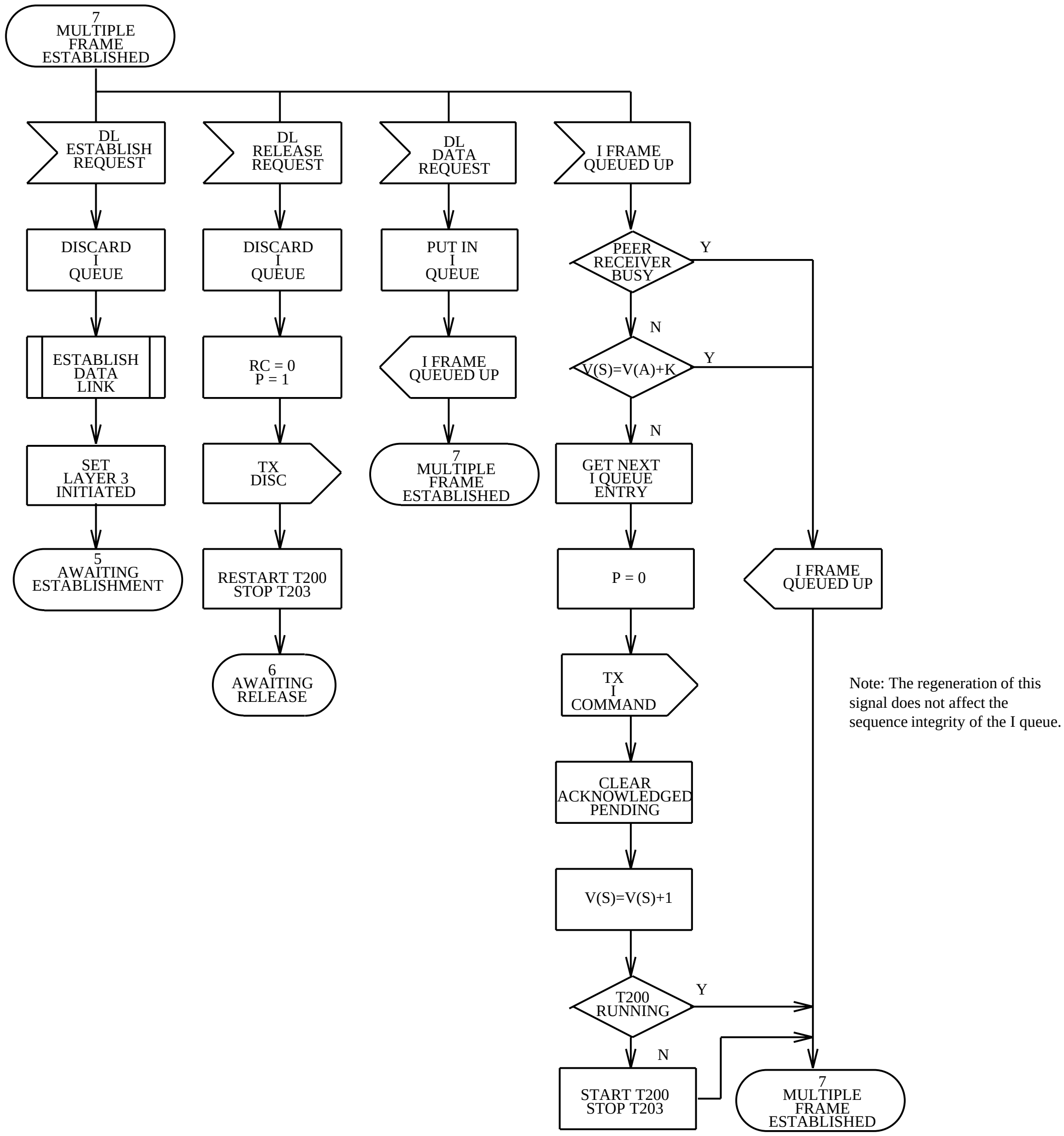


Figure 3.7-6 — Link Layer Point-to-Point: State 7, Multiple Frame Established (1 of 8)

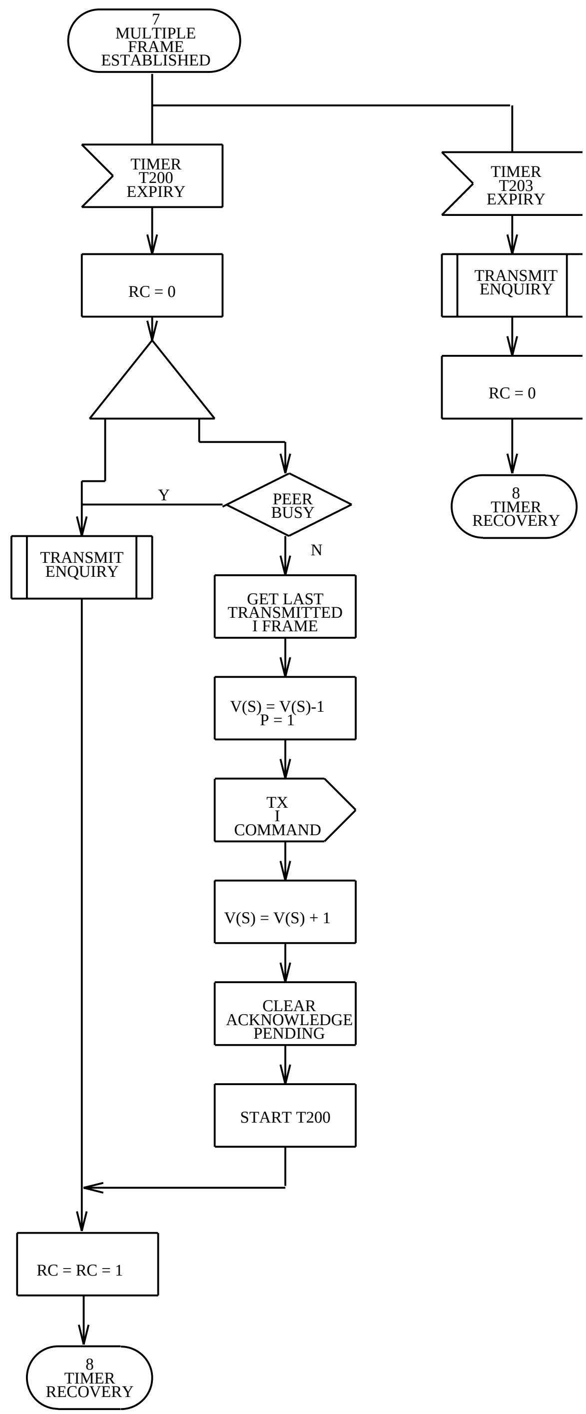


Figure 3.7-6 — Link Layer Point-to-Point: State 7, Multiple Frame Established (2 of 8)

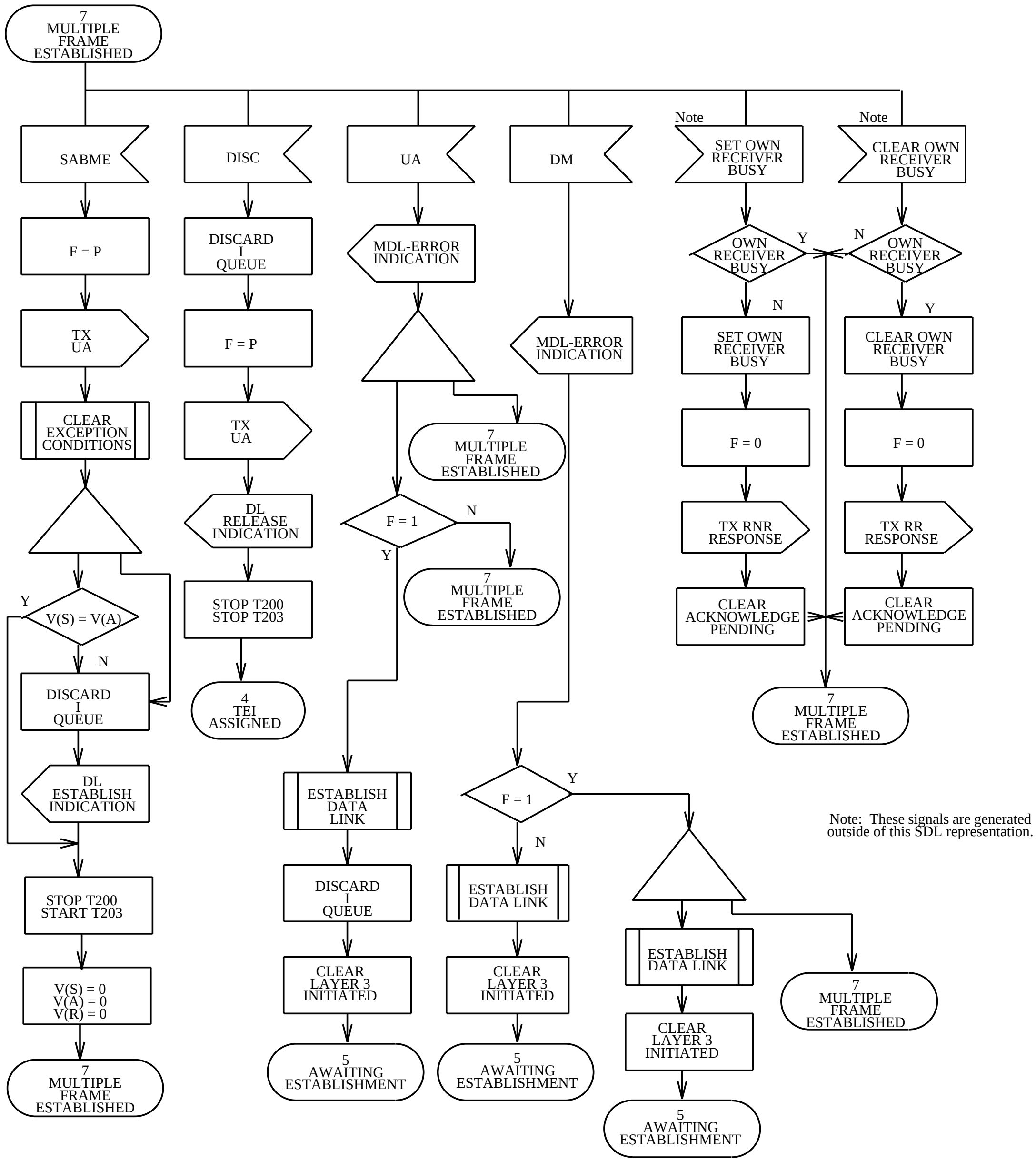


Figure 3.7-6 — Link Layer Point-to-Point: State 7, Multiple Frame Established (3 of 8)

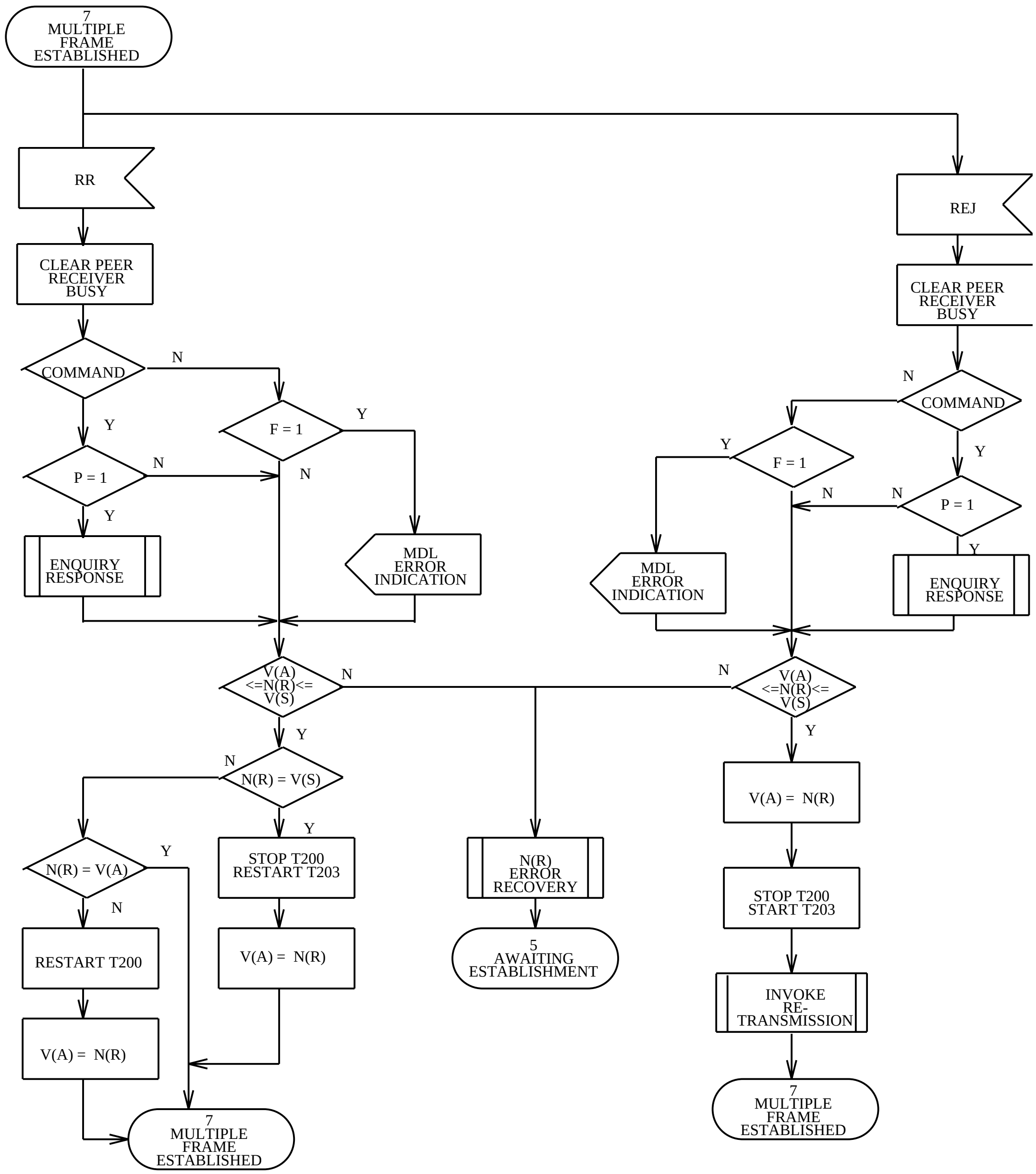


Figure 3.7-6 — Link Layer Point-to-Point: State 7, Multiple Frame Established (4 of 8)

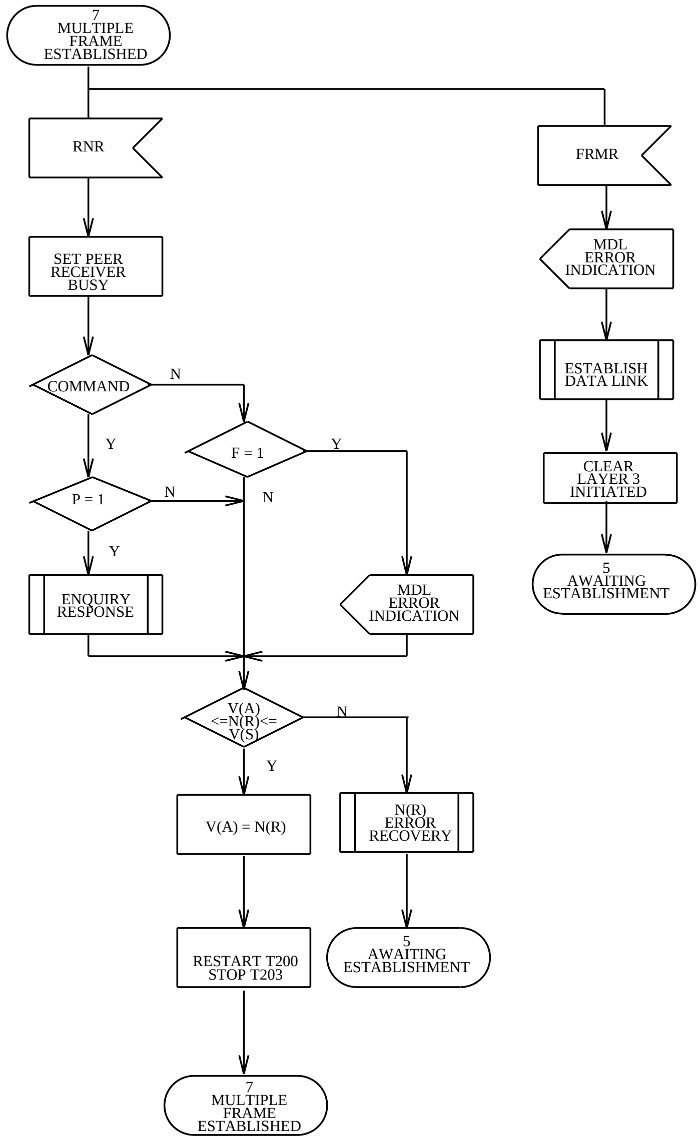


Figure 3.7-6 — Link Layer Point-to-Point: State 7, Multiple Frame Established (5 of 8)

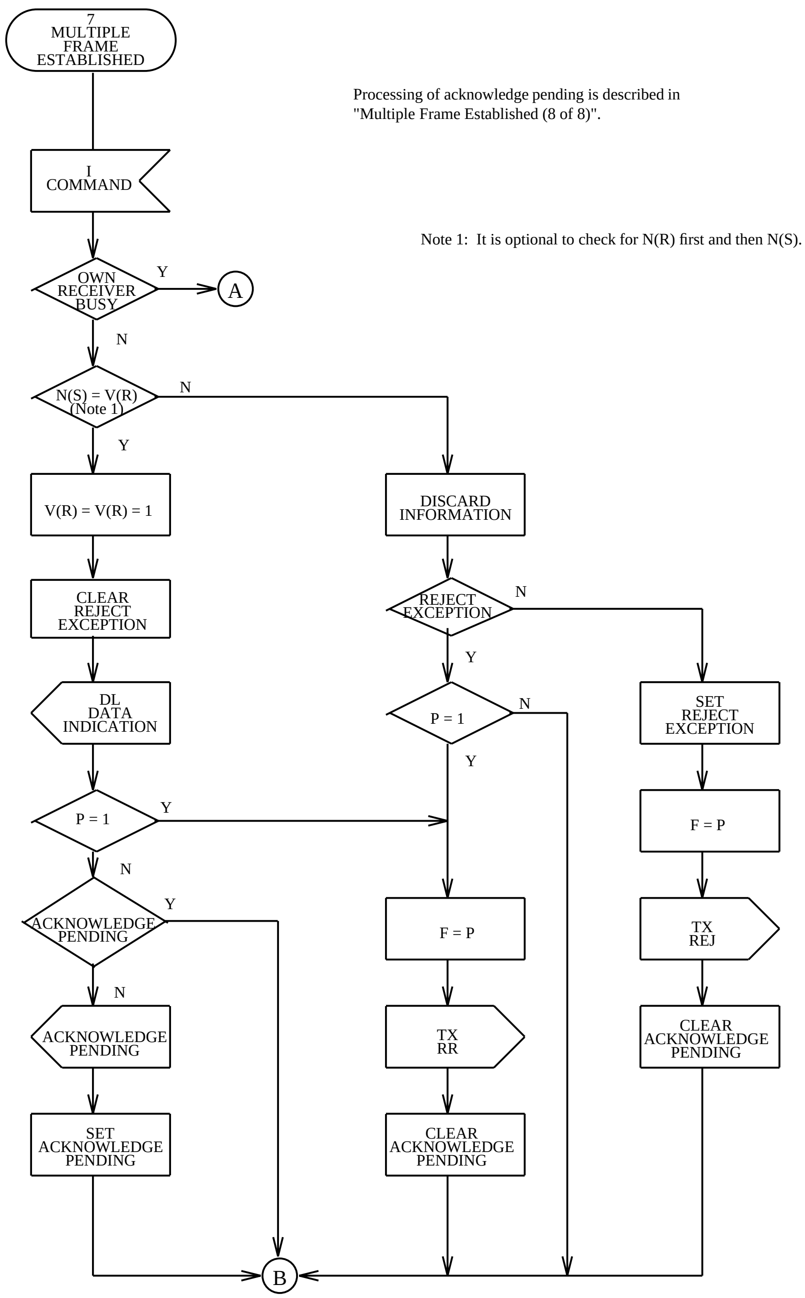


Figure 3.7-6 — Link Layer Point-to-Point: State 7, Multiple Frame Established (6 of 8)

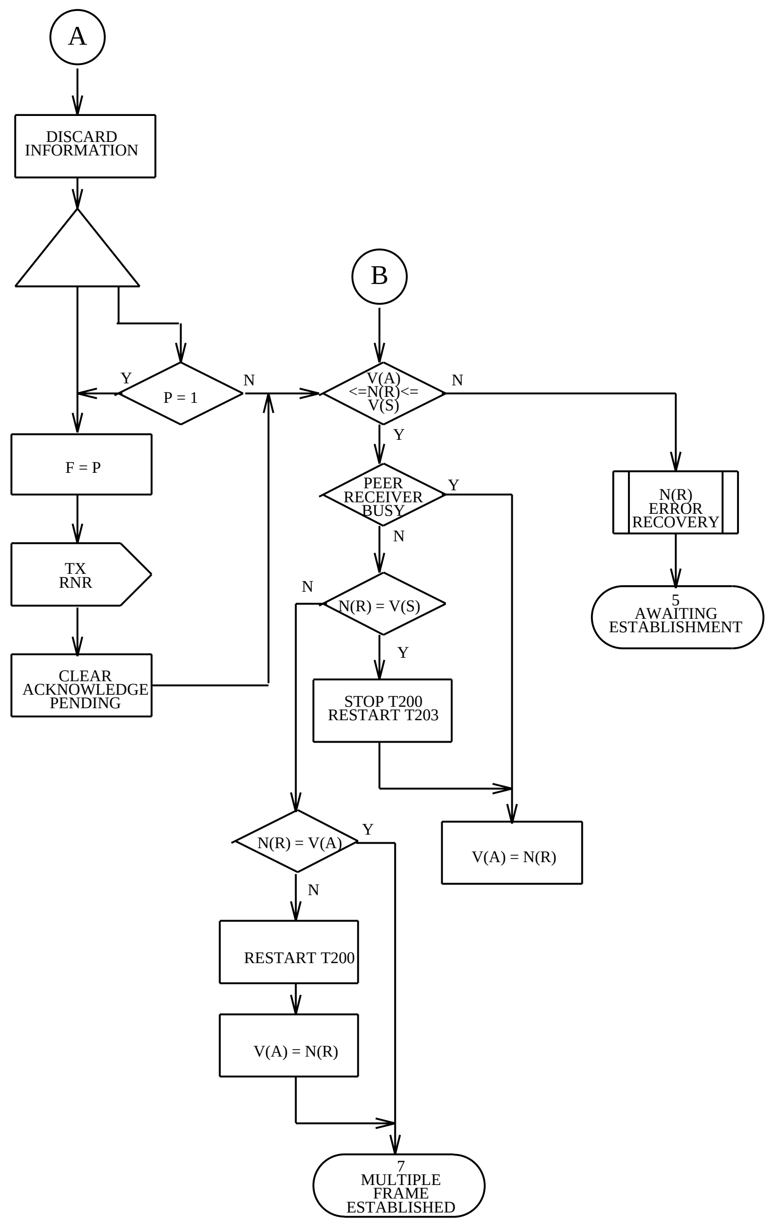


Figure 3.7-6 — Link Layer Point-to-Point: State 7, Multiple Frame Established (7 of 8)

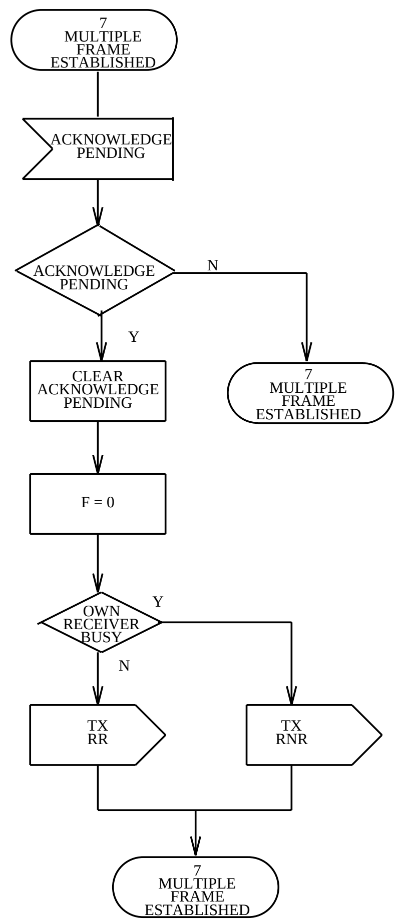


Figure 3.7-6 — Link Layer Point-to-Point: State 7, Multiple Frame Established (8 of 8)

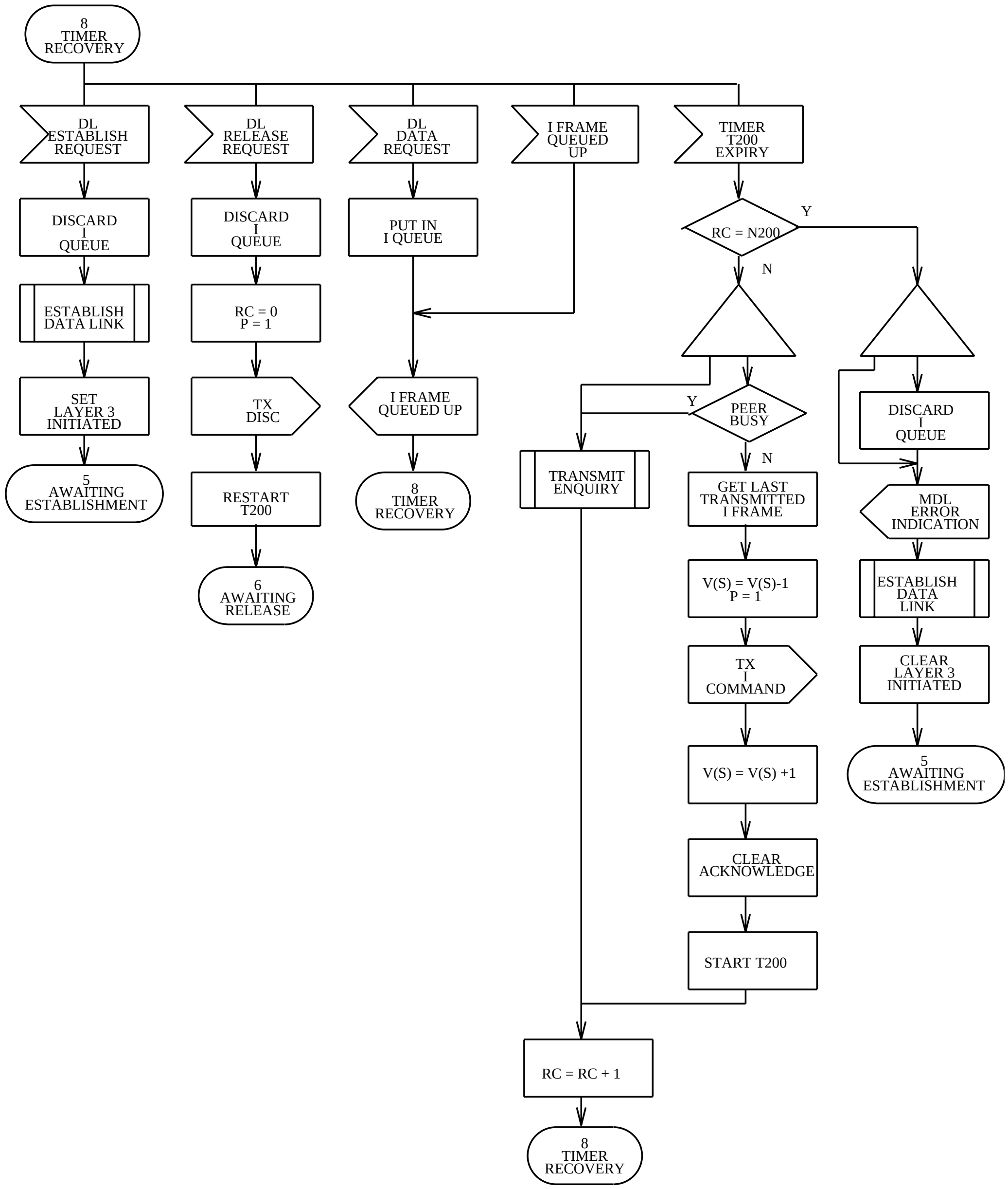


Figure 3.7-7 — Link Layer Point-to-Point: State 8, Timer Recovery (1 of 7)

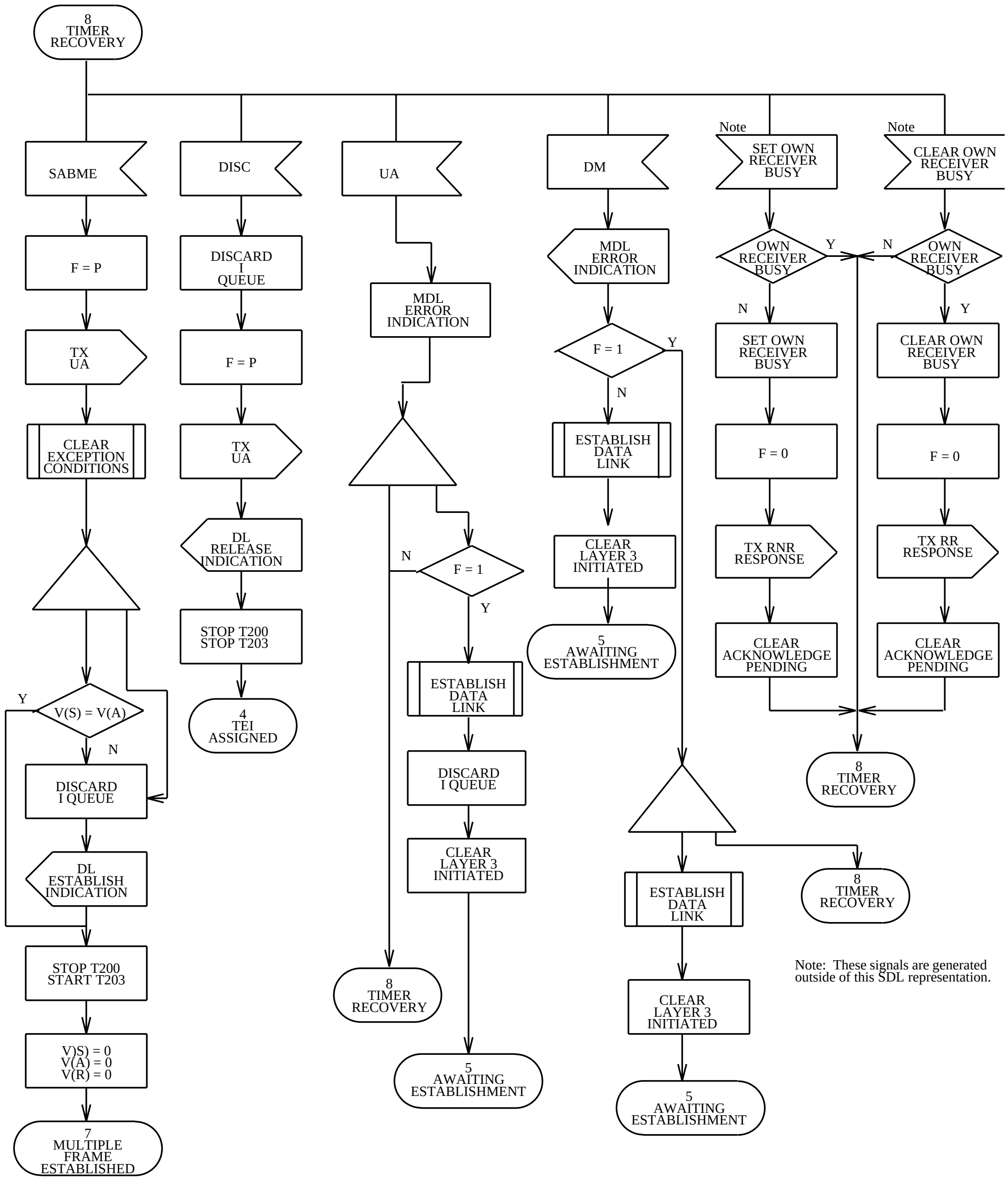


Figure 3.7-7 — Link Layer Point-to-Point: State 8, Timer Recovery (2 of 7)

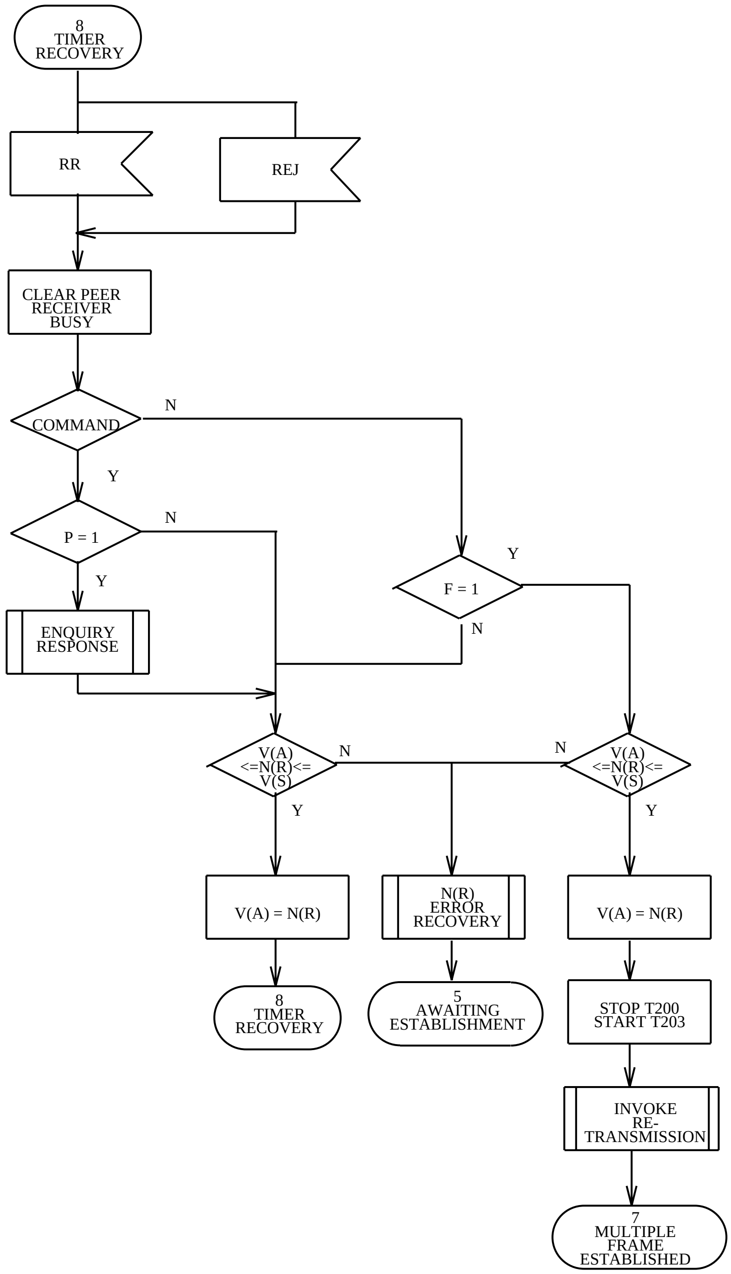


Figure 3.7-7 — Link Layer Point-to-Point: State 8, Timer Recovery (3 of 7)

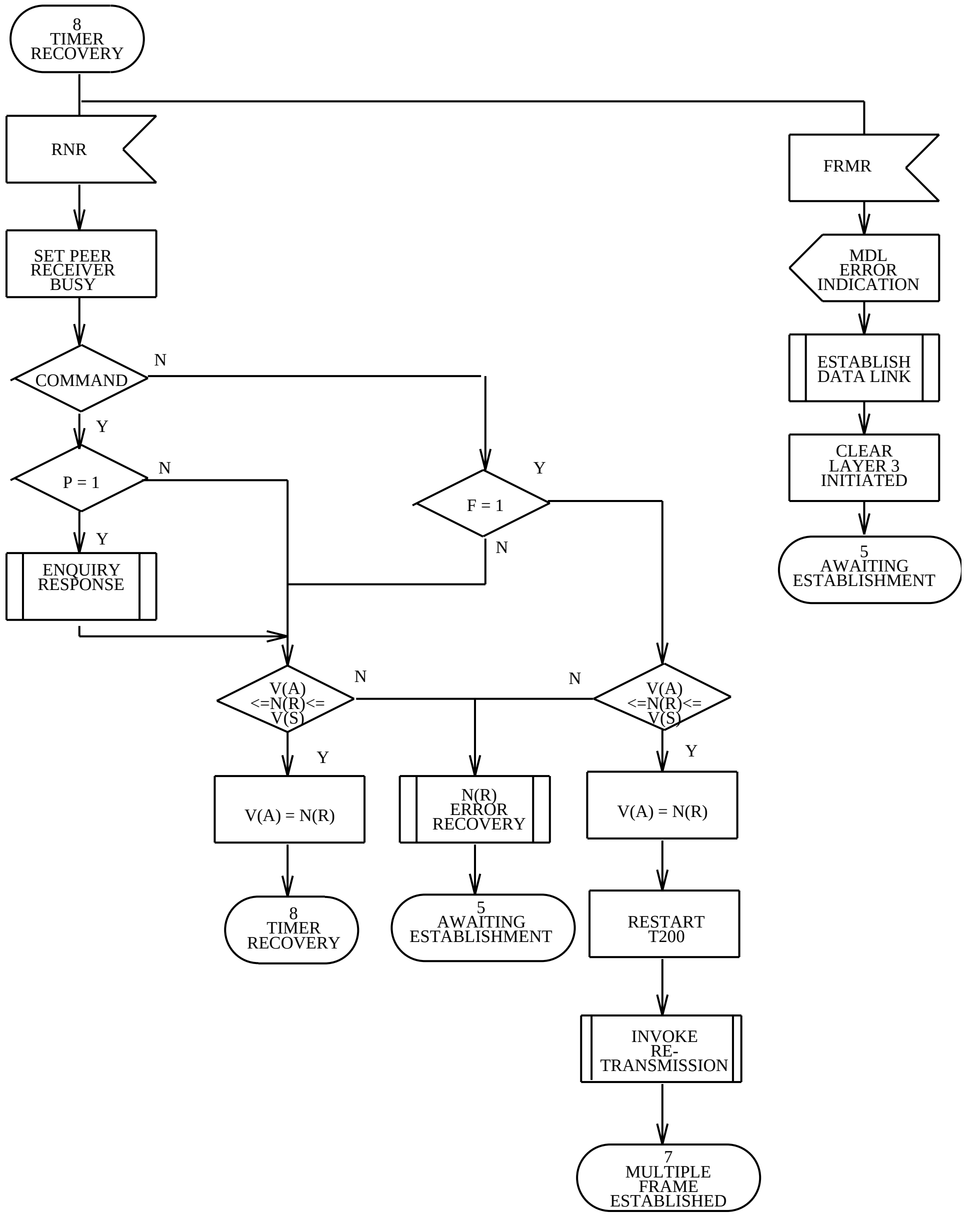


Figure 3.7-7 — Link Layer Point-to-Point: State 8, Timer Recovery (4 of 7)

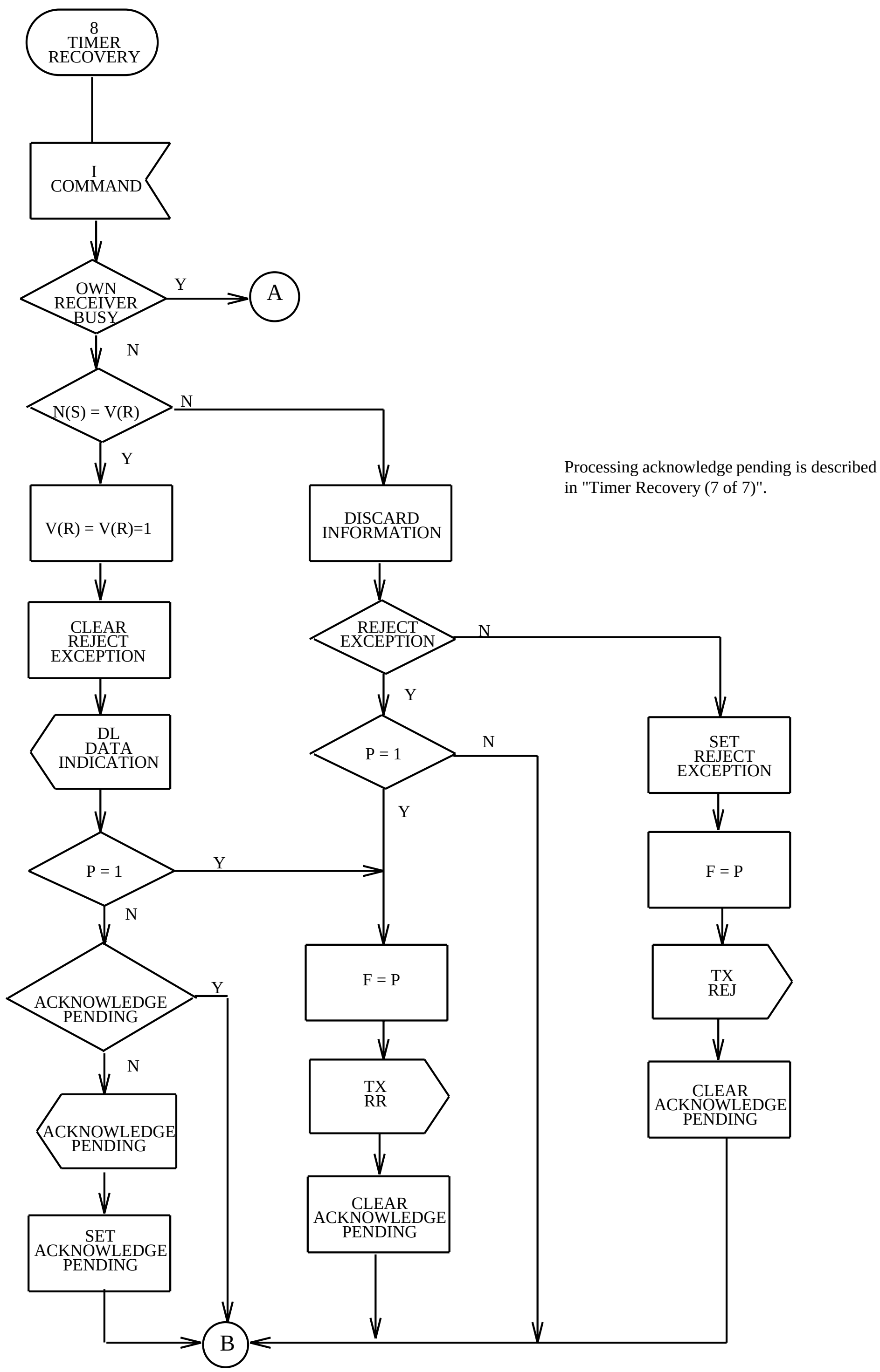


Figure 3.7-7 — Link Layer Point-to-Point: State 8, Timer Recovery (5 of 7)

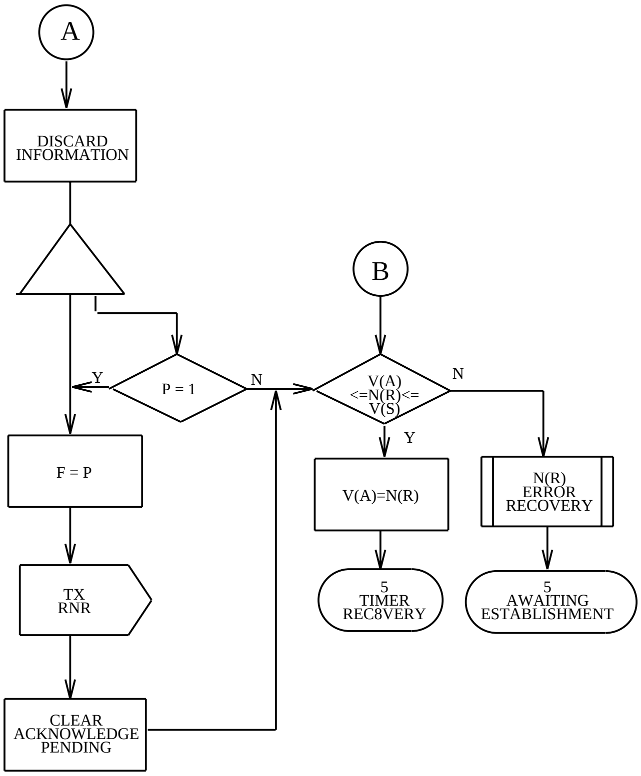


Figure 3.7-7 — Link Layer Point-to-Point: State 8, Timer Recovery (6 of 7)

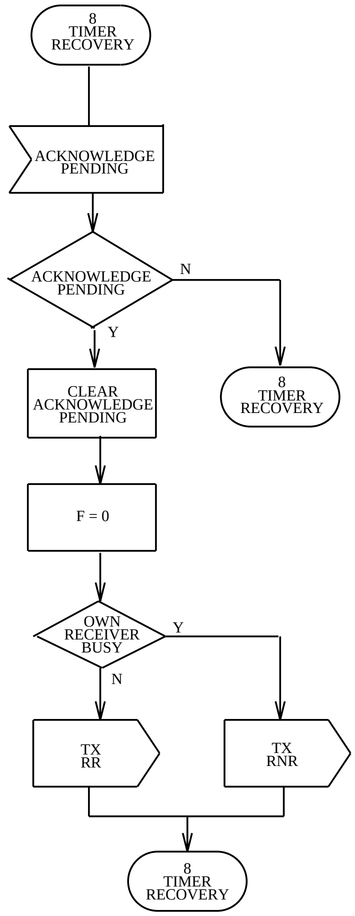
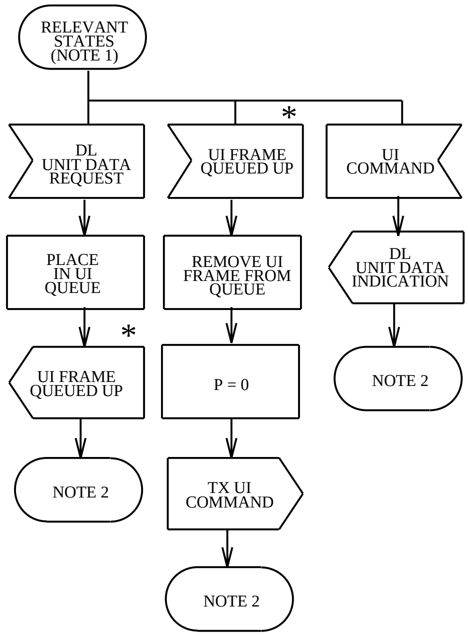


Figure 3.7-7 — Link Layer Point-to-Point: State 8, Timer Recovery (7 of 7)

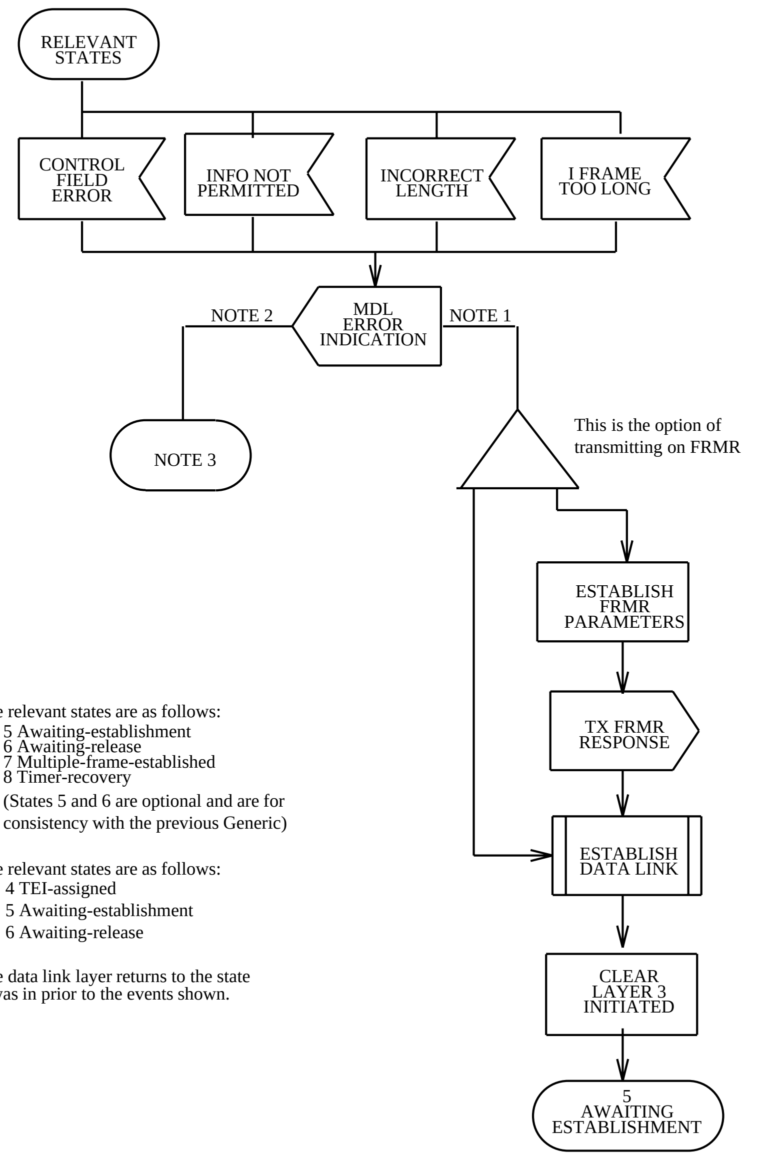


* Unnumbered information transfer on point-to-point data link.

NOTE 1: The relevant states are as follows:
4 TEI-assigned
5 Awaiting-establishment
6 Awaiting-release
7 Multiple-frame-established
8 Timer-recovery

NOTE 2: The data link layer returns to the state it was in prior to the events shown.

Figure 3.7-8 — Link Layer Point-to-Point: Relevant States (1 of 3)



NOTE 1: The relevant states are as follows:
5 Awaiting-establishment
6 Awaiting-release
7 Multiple-frame-established
8 Timer-recovery
(States 5 and 6 are optional and are for consistency with the previous Generic)

NOTE 2: The relevant states are as follows:
4 TEI-assigned
5 Awaiting-establishment
6 Awaiting-release

NOTE 3: The data link layer returns to the state it was in prior to the events shown.

Receiving frame with incorrect formal or frame not implemented (FRMR events)

Figure 3.7-8 — Link Layer Point-to-Point: Relevant States (2 of 3)

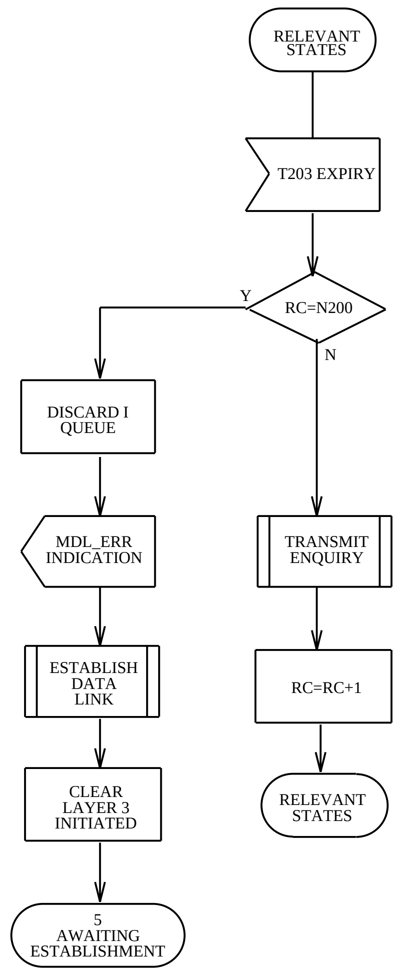


Figure 3.7-8 — Link Layer Point-to-Point: Relevant States (3 of 3)

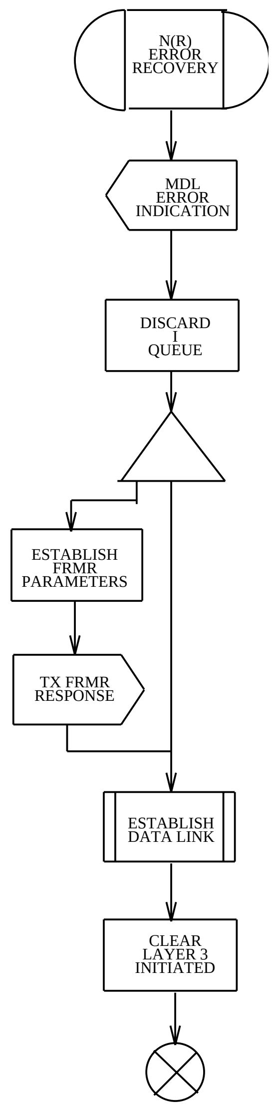


Figure 3.7-9 — Link Layer Point-to-Point: Procedures (1 of 3)

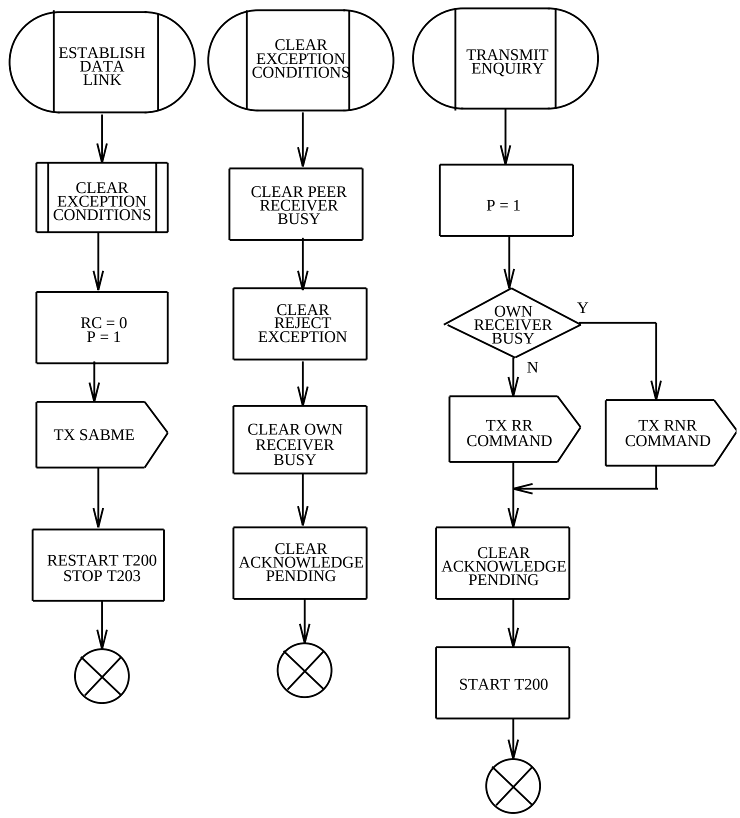
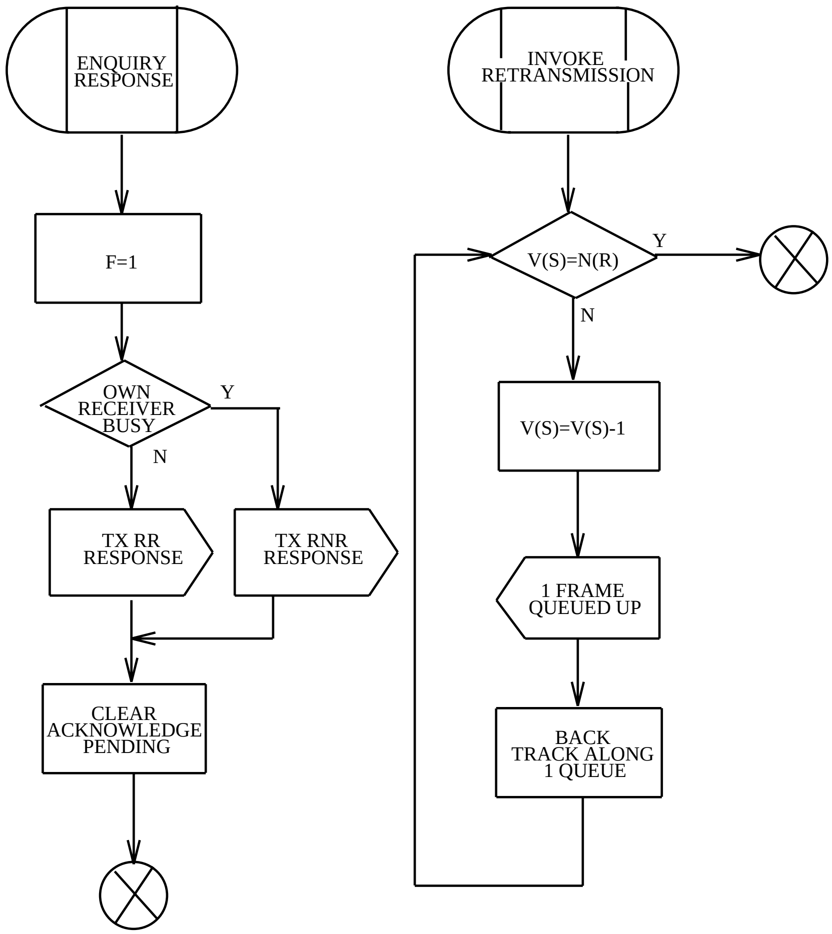


Figure 3.7-9 — Link Layer Point-to-Point: Procedures (2 of 3)



NOTE: The generation of the correct number of signals in order to cause the required retransmission of I frames does not alter their sequence integrity.

Figure 3.7-9 — Link Layer Point-to-Point: Procedures (3 of 3)

References

1. ITU-T Recommendation Q.921 (I.441), “ISDN User-Network Interface Data Link Layer Specification.”
2. ITU-T Recommendation Q.920 (I.440), “ISDN User-Network Interface Data Link Layer—General Aspects.”

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4.4 DATA ELEMENTS. 4.4-1

4. LAYER 3: THE PRI NETWORK INTERFACE LAYER

This chapter is subdivided as follows:

- Section 4.1, “General Information about the Network Interface Layer”
- Section 4.2, “Message Functional Definitions”
- Section 4.3, “Information Elements.”

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4.1 GENERAL INFORMATION ABOUT THE NETWORK INTERFACE LAYER

4.1.1 HISTORY OF SUPPORTED SOFTWARE RELEASES

4.1.1.1 5E11 Software Release

In the 5E11 software release, the Calling Name for ISDN PRI feature and the Call-by-Call (CBC) Service Selection for Hotel/Motel (HM) and Selective Class of Call Screening (SCOCS) feature were introduced for both Custom and National ISDN PRIs. This release supports the following:

- Call associated common element procedures for Privacy of Calling Name (PCN) requests and for Calling Name Delivery (CNAM) to the terminating CPE
- New value for the service discriminator octet (also known as protocol profile) of the facility IE—networking extensions
- Support for receipt of the interpretation and the network facility extensions components in the facility IE
- Support for up to five components in a single facility IE
- Additional national specific cause code value of 53 “service operation violated”
- New facility coding values and support for CBC Service Selection for HM and SCOCS services.

4.1.1.2 5E12 Software Release

In the 5E12 software release, PRI functionality included the following enhancements:

- The size of the called party number IE was increased.
- Rules for populating the type of number and the numbering plan identification fields in the called party number IE were modified to comply further with Bellcore recommendations.

4.1.1.3 5E13 Software Release

In the 5E13 software release, PRI Two B-channel Transfer was introduced, allowing two independent calls on two B-channels of an ISDN PRI to be transferred away from the PRI and connected to each other.

Also during this time frame, cause codes and location indicators were modified to align better with Bellcore recommendations, and a software update made available the PRI Two B-channel Transfer Notification to Controller subscription option on both the National ISDN PRI and the Custom PRI.

4.1.1.4 5E14 Software Release

In the 5E14 software release, the invoke identifier component of the facility information element was expanded, affecting all services. In addition, PRI B-channel Negotiation was introduced for both National ISDN PRI and Custom PRI.

Also during this time frame, software updates made available the Originating Switch Calling Name feature and the PRI Two B-channel Transfer Notification to Controller subscription option on both the National ISDN PRI and the Custom PRI.

Beginning with a software update for 5E14 Feature Release 3, the Codeset 6 generic digits IE is passed to service nodes to identify the type of call origination.

4.1.2 CALL STATES

The following call states are supported by *5ESS*® switch central office (CO) in its implementation of the ISDN PRI.

Call States on Both Sides of the Interface	
Null	State 0
Outgoing Call Proceeding	State 3
Call Delivered	State 4
Call Received	State 7
Connect Request	State 8
Incoming Call Proceeding	State 9
Active	State 10
Disconnect Request	State 11
Disconnect Indication	State 12
Tone Active	State 18
Release Request	State 19

Call States on the Network Side of the Interface Only	
Call Present	State 6

Call States on the User Side of the Interface Only	
Call Initiated	State 1

The following subsections provide brief explanations of the purposes of the call states in the preceding table for both the network side and the user side of the PRI. The procedures for call control are given in “Call Control Procedures,” Section 5. “Symmetrical User SDL Diagrams,” Section 8, contains optional procedures (as an extension to the basic procedures) to allow symmetric signaling.

4.1.2.1 Call States at the User Side of the Interface

The states that can exist on the user side of the user-network interface are defined in this section. The states are prefixed with “U” to signify user side.

1. Null State (U0): No call exists.
2. Call Initiated (U1): This state exists for an outgoing call, when the user requests call establishment from the network.
3. Outgoing Call Proceeding (U3): This state exists for an outgoing call when the user has received acknowledgment that the network has received all call information necessary to effect call establishment.
4. Call Delivered (U4): This state exists for an outgoing call, when the calling user has received an indication that remote user alerting has been initiated.
5. Call Received (U7): This state exists for an incoming call when the user has initiated alerting but has not yet answered.
6. Connect Request (U8): This state exists for an incoming call when the user has answered the call and is waiting to be awarded the call.

7. Incoming Call Proceeding (U9): This state exists for an incoming call when the user has sent acknowledgment that the user has received all call information necessary to effect call establishment.
8. Active (U10): This state exists for an incoming call when the user has received an acknowledgment 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.
9. Disconnect Request (U11): 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.
10. Disconnect Indication (U12): This state exists when the user has received an invitation to disconnect because the network has disconnected the end-to-end connection (if any).
11. Release Request (U19): This state exists when the user has requested the network to release and is waiting for a response.

4.1.2.2 Network Call States

The call states that may exist on the network side of the user-network interface are defined in this section. The states are prefixed with “N” to signify network side.

1. Null State (N0): No call exists.
2. Outgoing Call Proceeding (N3): This state exists for an outgoing call when the network has sent acknowledgment that the network has received all call information necessary to effect call establishment.
3. Call Delivered (N4): This state exists for an outgoing call when the network has indicated that remote user alerting has been initiated.
4. Call Present (N6): This state exists for an incoming call when the network has sent a call establishment request but has not yet received a satisfactory response.
5. Call Received (N7): This state exists for an incoming call when the network has received an indication that the user is alerting but has not yet received an answer.
6. Connect Request (N8): This state exists for an incoming call when the network has received an answer but the network has not yet awarded the call.
7. Incoming Call Proceeding (N9): This state exists for an incoming call when the network has received acknowledgment that the user has received all call information necessary to effect call establishment.
8. Active (N10): This state exists for an incoming call when the network has awarded the call to the called user. This state exists for an outgoing call when the network has indicated that the remote user has answered the call.
9. Disconnect Request (N11): This state exists when the network has received a request from the user to clear the end-to-end connection (if any).
10. Disconnect Indication (N12): This state exists when the network has disconnected the end-to-end connection (if any) and has sent an invitation to disconnect the user-network connection.

11. Release Request (N19): This state exists when the network has requested the user to release and is waiting for a response.

12. Tone Active (N18): This state exists when a network disconnect request is received (the call establishment attempt failed) and the network desires to play an announcement or a tone.

4.1.3 LAYER 3 MESSAGES AND INFORMATION ELEMENTS

This part of the specification defines the Layer 3 protocol options and service-related procedures that will be supported by the *5ESS* switch in the implementation of the ISDN PRI. Also detailed in the following sections will be any implementation options supported by *5ESS* switch that affect call control procedures. These implementation options include, but are not limited to, procedures for accessing features and services supported by *5ESS* switch over a PRI.

4.1.4 MESSAGES

4.1.4.1 General Message Format

Within this protocol, every message shall consist of the following parts:

a. protocol discriminator

b. call reference

c. message type

d. other IEs, as required

IEs a, b, and c are common to all the messages and shall always be present; d IEs are specific to each message type.

This organization is illustrated in the example shown in Figure 4.1-1.

8	7	6	5	4	3	2	1	
Protocol discriminator								Octet 1
0	0	0	0	Length of call reference value (in octets)				2
Call reference value [octet(s)]								3, 3a
0	Message type							4
Other information elements as required								etc.

Figure 4.1-1 — General Message Organization Example

Within each octet, the bit designated Bit 1 is transmitted first, followed by Bits 2, 3, 4, and so forth. Similarly, the octets are sent in the order shown in the figure, that is, Octet 1 is sent first, followed by Octet 2, and so forth.

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

Unless specified otherwise, a particular IE may be 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.

When a field, such as the call reference value, 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 the field.

4.1.4.2 Summary of Messages

The following messages are used in circuit-mode connections:

Call Establishment Messages:

ALERTING
CALL PROCEEDING
CONNECT
CONNECT ACKNOWLEDGE
PROGRESS
SETUP

Call Clearing Messages:

DISCONNECT
RELEASE
RELEASE COMPLETE
RESTART
RESTART ACKNOWLEDGE

Miscellaneous Messages:

NOTIFY
STATUS
STATUS ENQUIRY
FACILITY

The following messages are covered in “Maintenance Capabilities and Procedures,” Section 9.

Maintenance Messages:

SERVICE
SERVICE ACKNOWLEDGE

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4.2 MESSAGE FUNCTIONAL DEFINITIONS

The following sections present a brief summary of each message used in call control. The summary includes:

- a list, in order of appearance, of the IEs allowed in that message
- an indication whether the IE is mandatory or optional in that message, “M” or “O”, respectively
- the associated length, in octets, of those IEs.

4.2.1 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. See Table 4.2-1.

Table 4.2-1 — ALERTING Message

INFORMATION ELEMENT	DIRECTION	TYPE	LENGTH
Protocol Discriminator	both	M	1
Call Reference	both	M	2-3
Message Type	both	M	1
Channel Identification	both	O[a]	4-8
Progress Indicator	both	O[b]	4
Redirecting Number	both	O	[c]
User-User	both	O	[c]
Locking Shift to Codeset 7	both	O	1
User-Specific (Codeset 7)	both	O	[c]

Note(s):
a. The Channel Identification IE is present only if this is the first response to the SETUP message.
b. Included in the event of interworking or in connection with the provision of in-band information/patterns.
c. The sum of the lengths of these IEs plus that of the Locking Shift to Codeset 7, if present, must be no more than 64 octets.

Message type: ALERTING
Direction: both

4.2.2 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 will be accepted. See Table 4.2-2.

Table 4.2-2 — CALL PROCEEDING Message

INFORMATION ELEMENT	DIRECTION	TYPE	LENGTH
Protocol Discriminator	both	M	1
Call Reference	both	M	2-3
Message Type	both	M	1
Channel Identification	both	M	4-8

Message type: CALL PROCEEDING
Direction: both

4.2.3 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. See Table 4.2-3.

Table 4.2-3 — CONNECT Message

INFORMATION ELEMENT	DIRECTION	TYPE	LENGTH
Protocol Discriminator	both	M	1
Call Reference	both	M	2-3
Message Type	both	M	1
Connected Number	both	O	[c]
Channel Identification	both	O[a]	4-8
Progress Indicator	n -> u	O[b]	4
Redirecting Number	both	O	[c]
User-User	both	O	[c]
Locking Shift to Codeset 7	both	O	1
User-Specific (Codeset 7)	both	O	[c]

Note(s):

a. The Channel Identification information element will be present only if this was the first response to a SETUP message.

b. The Progress Indicator information element is included if the terminating interface is non-ISDN line.

c. The sum of the lengths of these IEs plus that of the Locking Shift to Codeset 7, if present, must be no more than 64 octets.

Message type: CONNECT
Direction: both

4.2.4 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. See Table 4.2-4.

Message type: CONNECT ACKNOWLEDGE
Direction: both

Table 4.2-4 — CONNECT ACKNOWLEDGE Message

INFORMATION ELEMENT	DIRECTION	TYPE	LENGTH
Protocol Discriminator	both	M	1
Call Reference	both	M	2-3
Message Type	both	M	1

Message type: CONNECT
Direction: both

4.2.5 DISCONNECT

This message is sent by the user to request the network to clear an end-to-end connection or by the network to indicate that the end-to-end connection is cleared. See Table 4.2-5.

Table 4.2-5 — DISCONNECT Message

INFORMATION ELEMENT	DIRECTION	TYPE	LENGTH
Protocol Discriminator	both	M	1
Call Reference	both	M	2-3
Message Type	both	M	1
Cause	both	M	[a]
Facility	both	O	[b]
User-User	both	O	[c]
Locking Shift to Codeset 7	both	O	1
User-Specific (Codeset 7)	both	O	[c]

Note(s):

a. The system accepts messages with Cause IEs with a minimum of 4 octets, but discards information beyond Octets 4 or 5 on the Custom or National ISDN PRI, respectively.

b. The length of the Facility IE is 4-240 but it may not overflow the maximum length of the message.

c. The sum of the lengths of these IEs plus that of the Locking Shift to Codeset 7, if present, must be no more than 64 octets.

Message type: DISCONNECT
Direction: both

4.2.6 FACILITY

This message is sent by the user or the network to pass information during stable calls. See Table 4.2-6.

Table 4.2-6 — FACILITY Message

INFORMATION ELEMENT	DIRECTION	TYPE	LENGTH
Protocol Discriminator	both	M	1
Call Reference	both	M	2-3
Message Type	both	M	1
Facility	both	M	3-240

Message type: FACILITY
Direction: both

4.2.7 NOTIFY

This message is sent by the network to the user to notify the user of an event that is independent of any call that may exist on the PRI. The network may send up to two Notification Indicator IEs in a NOTIFY message. See Table 4.2-7.

Table 4.2-7 — NOTIFY Message

INFORMATION ELEMENT	DIRECTION	TYPE	LENGTH
Protocol Discriminator	n -> u	M	1
Call Reference (NULL)	n -> u	M	1
Message Type	n -> u	M	1
Notification Indicator[a]	n -> u	M	[b]

Note(s):
a. The switch may send up to two Notification Indicator IEs per NOTIFY message.
b. The length of the Notification Indicator IE is 3-255 but it may not overflow the maximum length of the message.

Message type: NOTIFY
Direction: Network to user

4.2.8 PROGRESS

This message is sent by the user or the network to indicate the progress of a call in the event of interworking or in relation with the provision of in-band information patterns. See Table 4.2-8.

Table 4.2-8 — PROGRESS Message

INFORMATION ELEMENT	DIRECTION	TYPE	LENGTH
Protocol Discriminator	both	M	1
Call Reference	both	M	2-3
Message Type	both	M	1
Cause	both	O	[a]
Progress Indicator	both	M	4
Progress Indicator	n -> u	[b]	4

Note(s):
a. The system accepts messages with Cause IEs with a minimum of 4 octets, but discards information beyond Octets 4 or 5 on the Custom or National ISDN PRI, respectively.
b. The second Progress Indicator IE is present if there is excessive call delay at the terminating interface.

Message type: PROGRESS
Direction: both

4.2.9 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. See Table 4.2-9.

Table 4.2-9 — RELEASE Message

INFORMATION ELEMENT	DIRECTION	TYPE	LENGTH
Protocol Discriminator	both	M	1
Call Reference	both	M	2-3
Message Type	both	M	1
Cause[a]	both	O	[b]
Facility	both	O	[c]

Note(s):
a. The Cause IE is mandatory if this is the first clearing message.
b. The system accepts messages with Cause IEs with a minimum of 4 octets, but discards information beyond Octets 4 or 5 on the Custom or National ISDN PRI, respectively.
c. The length of the Facility IE is 3-240 but it may not overflow the maximum length of the message.

Message type: RELEASE
Direction: both

4.2.10 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 shall release the call reference. See Table 4.2-10.

Table 4.2-10 — RELEASE COMPLETE Message

INFORMATION ELEMENT	DIRECTION	TYPE	LENGTH
Protocol Discriminator	both	M	1
Call Reference	both	M	2-3
Message Type	both	M	1
Cause[a]	both	O	[b]
Facility	both	O	[c]

Note(s):

a. The Cause IE is mandatory if this is the first clearing message.

b. The system accepts messages with Cause IEs with a minimum of 4 octets, but discards information beyond Octets 4 or 5 on the Custom or National ISDN PRI, respectively.

c. The length of the Facility IE is 3-240 but it may not overflow the maximum length of the message.

Message type: RELEASE COMPLETE
Direction: both

4.2.11 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 RESTART message is used on the National ISDN PRI to initialize B-channels to an in-service state. (See “B-channel Maintenance Procedures for National ISDN PRI,” Section 9.3.2.) See Table 4.2-11.

Table 4.2-11 — RESTART Message

INFORMATION ELEMENT	DIRECTION	TYPE	LENGTH
Protocol Discriminator	both	M	1
Call Reference	both	M	2
Message Type	both	M	1
Channel Identification	both	O	4-8[a]
Restart Indicator	both	M	3

Note(s):

a. In the incoming direction, for interface restart, the Channel Identification can be 3 octets long.

Message type: RESTART
Direction: both

4.2.12 RESTART ACKNOWLEDGE

This message is sent to acknowledge the receipt of a RESTART message and to indicate that the requested restart is complete. Table 4.2-12 shows the RESTART ACKNOWLEDGE message.

Table 4.2-12 — RESTART ACKNOWLEDGE Message

INFORMATION ELEMENT	DIRECTION	TYPE	LENGTH
Protocol Discriminator	both	M	1
Call Reference	both	M	2
Message Type	both	M	1
Channel Identification	both	O	4-8[a]
Restart Indicator	both	M	3

Note(s):
a. In the incoming direction, for interface restart, the Channel Identification can be 3 octets long.

Message type: RESTART ACKNOWLEDGE
Direction: both

4.2.13 SETUP

This message is sent by the calling user to the network and by the network to the called user to initiate call establishment. See Table 4.2-13.

Table 4.2-13 — SETUP Message

INFORMATION ELEMENT	DIRECTION	TYPE	LENGTH
Protocol Discriminator	both	M	1
Call Reference	both	M	2-3
Message Type	both	M	1
Bearer Capability	both	M	4-6
Channel Identification	both	M	4-8
Facility	both	O	[a]
Progress Indicator	n -> u	O[b]	4
Network Specific Facilities	both	O	4-14
Calling Party Number	both	O[c]	3-19
Called Party Number	both	M	3-21
Redirecting Number	both	O	[d]
Transit Network Selection	both	O[e]	6-7
Low Layer Compatibility	both	O	[d]
User-User	both	O	[d]
Locking Shift to Codeset 5	both	O	1
Precedence Level Information	both	O[f]	7
Locking Shift to Codeset 6	both	O	1
Generic Digits	n -> u	O	4
User-Entered Code	both	O	4-18
Traveling Class Mark	both	O	6
Locking Shift to Codeset 7	both	O	1
User-Specific (Codeset 7)	both	O	[d]

Note(s):

a. The length of the Facility IE is 3-240 but it may not overflow the maximum length of the message.

b. Progress Indicator IE is present if the incoming call has originated from a non-ISDN source.

c. Inclusion of the Calling Party Number (CgPN) is recommended on all E911 calls for the service to be provided as intended.

d. The sum of the lengths of these IEs plus that of the Locking Shift to Codeset 7, if present, must be no more than 64 octets. The length of the Low Layer Compatibility IE must be between 4 and 16 bytes.

e. The Transit Network Selection (TNS) IE is present to request access to an interexchange carrier. In the Custom PRI, if both Network Specific Facility (NSF) and TNS are present in a SETUP message, the carrier code specified in the NSF IE will take precedence. For the National ISDN PRI, see “PRI Service-Specific Information” Section 11.

f. Element for the MLPP feature.

Message type: SETUP
Direction: both

4.2.14 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 certain error conditions. See Table 4.2-14.

Table 4.2-14 — STATUS Message

INFORMATION ELEMENT	DIRECTION	TYPE	LENGTH
Protocol Discriminator	both	M	1
Call Reference	both	M	2-3
Message Type	both	M	1
Cause	both	M	[a]
Call State	both	M	3

Note(s):
a. The system accepts messages with Cause IEs with a minimum of 4 octets, but discards information beyond Octets 4 or 5 on the Custom or National ISDN PRI, respectively.

Message type: STATUS
Direction: both

4.2.15 STATUS ENQUIRY

This message is sent by the user or the network at any time to solicit a STATUS message from the peer Layer 3 entity. Sending a STATUS message in response to a STATUS ENQUIRY message is mandatory. See Table 4.2-15.

Table 4.2-15 — STATUS ENQUIRY Message

INFORMATION ELEMENT	DIRECTION	TYPE	LENGTH
Protocol Discriminator	both	M	1
Call Reference	both	M	2-3
Message Type	both	M	1

Message type: STATUS ENQUIRY
Direction: both

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4.3 INFORMATION ELEMENTS

4.3.1 COMMON INFORMATION ELEMENTS

The following IEs are present in all messages: protocol discriminator, call reference, and message type.

4.3.1.1 Protocol Discriminator

The purpose of the protocol discriminator is to distinguish messages for user-network call control from other messages such as maintenance messages. The protocol discriminator is the first part of every message.

Note: A protocol discriminator field is also included in the user-user IE to indicate the user protocol within the user information. Table 4.3-1 shows the protocol discriminator IE layout.

Table 4.3-1 — Protocol Discriminator Information Element Layout

OCTET	FIELD	BITS	VALUE	MEANING
1	Protocol Discriminator	8-1	00001000	Q.931[a] user-network call control messages
			00000011	Custom PRI maintenance messages
			01000011	National ISDN PRI maintenance messages
Note(s): a. Also includes Q.932 supplementary services messages.				

4.3.1.2 Call Reference

The purpose of the call reference is to identify the call or facility registration/cancellation request at the local user-network interface to which the particular message applies. The call reference does not have end-to-end significance across ISDNs. The call reference is the second part of every message.

Except in the case of the null call reference, whose coding is displayed in Table 4.3-3, the call reference element may be two or three octets long. A two-octet global call reference IE is coded with the first octet “0000 0001” and the second octet “F000 0000,” where F is the call reference flag. The three-octet global call reference IE is coded first octet “0000 0010,” second octet “F000 0000,” and third octet “0000 0000.” The equipment receiving a message containing the global call reference should interpret the message as pertaining to all call references associated with the appropriate datalink connection identifier.

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 lifetime of a call. After 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 pertains to a call originated at opposite ends of the link.

All endpoints must recognize call reference values of 0 to 32767, but may place an upper limit on the number of simultaneous active call references for any D-channel. The upper limit is an implementation option.

The call reference flag can take the values “0” or “1”. The call reference flag is used to identify which end of the Layer 2 logical link originated a call reference. The origination side always sets the call reference flag to “0”. The destination side always sets the call reference flag to “1”.

Hence, the call reference flag identifies who allocated the call reference value for this call. The only purpose of the call reference flag is to resolve simultaneous attempts to allocate the same call reference value.

If in the case of RESTART and RESTART ACKNOWLEDGE, when the channel identification IE is included, equipment receiving such a message shall interpret the message as pertaining to all call references associated with the channel or interface specified in the channel identification IE. When the channel identification IE is absent, the message shall be interpreted as pertaining to the interface containing the D-channel. Table 4.3-2 shows the call reference IE layout.

Table 4.3-2 — Call Reference Information Element Layout

OCTET	FIELD	BITS	VALUE	MEANING
1	Reserved	8-5	0000	Zero value expected
	Length	4-1	binary	Length of call reference value (in octets)
2	Flag	8	0	Message sent from side that originates call reference
			1	Message sent to side that originates call reference
	Value	7-1	binary	Call reference value
3	Value	8-1	binary	Call reference value

The null call reference is coded as shown in Table 4.3-3.

Table 4.3-3 — Null Call Reference

8 7 6 5	4 3 2 1	
0 0 0 0	0 0 0 0 Length	Octet 1

4.3.1.3 Message Type

The purpose of the message type is to identify the function of the message being sent. Table 4.3-4 shows the Message type IE layout.

Table 4.3-4 — Message Type Information Element Layout

OCTET	CLASS BITS 8-6	MESSAGE BITS 5-1	MESSAGE NAME	CLASS TYPE
1	000	00001	ALERTING	Call Establishment
		00010	CALL PROCEEDING	
		00111	CONNECT	
		01111	CONNECT ACKNOWLEDGE	
		00011	PROGRESS	
		00101	SETUP	
	010	00101	DISCONNECT	Call Disestablishment
		01101	RELEASE	
		11010	RELEASE COMPLETE	
		00110	RESTART	
		01110	RESTART ACKNOWLEDGE	
	011	00010	FACILITY	Miscellaneous
		01110	NOTIFY	
		11101	STATUS	
		10101	STATUS ENQUIRY	
	000	01111	SERVICE	Maintenance
		00111	SERVICE ACKNOWLEDGE	

4.3.2 SUMMARY OF MESSAGE-DEPENDENT ELEMENTS

The following IEs are present in some messages and are not present in other messages, as indicated in “Message Functional Definitions,” Section 4.2.

Table 4.3-5 — Information Elements

Single-octet information elements:
Locking Shift
The following IEs are listed in alphabetical order, the same order as used in the detailed layouts that follow.

Variable length information elements:
Bearer Capability
Call State
Called Party Number
Calling Party Number
Cause
Channel Identification
Connected Number
Facility
Generic Digits (Codeset 6)
Low Layer Compatibility
Network Specific Facilities
Notification Indicator
Precedence Level (Codeset 5)
Progress Indicator
Redirecting Number
Restart Indicator
Transit Network Selection
Traveling Class Mark (Codeset 6)
User-Entered Code (Codeset 6)
User-Specific in Codeset 7
User-User

4.3.3 INFORMATION ELEMENT LAYOUTS

4.3.3.1 Information Element Coding

The coding of other IEs follows the coding rules described in the following paragraphs. These rules are formulated to allow each piece of equipment that processes a message to find IEs important to it, and yet remain ignorant of IEs not important to that equipment.

Two categories of IEs are defined:

a. Single octet IEs.
Single octet IEs may appear at any point in the message.

b. Variable length IEs.
The order of appearance of the variable length IEs in a message is according to ascending numerical order of the code values of the IE identifier. This allows the

receiving equipment to detect the presence or absence of a particular IE without scanning through an entire message.

An optional variable-length IE may be present, but empty. This should be interpreted by the receiver as equivalent to that IE being absent. Similarly, an absent IE should be interpreted by the receiver as equivalent to that IE being empty.

The layout of a single octet IE is given in Figure 4.3-1.

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

Figure 4.3-1 — Single Octet Information Element Format

The IE identification is in bit positions 7, 6, 5.

The layout of a variable length IE is given in Figure 4.3-2.

8	7	6	5	4	3	2	1	
0	Information element identifier							Octet 1
Length of contents of information element (octets)								2
Contents of information element								3 etc.

Figure 4.3-2 — Variable Length Information Element Format

The following rules apply for the coding of variable length IEs such as Octet 3:

a. The first digit in the octet number identifies one octet or a group of octets.

b. Each octet group is a self contained entity. The internal structure of an octet group may be defined in alternative ways.

c. An octet group is formed by using some extension mechanism. The preferred extension mechanism is to extend an octet (N) through the next octet(s) (Na, Nb, and so forth) by using Bit 8 in each octet as an extension bit. The bit value “0” indicates that the octet continues through the next octet. The bit value “1” indicates that this octet is the last octet. If one octet (Nb) is present, also the preceding octets (N and Na) must be present.

d. In addition to the extension mechanism defined previously, an octet (N) may be extended through the next octet(s) (N.1, N.2, and so forth) by indications in Bits 7-1 (of octet N).

e. The mechanisms in c and d may be combined.

4.3.3.2 Codesets

According to the convention that Bit 8 determines whether the element is continued to the next octet, it follows that single octet IEs are coded with a 1 in Bit 8 of the IE identifier and multiple octet (or variable length) IEs are coded with a 0 in Bit 8. The number of possible variable-length IE identifier values, based on the remaining 7 bits, is 128. By using one of the single octet IEs to define different codesets, and a mechanism to shift from one codeset to another, one can expand the number of IEs beyond 128.

The following convention is used. The codeset in use at any given time is referred to as the “active codeset.” Codeset 0 is the initially active codeset. That is, initially the IEs in any message are considered to be from Codeset 0. Transitions to a different codeset are effected by interposing a locking shift IE after the last Codeset 0 IE, and before the IEs from the next codeset. The locking shift IE changes the active codeset.

From the structure of the locking shift IE, as shown in the following list, there are 8 possible codesets. The specified codeset remains active until another locking shift IE that specifies the use of another codeset is encountered. For example, Codeset 0 is active at the start of message content analysis. If a locking shift to Codeset 6 is encountered, the next IEs will be interpreted according to the IE identifiers assigned in Codeset 6, until another shift IE is encountered.

This procedure is used only to shift to a higher order codeset than the one being left.

The locking shift is valid only within the message that contains the locking shift IE. At the start of every message content analysis, the active codeset is Codeset 0.

The following codesets are recognized:

- Codeset 0, the default initial codeset. The set of IEs from Codeset 0 that are recognized by the *5ESS*® switch are those not indicated as belonging to another codeset in Table 4.3-5.
- Codeset 5, which is provided for national specific IEs, contains the precedence level IE.
- Codeset 6, which is reserved for IEs specific to the local network (either public or private). As such they do not have significance across the boundaries between local networks, or across a national, or international boundary. Therefore, Codeset 6 IEs shall be handled according to the procedures for unrecognized IEs. The Codeset 6 IEs that are supported by the *5ESS* switch are the user-entered code IE, the traveling class mark IE, and the generic digits IE.
- Codeset 7, which is reserved for user-specific IEs. Codeset 7 IE shall be handled according to the procedures for unrecognized IEs by the first exchange in the local network, unless allowed by a future service definition, bilateral agreement, or provision is made to support this across the local network for a specific user.

A user or network equipment must have the capability to recognize a shift IE and to determine the length of the following IE, although the equipment need not be able to interpret and act upon the content of the IE. This enables the equipment to determine the start of a subsequent IE.

4.3.3.3 Layouts of Specific Information Elements

4.3.3.3.1 Locking Shift

The locking shift is supported to shift to Codesets 5, 6, and 7. The locking shift can occur only after the last IE in Codeset 0. When multiple locking shifts occur within the same message, the codesets must occur in increasing value (that is, Codeset 6 must occur before Codeset 7). After the locking shift IE, one or more IEs pertaining to the designated codeset may follow.

The locking shift applies only within the message that contains the locking shift IE. As each succeeding message is analyzed, Codeset 0 is the initially active codeset. See Table 4.3-6 for the layout of the locking shift IE.

Table 4.3-6 — Locking Shift Information Element Layout

OCTET	FIELD	BITS	VALUE	MEANING
1	Extension	8	1	Last octet of description
	Information Element Identifier	7-5	001	Shift identifier
	Shift Type	4	0	Locking type
	New Codeset Identification	3-1	101	Codeset 5—National-Specific information elements
			110	Codeset 6—Network Specific information elements
			111	Codeset 7—User-Specific information elements

4.3.3.4 Bearer Capability

The purpose of the bearer capability IE is to indicate a requested ITU-T Recommendation I.231 bearer service to be provided for the call by the network, or to indicate the bearer service required on calls passing to the user over the network. The maximum length of this IE is 8 octets when International Telecommunications Union-Telecommunication Standardization Sector (ITU-TS) standard coding is used.

The bearer capability IE is structured differently for narrowband (64-kbps), wideband fixed rates (384-kbps and 1536-kbps), and wideband multirate information transfer rates. Therefore, separate layout tables are shown for narrowband, wideband fixed rates, and wideband multirates. The Tables 4.3-7, 4.3-8, and 4.3-9 show the codings that are meaningful in the three cases.

Table 4.3-7 — Bearer Capability Information Element Layout-Narrowband Information Transfer Rate

OCTET	FIELD	BITS	VALUE	MEANING
1	Extension	8	0	Multiple octet element
	Information Element Identifier	7-1	0000100	Bearer Capability
2	Length	8-1	binary	Length of information element contents
3	Extension	8	1	Last octet of the description
	Coding Standard	7-6	00	ITU-TS standardized coding
	Information Transfer Capability (ITC)	5-1	00000	Speech
			01000	Unrestricted digital information[a]
			01001	Restricted digital information
			10000	3.1-kHz audio (modem)
4	Extension	8	0	Description extended through next octet
			1	Last octet of the description
	Transfer Mode	7-6	00	Circuit mode
	Information Transfer Rate	5-1	10000	64 kbps
4a[b]	Extension	8	1	Last octet of the description
			0	Description extended through next octet
	Structure	7-5	000	Default (that is, 8-kHz integrity)
	Configuration	4-3	00	Point-to-point
	Establishment	2-1	00	Demand
4b[c]	Extension	8	1	Last octet of the description
	Symmetry	7-6	00	Bidirectional symmetrical
	Information Transfer Rate	5-1		Field must be coded same as in Octet 4
5[d]	Extension	8	0	Description extended through next octet
			1	Last octet of the description
	Layer Identification	7-6	01	Layer 1
	Protocol Identification	5-1	00001	ITU-TS rate adaption V.110/X.30
			00010	ITU-T Recommendation G.711 μ-law speech
5a	Extension	8	1	Last octet of the description
			0	Description extended through next octet

See note(s) at end of table.

Table 4.3-7 — Bearer Capability Information Element Layout-Narrowband Information Transfer Rate (Contd)

OCTET	FIELD	BITS	VALUE	MEANING
	Synchronous/ Asynchronous	7	0	Synchronous
	Spare	6	0	Spare
	User Rate	5-1	01111	56 kbps ITU-T Recommendation V.110 (I.463)

Note(s):

a. If ITC in Octet 3 is coded unrestricted digital information, then Octet 5 is not coded.

b. Octet 4a is optional. The values are not checked if they are provided.

c. Octet 4b is optional. The values are checked if they are provided.

d. For µ-law speech protocol identification, the extension bit must be set to 1, and Octet 5a is not coded. For rate adaption consistent with ITU-T Recommendations V.110 (I.463) / X.30, the extension bit is set to 0, and Octet 5a is coded.

Table 4.3-8 — Bearer Capability Information Element Layout-Wideband Fixed Information Transfer Rates

OCTET	FIELD	BITS	VALUE	MEANING
1	Extension	8	0	Multiple octet element
	Information Element Identifier	7-1	0000100	Bearer Capability
2	Length	8-1	binary	Length of information element contents
3	Extension	8	1	Last octet of the description
	Coding Standards	7-6	00	ITU-TS Standardized Coding
	Information Transfer Capability (ITC)[a]	5-1	01000	Unrestricted digital information
4	Extension	8	0	Description extended through next octet
			1	Last octet of the description
	Transfer Mode	7-6	00	Circuit mode
	Information Transfer Rate (ITR)	5-1	10011	384 kbps (fixed rate)
			10101	1536 kbps (fixed rate)
4a[b]	Extension	8	1	Last octet of the description
			0	Description extended through next octet
	Structure	7-5	000	Default (that is, 8-kHz integrity)
	Configuration	4-3	00	Point-to-point
	Establishment	2-1	00	Demand
4b[c]	Extension	8	1	Last octet of the description
	Symmetry	7-6	00	Bidirectional symmetrical
	Information Transfer Rate	5-1		Field must be coded same as in Octet 4

Note(s):

a. For wideband fixed rate ITRs, 384-kbps and 1536-kbps, only unrestricted digital information ITC is allowed.

b. Octet 4a is optional and is not used. The values are not checked if they are provided.

c. Octet 4b is optional. The values are checked if they are provided but are not used.

Table 4.3-9 — Bearer Capability Information Element Layout-Wideband Multirate Information Transfer Rates

OCTET	FIELD	BITS	VALUE	MEANING
1	Extension	8	0	Multiple octet element
	Information Element Identifier	7-1	0000100	Bearer Capability
2	Length	8-1	binary	Length of information element contents
3	Extension	8	1	Last octet of the description
	Coding Standards	7-6	00	ITU-TS Standardized Coding
	Information Transfer Capability (ITC)[a]	5-1	01000	Unrestricted digital information
4 (ITR)	Extension	8	0	Description extended through next octet
			1	Last octet of the description
	Transfer Mode	7-6	00	Circuit mode
	Information Transfer Rate	5-1	11000	Multirate (MR) 64-kbps base rate
4a[b]	Extension	8	1	Last octet of the description
			0	Description extended through next octet
	Structure	7-5	000	Default (that is, 8-kHz integrity)
	Configuration	4-3	00	Point-to-point
	Establishment	2-1	00	Demand
4b[c]	Extension	8	1	Last octet of the description
	Symmetry	7-6	00	Bidirectional symmetrical
	Information Transfer Rate	5-1		Field must be coded same as in Octet 4
5	Extension	8	1	Last octet of the description
	Transfer Rate Multiplier (required when ITR = MR)	7-1	0000010	N = 2 (128 kbps)
			0000011	N = 3 (192 kbps)
			.	.
			.	.
			binary N	N = 2, ... , 24 (N X 64 kbps)
			.	.

See note(s) at end of table.

Table 4.3-9 — Bearer Capability Information Element Layout-Wideband Multirate Information Transfer Rates (Contd)

OCTET	FIELD	BITS	VALUE	MEANING
			.	.
			0011000	N = 24 (1536 kbps)

Note(s):

a. For wideband multirate ITR, only unrestricted digital information ITC is allowed.

b. Octet 4a is optional and is not used. The values are not checked if they are provided.

c. Octet 4b is optional. The values are checked if they are provided but are not used.

4.3.3.5 Call State

The purpose of the call state IE is to characterize the current status of a call. The maximum length of this IE is three octets when ITU-TS standard coding is used. Tables 4.3-10 and 4.3-11 show the call state information layouts for the user and network states.

Table 4.3-10 — Call State Information Element Layout-User States

OCTET	FIELD	BITS	VALUE	MEANING	STATE NAME
1	Extension	8	0	Multiple octet element	
	Information Element Identifier	7-1	0010100	Call state	
2	Length	8-1	00000001	Length of IE contents	
3	Coding Standard	8-7	00	ITU-TS standardized	
	Call State Value	6-1	000000	0	Null
			000001	1	Call Initiated (user only)
			000011	3	Outgoing call proceeding
			000100	4	Call delivered
			000111	7	Call Received
			001000	8	Connect request
			001001	9	Incoming call proceeding
			001010	10	Active
			001011	11	Disconnect request
			001100	12	Disconnect Indication
			010010	18	Tone active
			010011	19	Release request

Table 4.3-11 — Call State Information Element Layout-Network States

OCTET	FIELD	BITS	VALUE	MEANING	STATE NAME
1	Extension	8	0	Multiple octet element	
	Information Element Identifier	7-1	0010100	Call state	
2	Length	8-1	00000001	Length of IE contents	
3	Coding Standard	8-7	00	ITU-TS standardized	
	Call State Value	6-1	000000	0	Null
			000011	3	Outgoing call proceeding
			000100	4	Call delivered
			000110	6	Call present (network only)
			000111	7	Call received
			001000	8	Connect request
			001001	9	Incoming call proceeding
			001010	10	Active
			001011	11	Disconnect request
			001100	12	Disconnect indication
			010010	18	Tone active
			010011	19	Release request

4.3.3.6 Called Party Number

The purpose of the called party number IE is to identify the called party of a call. The maximum length of the called party number IE is 35 octets. Although in feature-specific cases a maximum of 32 address digits from an originating user can be accepted, a maximum of 18 address digits will be accepted for routing and delivery to the terminating user. Beginning with the 5E12 software release, the CDMA Data feature can route and deliver a maximum of 29 digits.

The *5ESS* switch will deliver the called party number to the terminating user with the numbering plan identification always set to the “ISDN/telephony numbering plan (Rec. E.164/E.163).” The *5ESS* switch will not use the code point corresponding to “telephony numbering plan (Rec. E.163)” on the terminating interface. Table 4.3-12 shows the layout of the called party number IE.

Information on how this information element is coded based on user dialing is provided in “Dialed Sequences and Coding of SETUP Message,” Section 5.2.14, and Table 5.2-6.

Table 4.3-12 — Called Party Number Information Element Layout

OCTET	FIELD	BITS	VALUE	MEANING
1	Extension	8	0	Multiple octet element
	Information Element Identifier	7-1	1110000	Called party number
2	Length	8-1	binary	Length of information element contents
3	Extension	8	1	Single octet field
	Type of Number	7-5	000	Unknown[a]
			001	International number[b]
			010	National number
			011	Network specific number [c]
			100	Subscriber (or local) number
	Numbering Plan Identification	4-1	0000	Unknown [d]
			0001	ISDN/telephony numbering plan (Rec. E.164/E.163)
			0010	Telephony numbering plan (Rec. E.163)
			1001	Private numbering plan
4,etc	Bit 8	8	0	Zero value expected
	Address Digits (IA5)	7-1	0110000	0
			0110001	1
			0110010	2
			0110011	3
			0110100	4
			0110101	5
			0110110	6
			0110111	7
			0111000	8
			0111001	9
			0101010	* (star)
			0100011	#

Note(s):

a. The type of number “unknown” is used when the user or the network has no knowledge of the type of number, such as international number, or national number. In this case the number digits field is organized according to the network dialing plan. For example, prefix or escape digits might be present.

Table 4.3-12 — Called Party Number Information Element Layout (Contd)

Note(s): (Contd) b. Regardless of whether the received called party number contains a “011” prefix, the *5ESS* switch will prepend “011” to the called party number prior to digit analysis, which can cause the call to fail. Refer to “Direct Dialed Calls,” Section 5.2.14.2 for further information. c. Applicable to PRIs serving DSN or AI/EO switches (TRKTYPE = MLPPDQI, MLPPDQO, and MLPPPQ). d. The numbering plan “unknown” is used when the user or the network has no knowledge of the numbering plan. In this case the number digits field is organized according to the network dialing plan. For example, prefix or escape digits might be present.

4.3.3.7 Calling Party Number

The purpose of the calling party number (CgPN) IE is to identify the origin of a call. The maximum length of this IE is 19 octets. Table 4.3-13 shows the layout of the CgPN IE.

Table 4.3-13 — Calling Party Number Information Element Layout

OCTET	FIELD	BITS	VALUE	MEANING
1	Extension	8	0	Multiple octet element
	Information Element Identifier	7-1	1101100	Calling party number
2	Length	8-1	binary	Length of information element contents
3	Extension	8	0	Field is extended through next octet
			1	Last octet of field
	Type of Number	7-5	000	Unknown[a]
			001	International number
			010	National number (default)
			011	Network specific number[b]
			100	Subscriber (or local) number
	Numbering Plan Identification	4-1	0000	Unknown[c]
			0001	ISDN/telephony numbering plan (Rec. E.164/E.163)
			0010	Telephony numbering plan (Rec. E.163)[d]
			1001	Private numbering plan[b]
3a[e]	Extension	8	1	Single octet field
	Presentation Indicator	7-6	00	Presentation allowed (default)
			01	Presentation restricted
			10	Number not available due to interworking
	Spare	5-3	000	Spare
	Screening Indicator	2-1	00	User provided-not network screened
			01	User provided, passed verification
			10	User provided, failed verification
			11	Network provided
4, etc.	Bit 8	8	0	Zero value expected
	Address Digits	7-1	IA5	IA5 digits

See note(s) at end of table.

Table 4.3-13 — Calling Party Number Information Element Layout (Contd)

Note(s):

a. The type of number “unknown” is used when the user or the network has no knowledge of the type of number, such as international number or national number. In this case the number digits field is organized according to the network dialing plan; such as, prefix or escape digits might be present.

b. Applicable to PRIs serving DSN or AI/EO switches (TRKTYPE = MLPPDQI, MLPPDQO, and MLPPPQ).

c. The numbering plan “unknown” is used when the user or the network has no knowledge of the numbering plan. In this case the number digits field is organized according to the network dialing plan. For example, prefix or escape digits might be present.

d. The telephony numbering plan (Rec. E.163) is accepted on an originating interface, but it is not used on a terminating interface. If telephony numbering plan (Rec. E.163) is received on an originating interface, it is recoded to ISDN/telephony numbering plan (Rec. E.164/E.163) when sent on a terminating interface.

e. If Octet 3a is omitted, then the calling party number is user provided (with no network screening) and presentation to the terminating user is permitted.

4.3.3.8 Cause

The purpose of the cause IE is to describe the reason for generating certain messages, to provide diagnostic information in the event of procedural errors, and to indicate the location of the cause originator. The maximum length allowed for this IE is 22 octets. Table 4.3-14 shows the layout for the cause IE. Note that the diagnostic (Octet 5) is supported on the National ISDN PRI, but not the Custom PRI. If the length of a received cause IE exceeds the supported lengths (4 octets for Custom PRI, 5 octets for National ISDN PRI) and is within the maximum allowed length (22 octets), the message containing the cause IE is accepted, but all octets beyond the supported lengths are discarded. The layout of Octet 4 is shown in Table 4.3-15.

Table 4.3-14 — Cause Information Element Layout

OCTET	FIELD	BITS	VALUE	MEANING
1	Extension	8	0	Multiple octet element
	Information Element Identifier	7-1	0001000	Cause
2	Length	8-1	binary	Length of information element contents
3	Extension	8	1	Last octet of the description
	Coding Std	7-6	00	CCITT standardized coding
			10	National standard
			11	Network-specific
	Spare	5	0	
	Location	4-1	0000	User
			0001	Private network serving local user
			0010	Public network serving local user
			0011	Transit network
			0100	Public network serving remote user
			0101	Private network serving remote user
			0111	International network
			1010	Network beyond interworking point
4	Bit 8	8	1	Single octet field
	Cause Value	7-1	binary	See Table 4.3-15.
5[a]	Diagnostic	8-1	binary	Diagnostic number

Note(s):
a. Only allowed on the National ISDN interface. Maximum of one diagnostic.

Table 4.3-15 — Cause Information Element Layout in Octet 4

OCTET	CLASS BITS 7-5	CAUSE BITS 4-1	CAUSE NUMBER	NAME OF CAUSE	CLASS TYPE
4	000	0001	1	Unassigned (unallocated) number	Normal event
		0010	2	No route specified to transit network	
		0011	3	No route to destination	
		0110	6	Channel unacceptable	
		1000	8	Preemption	
		1001	9	Preemption – circuit reserved for reuse	
	001	0000	16	Normal call clearing	Normal event
		0001	17	User busy	
		0010	18	No user responding	
		0011	19	User alerting, no answer	
		0101	21	Call rejected	
		0110	22	Number changed	
		1011	27	Destination out of order	
		1100	28	Invalid number format	
		1110	30	Response to STATUS Enquiry	
		1111	31	Normal; unspecified	
	010	0010	34	No circuit or channel available	Resource unavailable
		0011	35	Call has been queued	
		1001	41	Temporary failure	
		1010	42	Network congestion	
		1011	43	Access information discarded	
		1100	44	Requested circuit or channel unavailable	
		1110	46	Precedence call blocked	
		1111	47	Resource unavailable – unspecified	
	011	0010	50	Facility not subscribed to	Service/option not available
		0011	51	Bearer capability incompatible with service request	
		0100	52	Outgoing calls barred	
		0101	53	Service operation violated	

Table 4.3-15 — Cause Information Element Layout in Octet 4 (Contd)

OCTET	CLASS BITS 7-5	CAUSE BITS 4-1	CAUSE NUMBER	NAME OF CAUSE	CLASS TYPE
		0110	54	Incoming calls barred	
		1001	57	Bearer capability not authorized	
		1010	58	Bearer capability not presently available	
		1111	63	Service or option not available, unspecified	
	100	0001	65	Bearer capability not implemented	Service/option not implemented
		0010	66	Channel type not implemented	
		0101	69	Requested facility not implemented	
	101	0001	81	Invalid Call Reference value	Invalid message
		0010	82	Identified channel does not exist	
		1000	88	Incompatible destination	
	110	0000	96	Mandatory information element is missing	Protocol error
		0001	97	Message type nonexistent or not implemented	
		0010	98	Message not compatible with the call state (Custom PRI)	
		0011	99	Information element non-existent or not implemented	
		0100	100	Invalid information element contents	
		0101	101	Message not compatible with the call state (National ISDN PRI)	
		0110	102	Recovery on timer expiration	
	111	1111	127	Interworking; unspecified	Interworking

A switch may generate an appropriate tone on the information channel that corresponds to a cause that has end-to-end significance (see Table 4.3-16).

Table 4.3-16 — Network Tone or Announcement Treatment Cause Numbers

NETWORK TONE OR ANNOUNCEMENT TREATMENT	CAUSE NUMBER(S)[a]
Busy tone	17
No circuit announcement	34, 42, and 54
Vacant code announcement	01, 22, 28, 65, and 66
Note(s): a. The default tone for the other causes will be a reorder announcement.	

The switch serving the end-user provides a blocked precedence announcement or re-order on receipt of a cause code value of 46 from the network.

4.3.3.9 Channel Identification

The purpose of the channel identification IE is to identify a channel within the interface(s) controlled by these signaling procedures. The default maximum length for this IE is 8 octets. See Table 4.3-17 for the channel identification IE layout.

Table 4.3-17 — Channel Identification Information Element Layout

OCTET	FIELD	BITS	VALUE	MEANING
1	Bit 8	8	0	Set value
	Information Element Identifier	7-1	0011000	Channel Identification
2	Length	8-1	binary	Length of information element contents
3	Extension	8	1	Last octet of description
	Interface identifier present	7	0	Interface implicitly identified[a]
			1	Interface explicitly identified[b]
	Interface type	6	0	Basic rate interface
			1	Other interface; for example, primary rate
	Spare	5	0	Spare
	Preferred/ Exclusive	4	0	Indicated channel is preferred[c]
			1	Exclusive; only the indicated channel is acceptable
	D-channel indicator	3	0	Channel identified is not the D-channel
			1	Channel identified is the D-channel
	Information channel selection	2-1	00	No channel
			01	As indicated in the following octets
3.1	Extension	8	1	Last octet of the description
	Interface Identifier	7-1	binary	Interface identifier[d]
3.2	Extension	8	1	Last octet of the description
	Coding standard	7-6	00	ITU-TS standardized for this specification
	Number/map	5	0	Channel is indicated by the channel number in Octet 3.3
			1	Channel(s) as indicated by the slot map in octet(s) 3.3
	Channel or map element type	4-1	0011	B-channel units

See note(s) at end of table.

Table 4.3-17 — Channel Identification Information Element Layout (Contd)

OCTET	FIELD	BITS	VALUE	MEANING
3.3[e]	Extension	8	1	Last octet of description (for channel only)
	Channel Number	7-1	binary	Channel number[f]
3.3	Slot Map	8-1		Bit positions corresponding to time slots occupied by wideband channels (see Table 4.3-18)

Note(s):

a. When the "interface identifier present" field in Octet 3 indicates "interface *implicitly* identified," Octet 3.1 is omitted.

b. When the "interface identifier present" field in Octet 3 When the "interface identifier present" field in Octet 3 indicates "interface *explicitly* identified" Octet 3.1 and possibly Octets 3.2 and 3.3 are used to explicitly identify the interface[f].

c. A *preferred* channel indication will be treated as *exclusive*, except in an outgoing SETUP message when PRI B-channel Negotiation is active.

d. When a whole interface is to be identified rather than channels on the interface, Octets 3.2 and 3.3 are omitted or ignored and Octet 3.1 is used to explicitly identify the interface. This is true for 1536-kbps calls using the fixed or multirate codepoints (where all channels on the interface are implied).

e. Either the "Channel Number" or "Slot Map" representation of Octet 3.3 is present depending on the value of the "Number/Map" field in Octet 3.2.

f. For this implementation, the range of channel numbers supported will be 1-24. Bit 8 in Octet 3.3 is reserved for extension.

The format of the slot map is shown in Table 4.3-18. Octet 3.3 consists of three octets (3.3.1 to 3.3.3). All wideband calls (H_0, H_{11}, or multirate) require the use of a slot map, except for those at the 1536-kbps rates.

Table 4.3-18 — Slot Map Representation of Octet 3.3.

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

Bits in the slot map corresponding to time slots occupied by wideband channels are set to 1, all other bits are set to 0.

For a 384-kbps call that uses the 384-kbps fixed information transfer rate in the bearer capability IE, the time slots occupied by a call are contiguous with a fixed starting point. The only slot assignments that are allowed for 384-kbps fixed calls are (a) 1-6, (b) 7-12, (c) 13-18, and (d) 19-24. Time slot assignments of 19-24 are available only if Time Slot 24 is not used for a D-channel.

In the Table 4.3-19, a 384-kbps is requested on Channels 7-12 using the fixed channel selection scheme.

Table 4.3-19 — Example of Fixed Rate Channel Selection

Octet	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1
3.3.1	0	0	0	0	0	0	0	0
3.3.2	0	0	0	0	1	1	1	1
3.3.3	1	1	0	0	0	0	0	0

4.3.3.10 Connected Number

The purpose of the connected number IE is to identify the connected party of a call. The maximum length of this IE is 18 octets. This IE is not interpreted or generated by the network but is carried transparently.

The coding of the IE identifier for the connected number IE is 0001100.

4.3.3.11 Facility

The purpose of the facility IE is to indicate the invocation and operation of ISDN supplementary services and networking extensions, as specified in ITU-T Recommendation Q.932. The *5ESS* switch supports the facility IE in Codeset 0 on both the National ISDN PRI and the Custom PRI. The *5ESS* switch does not support the use of the facility IE in Codeset 6. If a message is received containing a facility IE in Codeset 6, the message is not rejected, but the facility IE is discarded.

The maximum length of the facility IE is 240 octets. Table 4.3-20 gives the layout of the facility IE. Values and inclusion conditions for the components that appear in the facility IE are given in Tables 4.3-24, 4.3-25, 4.3-26, and 4.3-27.

Table 4.3-20 — Facility Information Element Layout

OCTET	FIELD	BITS	VALUE	MEANING
1	Extension	8	0	Multiple octet element
	Information Element Identifier	7-1	0011100	Facility
2	Length	8-1	binary	Length of information element contents
3	Extension	8	1	Last octet of description
		7-6	00	Spare
	Service Discriminator	5-1	10001 11111	Supplementary services Networking extensions
3.1	Network Facility Extension	8-1	see Section 4.3.3.11.1.1	Not used for public network services
3.2	Network Protocol Profile Component	8-1	see Section 4.3.3.11.1.1	Do not include; switch will discard entire facility IE if it contains NPP
3.3	Interpretation Component	8-1	see Section 4.3.3.11.1.1	Specifies what action the switch should take on receiving an unrecognized operation value
4, etc.	Service Component	8-1	see Sections 4.3.3.11.1.2 and 4.4	Service specific

4.3.3.11.1 Components

4.3.3.11.1.1 Networking Extensions Components

When the facility IE contains a service discriminator of "networking extensions," one or more of the optional components shown in Table 4.3-20 as Octets 3.1, 3.2, and 3.3 may be present in the facility IE. For details about the optional components, see Tables 4.3-21, 4.3-22, and 4.3-23. For detailed encodings of component-dependent data elements, see Section 4.4.

Table 4.3-21 — Networking Facilities Extension (NFE) Component

DATA ELEMENT	VALUE	INCLUSION CONDITIONS
Component Type	NFE	Not Used [a]
Source Entity	EndPINX	Not Used [a]
Source Entity Address		Not Used [a]
Destination Entity	EndPINX	Not Used [a]
Destination Entity Address		Not Used [a]

Note(s):

a. The NFE will be ignored by the *5ESS* switch for public network PRI services; no checking will be performed on the contents of the NFE. The minimum encoded length of the NFE component is 6 bytes; this is checked. Minimum overall length (sum of component tag length and component length), therefore, is 8 bytes.

Direction: CPE to NTWK (PCN)[1]

Table 4.3-22 — Network Protocol Profile (NPP) Component

DATA ELEMENT	VALUE	INCLUSION CONDITIONS
Component Type	NPP	Not Used [a]
Protocol Profile	Value of Protocol Profile	Not Used [a]

Note(s):

a. The NPP will not be supported. If an NPP component is received by the *5ESS* switch in a facility IE, the entire facility IE will be discarded.

Direction: CPE to NTWK (PCN)[2]

Table 4.3-23 — Interpretation Component

DATA ELEMENT	VALUE	INCLUSION CONDITIONS
Component Type	Interpretation	Must Include
Interpretation Value	Error Recovery Procedure	Must Include

Direction: both

4.3.3.11.1.2 Service Components

Tables 4.3-24, 4.3-25, 4.3-26, and 4.3-27 show the service components used in the facility IE. The data elements used in these service components are defined in “Data Elements,” Section 4.4.

1. The NFE is not expected for public network ISDN services. It may be included, however, by some PBXs in a facility IE containing a PCN request and must be recognized and ignored by the *5ESS* switch.
2. The NPP is not expected for public network services. If present in a facility IE, the IE is discarded and a STATUS message returned to the originating CPE.

Table 4.3-24 — Invoke Component

DATA ELEMENT	VALUE	INCLUSION CONDITIONS
Component Type	Invoke	Must Include
Invoke Identifier	Any value not in use	Must Include
Operation Value	variable	Must Include
Arguments	variable	If defined for operation

Table 4.3-25 — Return Result Component

DATA ELEMENT	VALUE	INCLUSION CONDITIONS
Component Type	Return Result	Mandatory
Invoke Identifier	Value from the Invoke	Mandatory
Sequence	Sequence	If results are returned
Operation Value	Value of Operation in Invoke	If results are returned
Arguments	variable	If defined for operation

Table 4.3-26 — Return Error Component

DATA ELEMENT	VALUE	INCLUSION CONDITIONS
Component Type	Return Error	Mandatory
Invoke Identifier	Value from the Invoke	Mandatory
Error Value	variable	Mandatory
Arguments	variable	If defined for operation

Table 4.3-27 — Reject Component

DATA ELEMENT	VALUE	INCLUSION CONDITIONS
Component Type	Reject	Mandatory
Invoke Identifier	From the Invoke	Mandatory
Problem Value	Reason for rejection	Mandatory

4.3.3.12 Generic Digits

Beginning with a software update for 5E14 Feature Release 3, the generic digits IE is used in Codeset 6 to carry two-digit information to any National ISDN PRI termination. This IE is carried in only the outbound SETUP message from the *5ESS* switch. The two-digit information represents the type of circuit-switched call origination, and is derived in any of the following ways:

- A single ANI-I information digit arrives at the switch if non-multifrequency signaling is used. For storing and passing this value, the switch prepends it with 0, and represents the value in a full byte as a two-digit binary number.

- A two-digit interexchange identification (II, also called ANI-II or ANI-2) arrives at the switch if equal access multi-frequency signaling is used. The switch stores and passes these digits in a full byte as the two-digit binary number.
- Three-digit originating line information (OLI) arrives at the switch if equal access ISDN user part (ISUP) network interconnect signaling is used. For storing and passing this value, the switch ignores the leading 0, and represents the value in a full byte as a two-digit binary number.

The use of call origination information is not limited. For example, an adjunct platform (referred to in AIN as a service node) may use the call origination type defined in the II or OLI information:

- To calculate charges for pre-paid card services
- To determine whether service should be denied.

The following exceptions in the delivery of call origination information can occur:

- When a call interaction (such as, but not limited to, an ASP trigger) has changed the II or OLI value, the switch delivers the latest value to the terminating PRI upon egress of the call from the switch.
- In the following cases, the outbound SETUP message *does not* include the generic digits IE:
  - — When the call originates on a line and terminates to a PRI on the same *5ESS* switch, and as a result the switch does not receive the proper II or OLI information.
  - — When the feature II/OLI Delivery for National ISDN PRI is not provisioned.
  - — When the II or OLI information in the call record is not valid (is not a value in the range 00 through 99)
  - — When the trunk type is not National ISDN PRI with a trunk class of EDSL (extended digital subscriber line) or EDSLHM (extended digital subscriber line for hotel/motel).

The terminating CPE must be able to receive and process the generic digits Codeset 6 IE. Table 4.3-28 provides the layout of this IE.

Table 4.3-28 — Generic Digits Information Element Layout

OCTET	FIELD	BITS	VALUE	MEANING
1	Extension	8	0	Multiple octet element
	Information Element Identifier	7-1	0110111	Generic Digits (0x37 hexidecimal)
2	Length	8-1	00000010	Length of information element contents
3	Encoding Scheme	8-6	000	Binary coded decimal (BCD) even
	Type of Generic Digits	5–1	00100	II/OLI Digits
4	BCD Digit 2	8–5	binary	Second digit of II/OLI information
	BCD Digit 1	4–1	binary	First digit of II/OLI information

Table 4.3-29 provides examples of hexidecimal encodings for the generic digits IE, based on II/OLI two-digit codes assigned to various call origination types.

Table 4.3-29 — Example Encodings of Generic Digits IE

Type of Call Origination	Example of II/OLI Information	Corresponding Generic Digits IE Encoding (Hex)
Equal Access POTS	00	37 02 04 00
Pay Phone	27	37 02 04 72
Hotel/Motel	06	37 02 04 60

4.3.3.13 High Layer Compatibility

Reserved for possible future use. The *5ESS* switch does not support this IE on the primary rate interface.

4.3.3.14 Low Layer Compatibility

The purpose of the low layer compatibility IE is to provide a means by which compatibility checking may be performed by an addressed entity (such as a remote user, an interworking unit, or a high layer function network node addressed by the calling user). The low layer compatibility IE is transferred transparently by an ISDN between the call originating entity, such as the calling user, and the addressed entity. The low layer compatibility IE is not interpreted by the network but is carried transparently and delivered to the terminating entity. The length is checked and must be between 4 and 16 bytes. The low layer compatibility IE identifier in Octet 1 is coded 1111100.

4.3.3.15 Network Specific Facilities

The purpose of the NSF IE is to indicate which network facilities are being invoked.

Within a NSF IE, one binary facility or one parameterized facility can be specified. No more than two NSF IEs may be included in a single message. The maximum length of this IE is 25 octets. Code points are identified in Tables 4.3-30, 4.3-31, and 4.3-32.

Table 4.3-30 — Network Specific Facilities Information Element Layout

OCTET	FIELD	BITS	VALUE	MEANING
1	Extension	8	0	Multiple octet element
	Information Element Identifier	7-1	0100000	Network Specific Facilities
2	Length	8-1	binary	Length of information element contents
3	Length of Network Identification	8-1	00000000	0 octets (Octets 3.1 and 3.2 not present)
			00000100	3-digit CIC 4 octets (includes Octet 3.1 and 3 repetitions of Octet 3.2)
			00000101	4-digit CIC 5 octets (includes Octet 3.1 and 4 repetitions of Octet 3.2)
3.1	Extension	8	1	Last octet of field
	Type of Network Identification	7-5	010	National network identification
	Network Identification Plan	4-1	0001	Interexchange carrier code
3.2 + repetitions	Network Identification Digits	8-1		IA5 characters for 3- or 4-digit code assigned to IECs by Bellcore
4	Parameterized/ Binary[a]	8	0	Parameters are associated with the requested facility, and they are specified in the following octets.
			1	Binary facility. No parameters are associated with the requested facility.
	Extension[a]	8	0	Multiple octet element.
			1	Last octet of the description.
	Expansion	7	1	Coding of facility is in the following 6 bits.
	Feature/ Service	6	0	Requested facility is a feature.
			1	Requested facility is a service.
	Facility Coding Value	5-1		As shown in Table 4.3-31.
5 +	Spare	8	0	0 value expected

See note(s) at end of table.

Table 4.3-30 — Network Specific Facilities Information Element Layout (Contd)

OCTET	FIELD	BITS	VALUE	MEANING
repetitions	Service Parameters	7-1		IA5 digits from 0 through 9

Note(s):

a. Up to the 5E12 software release, Bit 8 of Octet 4 was coded and interpreted as a parameterized/binary field on both the Custom PRI and the National ISDN PRI. A parameterized/binary field indicates whether the NSF IE includes service parameters that are coded in Octet 5 (are parameterized, not binary). This interpretation is the same as that used on the *4ESS*™ Switch, but is not compliant with Bellcore National ISDN specifications.

   Beginning with a 5E12 software update, Bit 8 may represent either a parameterized/binary field or an extension field for National ISDN PRIs. Interpretation as an extension field indicates whether the Octet 4 information extends to the next octet. The presence of service parameters is inferred from the length of the NSF IE. Interpretation of Bit 8 of Octet 4 as an extension field is compliant with Bellcore specifications. The extension interpretation is not valid for Custom PRIs.

Table 4.3-31 — Network Specific Facilities Information Element Layout of the Coding of Octet 4—Parameterized/Binary Interpretation of Bit 8

Octet	Coded Value 8 7 6 5 4 3 2 1	Description	Parameterized/ Binary	Service/ Feature
4	0 1 1 0 0 0 0 1	WATS Band Selection	Parameterized	Service
	0 1 1 1 0 0 1 0	National ISDN Banded OUTWATS		
	0 1 1 1 0 0 1 1	Foreign Exchange Selection		
	0 1 1 1 0 1 0 0	Tie Trunk Selection		
	0 1 1 1 0 1 1 0	SCOCS Service Selection		
	1 1 0 0 0 1 0 1	Operator (local exchange)	Binary	Feature
	1 1 0 0 0 1 1 0	Operator (default common carrier)		
	1 1 1 0 0 0 0 1	Access for Virtual Private Network (for example, Software Defined Network)	Binary	Service
	1 1 1 0 0 0 1 0	*MEGACOM*[a] 800 telecommunications service		
	1 1 1 0 0 0 1 1	*MEGACOM* telecommunications service		
	1 1 1 0 0 1 0 0	INWATS		
	1 1 1 0 0 1 0 1	WATS maximal subscribed band		
	1 1 1 0 0 1 1 0	*ACCUNET*[b] Switched Digital Services		
	1 1 1 0 0 1 1 1	International Long Distance Service		
	1 1 1 0 1 0 0 0	International 800		
	1 1 1 0 1 0 1 1	Electronic Tandem Network		
	1 1 1 0 1 1 0 1	Private Virtual Network[e]		
	1 1 1 1 0 0 0 0	AT&T *DIAL-IT*[c] 900 and *MultiQuest*[d]		
	1 1 1 1 0 0 0 1	National ISDN INWATS		

See note(s) at end of table.

Table 4.3-31 — Network Specific Facilities Information Element Layout of the Coding of Octet 4—Parameterized/Binary Interpretation of Bit 8 (Contd)

Octet	Coded Value 8 7 6 5 4 3 2 1	Description	Parameterized/ Binary	Service/ Feature
	1 1 1 1 0 0 1 0	National ISDN Unbanded OUTWATS Selection		
	1 1 1 1 0 1 0 1	Hotel/Motel Service Selection		

Note(s):
a. Registered servicemark of AT&T.
b. Registered servicemark of AT&T.
c. Registered servicemark of AT&T.
d. Registered servicemark of AT&T.
e. Reserved value.

Table 4.3-32 — Network Specific Facilities Information Element Layout of the Coding of Octet 4—Extension Field Interpretation of Bit 8

Octet	Coded Value 8 7 6 5 4 3 2 1	Description	Service/ Feature
4	1 1 1 1 0 0 1 0	National ISDN OUTWATS Selection	Service
	1 1 1 1 0 0 1 1	Foreign Exchange Selection	
	1 1 1 1 0 1 0 0	Tie Trunk Selection	
	1 1 1 1 0 1 1 0	SCOCS Service Selection	
	1 1 0 0 0 1 0 1	Operator (local exchange)	Feature
	1 1 0 0 0 1 1 0	Operator (default common carrier)	
	1 1 1 0 0 0 0 1	Access for Virtual Private Network (for example, Software Defined Network)	Service
	1 1 1 0 0 0 1 0	*MEGACOM* 800 telecommunications service	
	1 1 1 0 0 0 1 1	*MEGACOM* telecommunications service	
	1 1 1 0 0 1 0 0	INWATS	
	1 1 1 0 0 1 0 1	WATS maximal subscribed band	
	1 1 1 0 0 1 1 0	*ACCUNET* Switched Digital Services	
	1 1 1 0 0 1 1 1	International Long Distance Service	
	1 1 1 0 1 0 0 0	International 800	
	1 1 1 0 1 0 1 1	Electronic Tandem Network	
	1 1 1 0 1 1 0 1	Private Virtual Network[a]	
	1 1 1 1 0 0 0 0	AT&T *DIAL-IT* 900 and *MultiQuest*	
	1 1 1 1 0 0 0 1	National ISDN INWATS	
	1 1 1 1 0 1 0 1	Hotel/Motel Service Selection	

Note(s):
a. Reserved value.

4.3.3.16 Notification Indicator

The purpose of the Notification Indicator IE is to carry notification information that may or may not relate to a call on a PRI. This IE is allowed in only the network-to-user direction. The Notification Indicator IE may be repeated in the NOTIFY message. Table 4.3-33 shows the IE layout of the Notification Indicator IE.

Table 4.3-33 — Notification Indicator Information Element Layout

OCTET	FIELD	BITS	VALUE	MEANING
1	Extension	8	0	Multiple octet element
	Information Element Identifier	7-1	0100111	Notification Indicator
2	Length	8-1	binary	Length of information element contents
3	Extension	8	0	Last octet of the description
			1	Description extended to next octet
	Notification Description	7-1	0000011	Discriminator for extension to ASN.1 encoded component
4	ASN.1 Encoded Data Structure		See Table 4.3-34	[a]

Note(s):
a. Octet 4 is included when Octet 3 is coded to "Discriminator for extension to ASN.1 encoded component."

Table 4.3-34 shows the structure of the contents of Octet 4 of the Notification Indicator IE.

Table 4.3-34 — ASN.1 Encoded Data Structure for Octet 4 of Notification Indicator IE

DATA ELEMENT	VALUE	INCLUSION CONDITIONS
Sequence[a]	Sequence	Must include
Notification value[a]	*variable*	Must include
Arguments	*variable*	Must include only if defined for notification

Note(s):
a. These data elements are defined in "Data Elements," Section 4.4.

4.3.3.17 Precedence Level

Table 4.3-35 shows the precedence level IE layout. The precedence level IE (Codeset 5) is applicable to PRIs serving DSN or AI/EO switches or in other private network arrangements.

Table 4.3-35 — Precedence Level Information Element Layout

OCTET	FIELD	BITS	VALUE	MEANING
1	Bit 8	8	0	Set value
	Information Element Identifier	7-1	1000001	Precedence Level
2	Length	8-1	00000101	Length of information element contents
3	Extension	8	1	Last octet of description
	Coding Standard	7-6	00	ITU-TS Standard
			10	National Standard[a]
	Spare	5	0	Spare
	Precedence Level	4-1	0000	Flash override
			0001	Flash
			0010	Immediate
			0011	Priority
			0100	Routine
4	Extension	8	1	Last octet of description
	Spare	7-5		Spare
	Change Value	4	0	Precedence level coding privilege may be changed at network boundaries[a]
			1	Precedence level coding privilege may not be changed at network boundaries
	Spare	3	0	Spare
	LFB Indicator	2-1	00	Look for Busy (LFB) allowed
			01	LFB not allowed[a]
			10	Path reserved
			11	Spare
5-7	MLPP Service Domain	8-1	binary	[b]

Note(s):
a. Only valid value.
b. The Multilevel Precedence and Preemption (MLPP) service domain uniquely identifies a domain administered by a particular ISDN. For the purpose of transmitting the MLPP service domain, the entire field shall be encoded in a pure binary representation of an unsigned integer value.

4.3.3.18 Progress Indicator

The purpose of the progress indicator IE is to describe an event that has occurred during the life of a call. The default maximum length of this IE is 4 octets. Table 4.3-36 shows the layout of the progress indicator IE.

Table 4.3-36 — Progress Indicator Information Element Layout

OCTET	FIELD	BITS	VALUE	MEANING
1	Extension	8	0	Multiple octet element
	Information Element Identifier	7-1	0011110	Progress indicator
2	Length	8-1	00000010	2 octets – length of IE contents
3	Extension	8	1	Last octet of the description
	Coding Standard	7-6	00	ITU-TS standardized coding
			10	National standard
			11	Network-specific
	Spare	5	0	Spare
	Location	4-1	0000	User
			0001	Private network serving the local user
			0010	Public network serving local user
			0011	Transit network[a]
			0100	Public network serving remote user
			0101	Private network serving the remote user
			0111	International network[b]
			1010	Network beyond the interworking point
4	Extension	8	1	Last octet of the description
	Progress Description[c]	7-1	0000001	#1 – Call is not end-to-end ISDN and/or further call progress information may be available in band.
			0000010	#2 – Called equipment is non-ISDN
			0000011	#3 – Calling equipment is non-ISDN
			0000100	#4 – Call has returned to the ISDN.
			0001000	#8 – In-band information or appropriate pattern now available.

See note(s) at end of table.

Table 4.3-36 — Progress Indicator Information Element Layout (Contd)

OCTET	FIELD	BITS	VALUE	MEANING
			0001010	#10 – Delay encountered at the terminating switch.

Note(s):

a. The transit network codepoint applies to the ITU-T or national coding standard.

b. The international network codepoint applies to only the network-specific coding standard.

c. Progress Descriptor 10 is supported on the National ISDN PRI. All others shown are ITU-TS standardized coding and are supported on both the National ISDN PRI and the Custom PRI.

4.3.3.19 Redirecting Number

The purpose of the redirecting number IE is to identify the number from which a call diversion or transfer was invoked. The maximum length of this IE is 20 octets. The redirecting number IE is not interpreted by the network but is carried transparently and delivered to the terminating entity. The contents of this IE are coded as in the connected number IE. Table 4.3-37 shows the redirecting number IE layout.

Table 4.3-37 — Redirecting Number Information Element Layout

OCTET	FIELD	BITS	VALUE	MEANING
1	Extension	8	0	Multiple octet element
	Information Element Identifier	7-1	1110100	Redirecting number
2	Length	8-1	binary	Length of information element contents
3	Extension	8	0	Field is extended through next octet
			1	Last octet of field
	Type of Number	7-5	000	Unknown
			001	International number
			010	National number (default)
			100	Subscriber number
	Numbering Plan Identification[a]	4-1	0000	Unknown
			0001	ISDN/telephony numbering plan (Rec. E.164/E.163)
			1001	Private numbering plan
3a	Extension	8	0	Field is extended through next octet
			1	Single octet field
	Presentation Status[a]	7-6	00	Presentation allowed
			01	Presentation prohibited
			10	Number not available
	Spare	5-3	000	Spare
	Origin of Number[a]	2-1	11	Network provided
3b	Extension	8	1	Single octet field
	Spare	7-5	000	Spare
	Reason for Redirection	4-1	0000	Unknown
			0001	Call forwarding busy
			0010	Call forwarding no reply
			1111	Call forwarding unconditional
4,etc	Bit 8	8	0	Zero value expected
	Address Digits	7-1	IA5	IA5 digits

Note(s):
a. All other values reserved.

4.3.3.20 Restart Indicator

The purpose of the restart indicator is to identify the class of the facility (that is, channel or interface) to be restarted. The maximum length of this IE is three octets. Table 4.3-38 shows the layout of the restart indicator.

Table 4.3-38 — Restart Indicator Layout

OCTET	FIELD	BITS	VALUE	MEANING
1	Extension	8	0	Multiple octet element
	Information Element Identifier	7-1	1111001	Restart indicator
2	Length	8-1	binary	Length of information element contents
3	Extension	8	1	Last octet of the description
		7-4	0000	Unused
	Class	3-1	000	Indicated B-channel
			110	Single interface
			111	Entire PRI interface

When indicated B-channel is specified the channel identification IE must specify the channel to be restarted. The channel to be restarted must be a B-channel.

When single interface is specified, if non-facility associated signaling is used, the channel identification IE must specify the interface to be restarted.

When the entire PRI interface coding value is specified, the channel identification IE is not used.

The *5ESS* switch will send a RESTART message for only an individual B-channel. The switch will, however, interpret and act on any restart indicator it receives.

4.3.3.21 Transit Network Selection

The purpose of the transit network selection (TNS) IE is to identify one requested transit network. The default maximum length of this IE is 6 octets. Table 4.3-39 shows the layout of the TNS IE.

Table 4.3-39 — Transit Network Selection Information Element Layout

OCTET	FIELD	BITS	VALUE	MEANING
1	Extension	8	0	Multiple octet element
	Information Element Identifier	7-1	1111000	Transit Network Selection
2	Length	8-1	binary	Length of information element contents
3	Extension	8	1	Last octet of description
	Type of Network Identification	7-5	010	National network identification
	Network Identification Plan	4-1	0001	Interexchange carrier code
4 +	Network Identification extensions	7-1		IA5 characters 3- or 4-digit code assigned to IECs by Bellcore

4.3.3.22 Traveling Class Mark

The purpose of the traveling class mark IE (in Codeset 6) is to identify the call privileges of the calling user. The following values apply to the *5ESS* switch implementation. The facility restriction level (FRL) field in the IE (Octet 4) is also referred to as the traveling class mark (TCM). Table 4.3-40 shows the layout of the traveling class mark IE.

Table 4.3-40 — Traveling Class Mark Information Element Layout

OCTET	FIELD	BITS	VALUE	MEANING
1	Extension	8	0	Multiple octet element
	Information Element Identifier	7-1	0001000	Traveling Class Mark
2	Length	8-1	binary	Length of information element contents
3	Extension	8	1	Last octet of the description
	Coding Standard	7-6	10	National standard
	Change Value	5	1	Required value
	Spare	4-1	0000	Zero value expected
4	Spare	8	0	Zero value expected
	Facility Restriction Level	7-1	0110000	0
			0110001	1
			0110010	2
			0110011	3
			0110100	4
			0110101	5
			0110110	6
			0110111	7
5	Spare	8	0	Zero value expected
	Satellite Hop Counter	7-1	0110000	0
			0110001	1
			0110010	2
			0110011	3
			0110100	4
			0110101	5
			0110110	6
			0110111	7
			0111000	8
			0111001	9
6	Extension	8	1	Last octet of the description
	End-to-End ISDN (Connectivity) Indication	7-1	0000000	No preference
			0000001	End-to-end ISDN required
			0000010	End-to-end ISDN preferred

4.3.3.23 User-Entered Code

This IE is used in Codeset 6 to carry the account code, authorization code, or other information identified in Table 4.3-41. Octet 2 of the IE indicates the total length of the contents of the rest of the IE.

Table 4.3-41 — User-Entered Code Information Element Layout

OCTET	FIELD	BITS	VALUE	MEANING
1	Spare	8	0	Zero value expected
	Information Element Identifier	7-1	0000010	User-entered code
2	Length of User Code	8-1	binary	Length
3	Extension	8	1	Last octet of the description
	Type of User Code (Codeset 6 Values Shown)	7-1	0000000	Any
			0000001	Account code
			0000010	Login digits
			0000011	Subscriber identification
			0000100	Authorization code
4-18[a]	Spare	8	0	Zero value expected
	User Code Digits	7-1		IA5 values

Note(s):

a. User code digits (Octet 4 and beyond, Bits 7-1). This is an optional field and the value is determined by the type of user code specified. There can be up to 15 octets of digits.

4.3.3.24 User-User

The user-user IE is used to exchange information between two users. This information is transported transparently through the network to the remote user. The restriction on the maximum length of this IE (including the length of the other IEs identified in “User-to-User Signaling Service,” Section 11.6) is 64 octets.

The user information field, Octet 4 and beyond, are coded according to the protocol discriminator, Octet 3, which is defined by the user and is transparent to the switch. The IE identifier is 1111110.

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4.4 DATA ELEMENTS

The following data elements are used in the components shown in “Service Components,” Section 4.3.3.11.1.2. Some of the data elements are also used by the Notification Indicator IE described in “Notification Indicator,” Section 4.3.3.16.

4.4.1 Component Type

8 7 6 5 4 3 2 1
Component type
Length
Length continued[a]

Note(s):
a. Included only if long form of length used.

- Component type

Bits 8 7 6 5 4 3 2 1	Meaning
1 0 1 0 0 0 0 1	Invoke
1 0 1 0 0 0 1 0	Return Result
1 0 1 0 0 0 1 1	Return Error
1 0 1 0 0 1 0 0	Reject
1 0 1 0 1 0 1 0	NFE
1 0 0 0 1 0 1 1	Interpretation
1 0 0 1 0 0 1 0	Network Protocol Profile

- Length

  The length indicates the length of the component, not including the type and length fields. There are two methods for encoding the length: short and long form.

  The short form is used to encode lengths of up to 127 octets; with Bit 8 set to “0”, and the remaining bits of the first (only) length octet coded using a binary number with Bit 1 being the least significant bit, as follows:

8	7 6 5 4 3 2 1
0	Length of contents

  The long form is used to encode lengths greater than 127 octets as follows. When used, Bit 8 of the first length octet is set to “1” and the remaining bits of the first octet (Bits 1-7) are set to indicate the number of octets that follow (always 0000001). The second octet is coded with a binary number indicating the length, with Bit 1 of the second octet being the least significant bit.

8	7	6	5	4	3	2	1
1	0	0	0	0	0	1	1
Length of contents							

4.4.2 Invoke Identifier

8	7	6	5	4	3	2	1
0	0	0	0	0	0	1	0
Invoke Identifier tag							
Invoke Identifier length							
Invoke Identifier							
Invoke Identifier continued as needed							

- Invoke identifier length

  The invoke identifier length is coded using the short form of length. For the *5ESS*® switch, the invoke identifier is either one or two octets long.

- Invoke identifier

  The invoke identifier is an integer that is coded as a 2's complement binary number in one or two octets.[1]

4.4.3 Null Identifier

8	7	6	5	4	3	2	1
0	0	0	0	0	1	0	1
Null identifier tag							
0	0	0	0	0	0	0	0
Null identifier length							

4.4.4 Operation Value

8	7	6	5	4	3	2	1
Operation value tag							
Operation value length							
Operation value							

- Operation value tag

1. This conforms to Bellcore, *PRI Common Element Procedures and Service Information Transport Generic Requirements*, Issue 1, October 1994 (GR-2823-CORE), which allows invoke identifiers of up to two octets in length.

Bits								
8	7	6	5	4	3	2	1	Meaning
0	0	0	0	0	0	1	0	Integer
0	0	0	0	0	1	1	0	Object identifier

- Operation value length

  The operation value length is coded using the short form of length.

- Operation value

  The operation value is coded as a 2's complement binary number in the fewest possible number of octets when the integer tag is used, or as an object identifier when the object identifier tag is used, as described in Section 4.4.5, "Object Identifier Value."

4.4.5 Object Identifier Value

An object identifier is a sequence of non-negative integer values coded as subidentifiers. The first two integer values of the sequence (X,Y) are used to form the first subidentifier using the formula (40×X+Y). Each subsequent integer value is the next subidentifier in the sequence. The subidentifiers are coded individually as unsigned binary numbers and then concatenated to form the object identifier.

For example, the object identifier for information Following operation {1 2 840 10005 0 4} is coded as:

8	7	6	5	4	3	2	1	Subidentifiers Represented
0	0	1	0	1	0	1	0	(40 × 1) + 2
	Subidentifier 1							
1	0	0	0	0	1	1	0	840
	Subidentifier 2							
0	1	0	0	1	0	0	0	
	Subidentifier 2 cont.							
1	1	0	0	1	1	1	0	10005
	Subidentifier 3							
0	0	0	1	0	1	0	1	
	Subidentifier 3 cont.							
0	0	0	0	0	0	0	0	0
	Subidentifier 4							
0	0	0	0	0	1	0	0	4
	Subidentifier 5							

4.4.6 Sequence

8	7	6	5	4	3	2	1
0	0	1	1	0	0	0	0
Sequence tag							
Sequence length[a]							

See note(s) at end of table.

Note(s):
a. Sequence length is coded as described in Section 4.4.1, “Component Type.”

4.4.7 Error Value

8 7 6 5 4 3 2 1
Error value tag
Error value length
Error value

- Error value tag

Bits 8 7 6 5 4 3 2 1	Meaning
0 0 0 0 0 0 1 0	Integer
0 0 0 0 0 1 1 0	Object Identifier

- Error value length

  The error value length is coded using the short form of length as described in Section 4.4.1, “Component Type.”

- Error value

  The error value is coded using a 2's complement binary number in the fewest number of octets when the integer tag is used, or as an object identifier when the object identifier tag is used, as described in Section 4.4.5, “Object Identifier Value.”

4.4.8 Problem Value

8 7 6 5 4 3 2 1
Problem value tag
Problem value length
Problem value

- Problem value tag

Bits 8 7 6 5 4 3 2 1	Meaning
1 0 0 0 0 0 0 0	General problem tag
1 0 0 0 0 0 0 1	Invoke problem tag
1 0 0 0 0 0 1 0	Return Result problem tag
1 0 0 0 0 0 1 1	Return Error problem tag

- Problem value length

  The problem value length is coded using the short form of length, as described in “Component Type,” Section 4.4.1.

- Problem value
  - General Problem

Bits 8 7 6 5 4 3 2 1	Meaning
0 0 0 0 0 0 0 0	Unrecognized component
0 0 0 0 0 0 0 1	Mistyped component
0 0 0 0 0 0 1 0	Badly structured component

  - Invoke Problem

Bits 8 7 6 5 4 3 2 1	Meaning
0 0 0 0 0 0 0 0	Duplicate invocation
0 0 0 0 0 0 0 1	Unrecognized operation
0 0 0 0 0 0 1 0	Mistyped argument

  - Return Result Problem

Bits 8 7 6 5 4 3 2 1	Meaning
0 0 0 0 0 0 0 0	Unrecognized invocation
0 0 0 0 0 0 1 0	Mistyped result

  - Return Error Problem

Bits 8 7 6 5 4 3 2 1	Meaning
0 0 0 0 0 0 0 0	Unrecognized invocation
0 0 0 0 0 0 1 0	Unrecognized error
0 0 0 0 0 0 1 1	Unexpected error
0 0 0 0 0 1 0 0	Mistyped parameter

4.4.9 Interpretation Value

The interpretation value is a single octet that is coded to one of three binary values, as shown in the following display.

8 7 6 5 4 3 2 1
Interpretation value

Bits 8 7 6 5 4 3 2 1	Meaning
0 0 0 0 0 0 0 0	Discard any invoke component containing an unrecognized operation value[a]
0 0 0 0 0 0 0 1	Clear call if any invoke component contains an unrecognized operation value
0 0 0 0 0 0 1 0	Discard any invoke component containing an unrecognized operation value and return a reject component

Note(s):
a. This is the only value sent by the switch.

4.4.10 Notification Value

8 7 6 5 4 3 2 1
Notification value tag
Notification value length
Notification value

- Notification value tag

Bits 8 7 6 5 4 3 2 1	Meaning
0 0 0 0 0 0 1 0	Integer
0 0 0 0 0 1 1 0	Object Identifier

- Notification value length

  The notification value length is coded using the short form of length as described in Section 4.4.1, “Component Type.”

- Notification value

  The notification value is coded using a 2’s complement binary number in the fewest number of octets when the integer tag is used, or as an object identifier when the object identifier tag is used, as described in Section 4.4.5, “Object Identifier Value.”

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5. CALL CONTROL PROCEDURES

This chapter is subdivided as follows:

- Section 5.1, "Call Control Procedures for Circuit-switched Calls"
- Section 5.2, "Topics Related to PRI Circuit-switched Call Control"
- Section 5.3, "Common Element Procedures for Service Control."

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5.1 CALL CONTROL PROCEDURES FOR CIRCUIT-SWITCHED CALLS

The procedures outlined here apply to both the Custom and National ISDN primary rate interfaces. These procedures are not intended to be a comprehensive presentation of call processing, but are included to provide a call control framework. The call states are listed in “Call States,” Section 4.1.2. The information elements (IEs) and the coding details for the Q.931 messages discussed in this section can be found in “Message Functional Definitions,” Section 4.2, and “Information Elements,” Section 4.3. Particulars for services can be found in “PRI Service-Specific Information,” Section 11; for example, call-by call access to foreign exchange (FX) and tie trunks can be found in “PRI Call-by-Call Service Selection,” Section 11.3.

Before these procedures are invoked, a reliable data link connection must be established between the two sides of the ISDN interface.

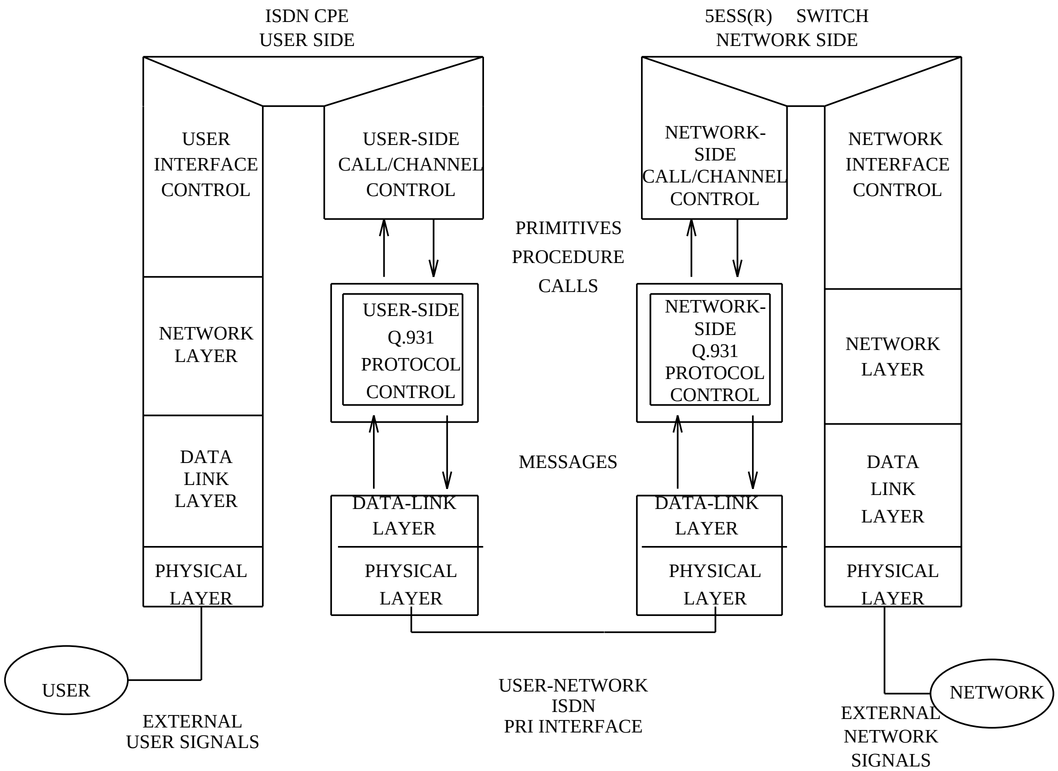
The call states referred to in this section cover the states perceived by the network, states perceived by the user, and states common to both user and network. Unless specifically qualified, all states described in the following text should be understood as common (see “Call States,” Section 4.1.2, for user and network call states).

Detailed specification and description language (SDL) diagrams for the procedures specified in this section are contained in “User Side SDL Diagrams,” Section 6.2, “Network Side SDL Diagrams,” Section 7.2, and “Symmetrical User Side SDL Diagrams,” Section 8.2. When there is an ambiguity in the narrative text, the SDL diagrams should be used to resolve conflict. Where the text and the SDL are in disagreement, the text should be used as the prime source.

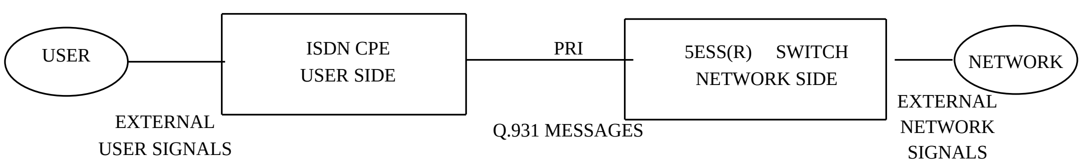
5.1.1 PRI CALL CONTROL OVERVIEW

5.1.1.1 Representation of Network and User Elements

A typical PRI configuration is shown in Figure 5.1-1, as represented as a protocol stack diagram. The *5ESS*® switch is composed of a PRI protocol stack, a general network interface protocol stack, and the internal *5ESS* switch functions such as routing. The network interface protocol could be SS7, for example. Similarly, the user side customer premises equipment (CPE) is represented as a general protocol stack for the user’s side of the PRI and a protocol stack for the interface between the private branch exchange (PBX) and the end-user equipment. The end-user equipment may be an ISDN BRI on the PBX, an analog termination, or possibly a trunk to another PBX or another PRI. Messages passed over the PRI that connects the *5ESS* switch to the PBX or other Class II equipment are covered by this specification. Information consists of electrical signals at the physical layer, Q.921 messages at the data link layer, and Q.931 messages passing between the data link layer and the network layer. This section is concerned with the operations at the network layer, as represented by the double boxes in Figure 5.1-1-a denoted user-side Q.931 protocol control and network-side Q.931 protocol control.



a. Protocol Stack diagram of Elements Between User and Network



b. Simplified Configuration from User to Network

Figure 5.1-1 — Representation of Switch as Network Side

Messages received from the network pass up through the network interface stack and result in the invocation of a primitive by the network call control element at the interface to the network Q.931 protocol layer. Similarly, messages sent out to the network from the network-side Q.931 protocol control element are initiated by invocation of a call control primitive at the network-side Q.931 protocol control element. The primitive results in an external message that is sent to the network. Similar considerations apply to the sending and receiving of messages from the user to the elements on the user side of Figure 5.1-1-a. Procedure calls may be invoked at the protocol control-call/channel control interface. Typically, procedure calls involve channel control or resource control operations.

In the detailed SDL diagrams of “User Side SDL Diagrams,” Section 6.2, “Network Side SDL Diagrams,” Section 7.2, and “Symmetrical User Side SDL Diagrams,” Section 8.2, the primitives are referred to specifically; however, for the overview of call control in this section, we shall consider a simplified representation as shown in Figure 5.1-1-b. In the simplified representation, we may consider that the elements on the network side switch are lumped together into a single element with two interfaces: a PRI interface through which Q.931 messages flow, and a network interface through which external network signals flow. Similarly, Figure 5.1-2-a shows the protocol stack diagram for the *5ESS* switch when it is configured as the symmetrical user side of the PRI. The simplified representation of the user side CPE, as shown in Figure 5.1-2-b shows all user side elements lumped together with the PRI interface, through which Q.931 messages flow, and a user interface through which external user signals are exchanged with the user side. The external user and network signals may be representative of equivalents of Q.931 messages.

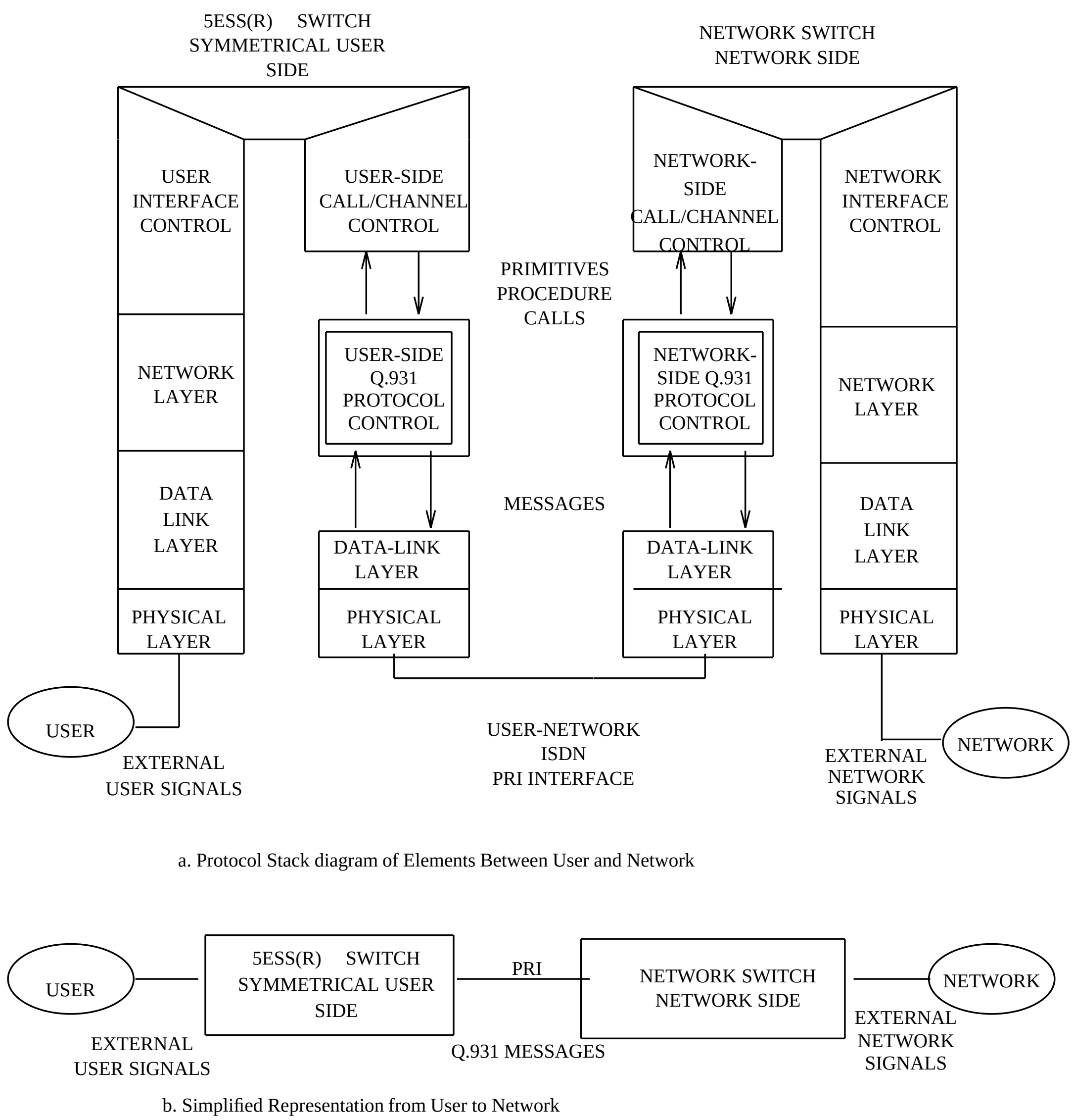


Figure 5.1-2 — Representation of Switch as Symmetrical User Side

5.1.1.2 Call States and Transitions

Figure 5.1-3 shows an overview of the call states and signals required to produce transitions between call states when the *5ESS* switch provides the network side of the PRI. The bubbles represent call states and the arrows represent transitions between states. As shown in the legend, the labels on the arrows indicate the stimuli received in the present state (at the tail of the arrow) that cause a transition to the next state (at the tip of the arrow). For example, when the network side of the PRI in the null (N0) state receives a SETUP message over the PRI, it transitions to the outgoing call proceeding (N3) state (provided that certain conditions are met, as described in the following sections). This is an example of a PRI call origination. Similarly, if a NETWORK SETUP signal is received by the *5ESS* central office (CO) switch from the network, the network side of the PRI transitions to the call present (N6) state, provided that certain conditions are met. This is an example of a PRI call termination. The NETWORK SETUP may appear to the switch as one of several indications, depending on the particular type of interface between the switch and the network. For example, if there were a PRI to the network, the NETWORK SETUP signal would be a Q.931 SETUP message, for an SS7 interface the NETWORK SETUP signal would be an SS7 initial address message (IAM) message.

Figure 5.1-3 shows only the normal signals that are received by the switch that can cause transitions to a progressive next state. The figure does not show signals sent out by the network side of the PRI or the response to other signals that may not produce a state transition. Also not shown are transitions that may occur due to error conditions, failure conditions, timer timeouts, and so forth. Timers shown in the figure, such as T303 and T310, indicate timers that are active in the state and that, upon expiry, would cause possible tear-down of the call. Note that timers may be started in a different state from that in which expiry is indicated in the figure. A specification of timers is given in “PRI Timers,” Section 5.2.6. States labeled STAT ENQ are those in which call status enquiries may be initiated, as described in “Call Activity Checks (STATUS ENQUIRY Procedures),” Section 5.2.1. States labeled STATUS are those in which a call may be cleared if a STATUS message is sent from that state in response to a STATUS ENQUIRY message.

A detailed representation is provided by the SDL diagrams in “Network Side SDL Diagrams,” Section 7.2. Thus Figure 5.1-3 represents the progression of states from the null (N0) state to the active (N10) state for PRI originations and terminations. The figure also shows the transitions for call clearing, from the active state to the null state, for the case of a DISCONNECT message received over the PRI and for the case of a NETWORK DISCONNECT indication received by the switch from the network.

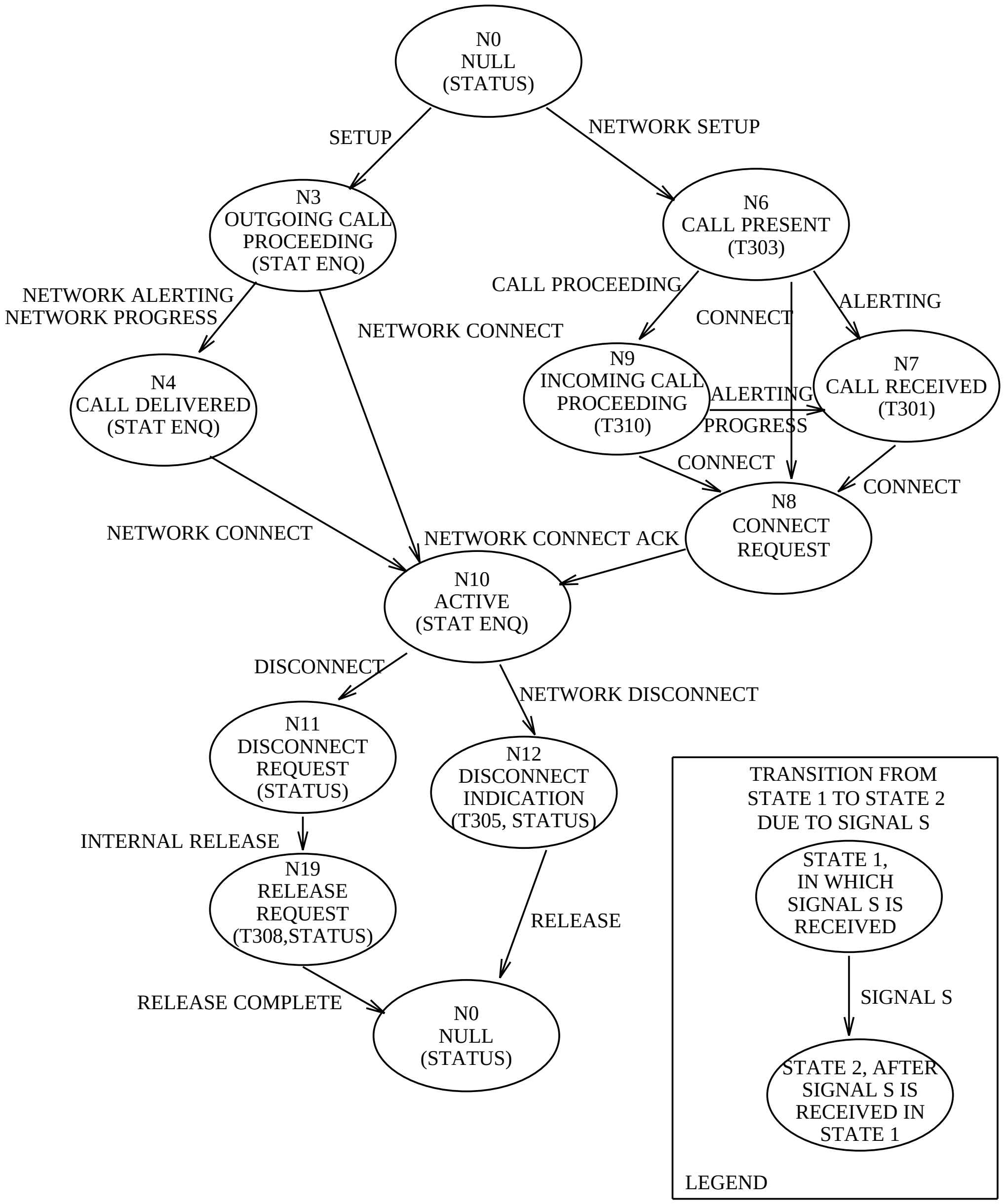


Figure 5.1-3 — Call States and Normal Transitions for Network Side

Figure 5.1-4 shows an overview of the call states and signals required to produce transitions between call states when the *5ESS* switch provides the symmetrical user side of the PRI. In this figure, an outgoing PRI call from the user side begins with a USER SETUP signal, which is received by the user side CPE from the user. An incoming PRI call is initiated by the receipt of a SETUP message over the PRI at the user's side of the PRI.

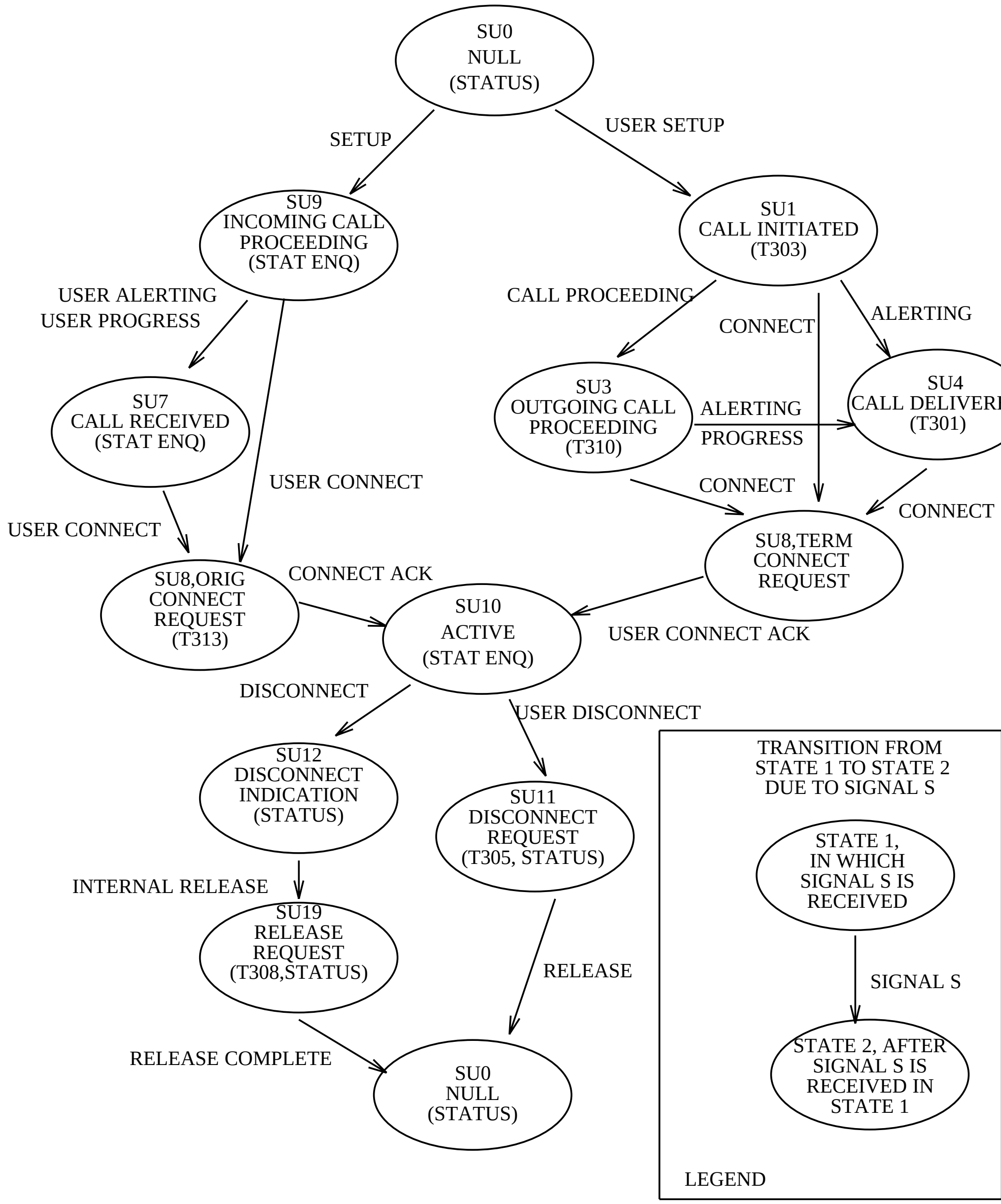


Figure 5.1-4 — Call States and Normal Transitions for Symmetrical User Side

As can be seen in Figure 5.1-3 and in Figure 5.1-4, for call originations, the symmetrical user side states correspond generally to the network side states, indicated as follows:

- Symmetrical user state SU9, incoming call proceeding, corresponds to network state N3, outgoing call proceeding.
- Symmetrical user state SU7, call received, corresponds to network state N4, call delivered.

- Symmetrical user state SU8, connect request, is used as an origination state as well as for a termination state. There is no corresponding state for network originations. Timer T313 applies to the SU8 state and does not act in the N8 state.

The discussion serves as an explanation of Figures 5.1-3 and 5.1-4; however the discussion sometimes goes beyond the level of detail in Figures 5.1-3 and 5.1-4. It may be helpful to refer to Figure 5.1-5 and “Network Side SDL Diagrams,” Section 7.2, and “Symmetrical User Side SDL Diagrams,” Section 8.2, for more detailed representations.

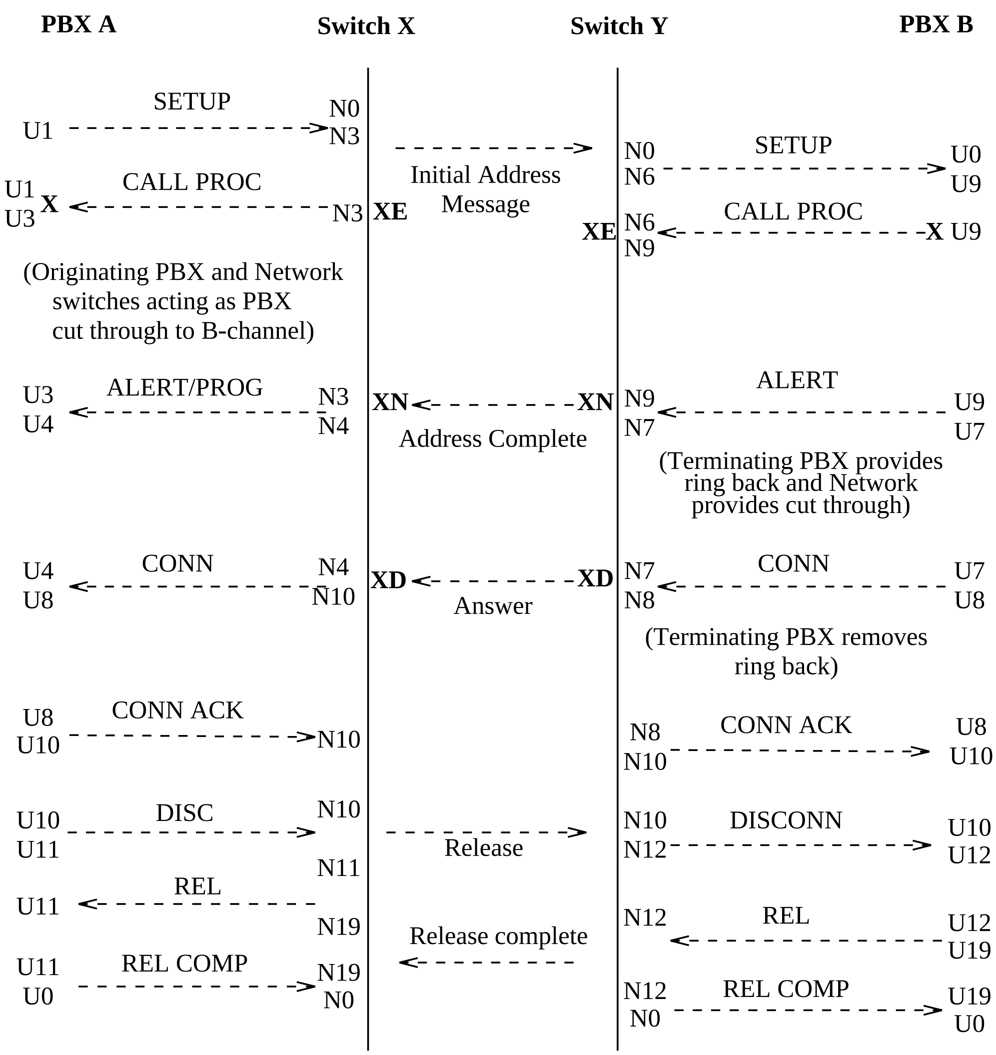
For terminations, the correspondence between symmetrical user states and network states is as follows:

1. Symmetrical user state SU1, call initiated, corresponds to network state N6, call present.
2. Symmetrical user state SU3, outgoing call proceeding, corresponds to network state N9, incoming call proceeding.
3. Symmetrical user state SU4, call delivered, corresponds to network state N7, call received.

For call tear down, the correspondence between symmetrical user states and network states is as follows:

- Symmetrical user state SU12, disconnect indication, corresponds to network state N11, disconnect request.
- Symmetrical user state SU11, disconnect request, corresponds to network state N12, disconnect indication.
- Symmetrical user state SU19, release request, corresponds to network state N19, release request.

Figure 5.1-5 shows the messages flowing across PRI interfaces for a call originated at a PBX (PBX A, configured as a user side of a PRI), carried over a PRI to a switch (switch X, configured as a network side of the PRI). The call flows to the network, indicated as an SS7 network to switch Y, where the call terminates on a PRI to PBX B. The end-users are interfaced to the two PBXs. Assuming that the end users are ISDN customers, this would be an end-to-end ISDN call. Also shown on Figure 5.1-5 are the network states and user states that are active when messages flow across the PBXs. Points at which paths are cut through are also indicated.



Note: XN denotes B-channel cut-through (Normal)
XD denotes B-channel cut-through (Delayed)
XE denotes B-channel cut-through (Early)
X denotes B-channel cut-through at the PBX

Figure 5.1-5 — Message Flow for ISDN Call

5.1.2 CALL ORIGINATION—NETWORK SIDE TREATMENT

This section describes the procedures that apply to basic circuit-switched call originations on the PRI (that is, incoming calls to the *5ESS* switch over the PRI).

5.1.2.1 Call Origination—Network Side

Call originations are initiated from the null (N0) state by the receipt of a SETUP message over the PRI. If for some reason the call cannot proceed because of the contents of the SETUP message or the requested channel or service is not available, a RELEASE COMPLETE message is returned with a cause code value indicating the reason for the failed call attempt.

After verifying the SETUP message content and allocating the requested channel, a CALL PROCEEDING message is returned in response to the SETUP message, a network call setup request is made, and the call state transitions to the outgoing call proceeding state (N3).

5.1.2.2 Outgoing Call Proceeding State—Network Side

When the network call is terminated, the response of the network determines the actions taken. In general, for non-ISDN terminations, a NETWORK PROGRESS indication is received at the network side of the PRI as a primitive from network side call control. See Figure 5.1-1.

On the Custom PRI, a PROGRESS message containing a progress indicator IE is returned across the PRI for all non-ISDN terminations.

On the National ISDN PRI, the message type returned across the PRI depends on the type of non-ISDN termination. A PROGRESS message containing the progress indicator IE is returned across the PRI when interworking occurs with a non-ISDN network trunk or when the call is routed to an in-band tone or announcement. For a non-ISDN line termination, either a PROGRESS or an ALERTING message may be returned as a recent change-able option. In compliance with Telcordia specifications, the default treatment is to return an ALERTING message across the National ISDN PRI.

The progress indicator indicates that the call is not end-to-end ISDN, that the destination is not ISDN, or that in-band information/treatment has been applied. For end-to-end ISDN terminations, a NETWORK ALERTING indication is received at the network side of the PRI from network side call control. An ALERTING message is sent across the PRI to the user. After sending the PROGRESS or ALERTING message, the call state transitions to the call delivered (N4) state.

If a NETWORK CONNECT indication is received while the call is in the outgoing call proceeding (N3) state, a CONNECT message is sent over the PRI and the call state transitions to the active (N10) state.

For cases in which the network call cannot be set up, either the call is released back to the originator where a tone/announcement may be applied, or a tone/announcement may be applied in-band. If a tone or announcement is applied, the call state transitions to the tone active (N18) state, which is not shown in Figure 5.1-3.

In general, for data calls, a DISCONNECT message is returned with a cause code value indicating the reason for the failure. For voice calls a tone/announcement is applied. Exceptions for voice include call termination failures that result in busy or reorder treatment, where the call is released back to the originator with a DISCONNECT containing a cause code value of 17 “user busy” or of 34 “no circuit or channel available”; in these cases, the treatment is applied by the originating switch/equipment. Other exceptions may occur due to implementation variations of switching equipment or procedures applied outside of the local network.

5.1.2.3 Call Delivered State—Network Side

When the called party answers, a NETWORK CONNECT indication that a network connection has been made is received in the call delivered (N4) state, a CONNECT message is returned over the PRI, and the call state transitions to the active (N10) state.

If the call terminated to a non-ISDN line and the *5ESS* switch PRI is configured as network side, a progress indicator IE indicating that the destination is not ISDN is included in the CONNECT message.

If the *5ESS* switch PRI is configured as user side when the CONNECT message is sent, Timer T313 is started. When a CONNECT ACKNOWLEDGE message is received, Timer T313 is stopped and the call state transitions to the active (N10) state. If no CONNECT ACKNOWLEDGE is received and Timer T313 expires, then the call is cleared. For a *5ESS* switch network side PRI, the CONNECT ACKNOWLEDGE message is optional (that is, Timer T313 does not apply).

5.1.3 CALL TERMINATION—NETWORK SIDE TREATMENT

This section describes the procedures that apply to basic circuit-switched call terminations at the PRI (that is, outgoing calls from the *5ESS* switch).

5.1.3.1 Call Termination—Network Side

When a NETWORK SETUP indication is received from the network that a call is to be terminated at the PRI, the *5ESS* switch reserves a B-channel, allocates a call-reference value, and sends a SETUP message over the PRI. If the call originated from a non-ISDN trunk and the *5ESS* switch PRI is configured as network side, a progress indicator IE indicating that the call is not end-to-end ISDN is included in the SETUP message.

Upon sending the SETUP message, Timer T303 is started and the call state transitions from the null (N0) state to the call present (N6) state.

5.1.3.2 Call Present State—Network Side

If no valid response is received and Timer T303 expires, then a second SETUP is sent and Timer T303 is started for a second time. If again no valid response is received and the second Timer T303 expires, the call is abandoned with no indication.

CALL PROCEEDING, ALERTING, and CONNECT messages are all valid as first nonclearing responses to a SETUP message. For the nonclearing messages, the channel identification IE is mandatory and must match the channel sent in the SETUP message.

Note: Unless Channel Negotiation is provisioned, the call is released with a RELEASE COMPLETE message containing a cause code value of 100 “invalid information element contents.”

The following actions are taken when a message is received in the call present (N6) state. Timer T303 is stopped and

- If a CONNECT message is received as the first response, the call state transitions to the connect request (N8) state.
- If a CALL PROCEEDING message is received as the first response, then Timer T310 is started and the call state transitions to the incoming call proceeding (N9) state. If no further response is received (for example, ALERTING or CONNECT) and Timer T310 expires, the call is released with a RELEASE message containing cause code value of 102 “recovery on timer expiration.”
- If an ALERTING message is received as the first response, then Timer T301 is started and the call state transitions to the call received (N7) state. If no further response is received (for example, CONNECT) and Timer T301 expires, the call is

released with a RELEASE message containing a cause code value of 102 “recovery on timer expiration.”

- If any call clearing message, DISCONNECT, RELEASE, or RELEASE COMPLETE is received as the first response, then either the call is cleared back to the originator or the appropriate tone/announcement is applied. For example, a DISCONNECT with a cause code value of 17 may result in busy tone being applied back to the originator.

5.1.3.3 Incoming Call Proceeding State—Network Side

The incoming call proceeding (N9) state is reached upon receipt of a CALL PROCEEDING message as the first response to the SETUP message. The procedures for receiving an ALERTING, PROGRESS, or CONNECT message in this state are the same as in the case of the first response to a SETUP message, with the exception that the channel identification IE is not mandatory and Timer T310 is stopped.

If a clearing message is received in the CALL PROCEEDING state, then the call is cleared back to the originator.

5.1.3.4 Call Received State—Network Side

The call received (N7) state is reached upon receipt of an ALERTING message as the first response to the SETUP message or following a CALL PROCEEDING message. The procedures for receiving a CONNECT message in the call received (N7) state are the same as in the case of the first response to a SETUP message, with the exception that the channel identification IE is not mandatory and the Timer T301 is stopped.

If a clearing message is received after receiving an ALERTING message, then the call is cleared back to the originator.

5.1.3.5 Connect Request State—Network Side

The connect request (N8) state is reached upon receipt of a CONNECT message from the user side of the PRI in the call present (N6), call received (N7), or incoming call proceeding (N9) states. When a network CONNECT ACKNOWLEDGE message is received, the call state moves to the active (N10) state.

5.1.3.6 Active State—Network Side

The active (N10) state is reached from the connect request (N8) state upon receipt of a NETWORK CONNECT ACKNOWLEDGMENT signal from the network side. A call in the active (N10) state remains in this state until a call clearing message is received.

5.1.4 CALL CLEARING—NETWORK SIDE TREATMENT

The following terms are used in the description of 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.

Normal call clearing is initiated when one of the following events occurs during a stable call, that is, when both the user side and the network side of the PRI are in the active (N10) states. The states and transitions are shown in Figure 5.1-3.

A NETWORK DISCONNECT indication is received from the network at the network side of the PRI. The network side sends a DISCONNECT message across the PRI to the user side, starts Timer T305, and transitions to the disconnect indication (N12) state.

In the disconnect indication (N12) state, when a RELEASE message is received, the channel is released and the call state transitions to the null (N0) state.

If Timer T305 expires (that is, no RELEASE message received in response to a DISCONNECT message), then a RELEASE message with a cause code value of 102 “recovery on timer expiration” is sent and Timer T308 is started. The call state transitions to the release request (N19) state.

In state N19, if Timer T308 expires (that is, no RELEASE COMPLETE message received in response to a RELEASE message), then a second RELEASE message with a cause code value of 102 “recovery on timer expiration” is sent, and Timer T308 is started for a second time. If again no RELEASE COMPLETE message is received and the second Timer T308 expires, then the channel allocated for the call is cleared by sending a RESTART message (see “RESTART,” Section 4.2.11, and “RESTART ACKNOWLEDGE PROCEDURES,” Section 4.2.12). The restart procedure results in the call state returning to the null (N0) state.

A DISCONNECT message is received from the user side of the PRI at the network side of the PRI. Upon receipt of the DISCONNECT message, a NETWORK DISCONNECT message is sent to the network and the call state transitions to the disconnect request (N11) state. The channel is disconnected, a RELEASE message is sent to the user side of the PRI, Timer T308 is started, and the call state transitions to the release request (N19) state. In the release request (N19) state, a RELEASE COMPLETE message results in a transition to the null (N0) state. Transitions to the null (N0) state also occur upon a second expiry of Timer T308.

5.1.4.1 Clearing Initiated by the Network when Tones/Announcements Not Provided

Clearing when in-band tones/announcements are provided is described in “In-Band Tones and Announcements,” Section 5.2.7. When in-band tones/announcements are not provided, the DISCONNECT message does not contain a progress indicator IE with Progress Descriptor 8 “in-band information or appropriate pattern now available.” The network shall initiate clearing by sending the DISCONNECT message, starting Timer T305, disconnecting the B-channel, and entering the disconnect indication (N12) state.

On the receipt of the DISCONNECT message without a progress indicator IE with Progress Descriptor 8, the user shall disconnect the B-channel, send a RELEASE message, start Timer T308, and enter the release request (N19) state.

On receipt of the RELEASE message, the network shall stop Timer T305, release the B-channel, send a RELEASE COMPLETE message, release the call reference, and return to the null (N0) state.

If Timer T305 expires, the network shall send a RELEASE message to the user with the cause code value originally contained in the DISCONNECT message or a cause code value of 102 “recovery on timer expiry,” start Timer T308, and enter the release request (N19) state.

5.1.5 CALL ORIGINATION—SYMMETRICAL USER SIDE TREATMENT

This section describes the procedures that apply to basic circuit-switched call originations on the PRI that is configured as a symmetrical user on a *5ESS* switch. See Figure 5.1-4 for the states and the transitions among them. The *5ESS* switch supports the symmetrical user side implementation when provisioned as a user side of the PRI. As seen in Figure 5.1-4, the symmetrical user side states correspond generally to the network side states as indicated in the following:

- Symmetrical user state SU9, incoming call proceeding, corresponds to network state N3, outgoing call proceeding.
- Symmetrical user state SU7, call received, corresponds to network state N4, call delivered.
- Symmetrical user state SU8, connect request, is used as an origination state as well as a termination state. There is no corresponding state for network originations. Timer T313 applies to the SU8 state and does not act in the N8 state.

5.1.5.1 Call Origination—Symmetrical User Side

Call originations are initiated from the null (SU0) state by the receipt of a SETUP message over the PRI. If for some reason the call cannot proceed because of the contents of the SETUP message or the requested channel or service is not available, a RELEASE COMPLETE message is returned with a cause code value indicating the reason for the failed call attempt.

After verifying the SETUP message content and allocating the requested channel, a CALL PROCEEDING message is returned in response to the SETUP message, a network call setup request is made, and the call state transitions to the incoming call proceeding (SU9) state.

5.1.5.2 Incoming Call Proceeding State—Symmetrical User Side

When the call to the user is terminated, the response of the user determines the actions taken.

On the Custom PRI, a PROGRESS message containing a progress indicator IE is returned across the PRI for all non-ISDN terminations.

On the National ISDN PRI, the message type returned across the PRI depends on the type of non-ISDN termination. A PROGRESS message containing the progress indicator IE is returned across the PRI when interworking occurs with a non-ISDN network trunk or when the call is routed to an in-band tone or announcement. For a non-ISDN line termination, either a PROGRESS or an ALERTING message may be returned as a recent change-able option. In compliance with Telcordia specifications, the default treatment is to return an ALERTING message across the National ISDN PRI.

The progress indicator indicates that the call is not end-to-end ISDN, that the destination is not ISDN, or that in-band information/treatment has been applied. For end-to-end ISDN terminations, an USER ALERTING indication is received at the network side of the PRI from the network. The user side sends an ALERTING message across the PRI to the network. After sending the PROGRESS or ALERTING message, the call state transitions to the call received (SU7) state.

If a USER CONNECT indication is received while the call is in the incoming call proceeding (SU9) state, a CONNECT message is sent over the PRI and the call state transitions to the active (SU10) state.

For cases in which the user call cannot be set up, either the call is released back to the originator where a tone/announcement may be applied or a tone/announcement may be applied in-band. If a tone or announcement is applied, the call state transitions to the tone active (SU18) state, which is not shown.

In general, for data calls a DISCONNECT message is returned with a cause code value indicating the reason for the failure; for voice calls a tone/announcement is applied. Exceptions for voice include call termination failures that result in busy or reorder treatment where the call is released back to the originator with a DISCONNECT containing a cause code value of 17 “user busy” or of 34 “no circuit or channel available”; in these cases, the treatment is applied by the originating switch/equipment. Other exceptions may occur due to implementation variations of switching equipment or procedures applied outside of the local network.

5.1.5.3 Call Received State—Symmetrical User Side

When the called party answers, a USER CONNECT indication that a user connection has been made is received in the call received (SU7) state, a CONNECT message is returned over the PRI, and the call state transitions to the connect request (SU8) state.

As the *5ESS* switch PRI is configured as user side, when the CONNECT message is sent, Timer T313 is started. When a CONNECT ACKNOWLEDGE message is received, Timer T313 is stopped and the call state transitions to the active (SU10) state. If no CONNECT ACKNOWLEDGE is received and Timer T313 expires, then the call is cleared.

5.1.5.4 Connect Request State—Symmetrical User Side

In the connect request (SU8) state for PRI originations, a transition is made to the active (SU10) state when a CONNECT ACKNOWLEDGMENT message is received from the network side.

5.1.6 CALL TERMINATION—SYMMETRICAL USER SIDE TREATMENT

This section describes the procedures that apply to basic circuit-switched call terminations at the PRI (that is, outgoing calls from a *5ESS* switch that is configured as a symmetrical user side of the PRI).

5.1.6.1 Call Termination—Symmetrical User Side

When a USER SETUP indication is received from the user that a call is to be terminated at the PRI, the *5ESS* switch reserves a B-channel, allocates a call-reference value, and sends a SETUP message over the PRI. If the call originated from a non-ISDN trunk and the *5ESS* switch PRI is configured as network side, a progress indicator IE indicating that the call is not end-to-end ISDN is included in the SETUP message.

Upon sending the SETUP message, Timer T303 is started and the call state transitions from the null (SU0) state to the call initiated (SU1) state.

5.1.6.2 Call Initiated State—Symmetrical User Side

If no valid response is received and Timer T303 expires, then a second SETUP is sent and Timer T303 is started for a second time. If again no valid response is received and the second Timer T303 expires, the call is abandoned with no indication.

CALL PROCEEDING, ALERTING, and CONNECT messages are all valid as first nonclearing responses to a SETUP message. For the nonclearing messages the channel identification IE is mandatory and must match the channel sent in the SETUP message.

The following actions are taken when a message is received in the call initiated (SU1) state. Timer T303 is stopped, and

- If a CONNECT message is received as the first response, the call state transitions to the connect request (SU8) state and a CONNECT ACKNOWLEDGE message is returned across the PRI. For terminations, when a USER CONNECT ACKNOWLEDGE indication is received from the user, the call state moves to the active (SU10) state.
- If a CALL PROCEEDING message is received as the first response, then Timer T310 is started and the call state transitions to the outgoing call proceeding (SU3) state. If no further response is received (for example, ALERTING or CONNECT) and Timer T310 expires, the call is released with a RELEASE message containing a cause code value of 102 “recovery on timer expiration.”
- If an ALERTING message is received as the first response, then Timer T301 is started and the call state transitions to the call delivered (SU4) state. If no further response is received (for example, CONNECT) and Timer T301 expires, the call is released with a RELEASE message containing a cause code value of 102 “recovery on timer expiration.”
- If any call clearing message, DISCONNECT, RELEASE, or RELEASE COMPLETE is received as the first response, then either the call is cleared back to the originator or the appropriate tone/announcement is applied. For example, a DISCONNECT with a cause code value of 17 may result in busy tone being applied back to the originator.

5.1.6.3 Outgoing Call Proceeding State—Symmetrical User Side

The outgoing call proceeding (SU3) state is reached upon receipt of a CALL PROCEEDING message as the first response to the SETUP message. The procedures for receiving an ALERTING, PROGRESS, or CONNECT message in this state are the same as in the case of the first response to a SETUP message, with the exception that the channel identification IE is not mandatory and the Timer T310 is stopped.

If a clearing message is received in the outgoing call proceeding (SU3) state, then the call is cleared back to the originator.

5.1.6.4 Call Delivered State—Symmetrical User Side

The call delivered (SU4) state is reached upon receipt of an ALERTING message as the first response to the SETUP message or following a CALL PROCEEDING message. The procedures for receiving a CONNECT message in the call delivered (SU4) state are the same as in the case of the first response to a SETUP message, with the exception that the channel identification IE is not mandatory and the Timer T301 is stopped.

If a clearing message is received after receiving an ALERTING message, then the call is cleared back to the originator.

5.1.6.5 Connect Request State—Symmetrical User Side

The connect request (SU8) state is reached upon receipt of a CONNECT message from the network side of the PRI in the call initiated (SU1), call delivered (SU4), or outgoing call proceeding (SU3) states. The connect request (SU8) state waits for receipt of a USER CONNECT ACKNOWLEDGMENT signal from the user. This signal must arrive before Timer T313 expires.

5.1.6.6 Active State—Symmetrical User Side

A call in the active (SU10) state remains in this state until a call clearing message is received.

5.1.7 CALL CLEARING—SYMMETRICAL USER SIDE TREATMENT

Normal call clearing is initiated when one of the following events occurs during a stable call, that is, when both the user side and the network side of the PRI are in the active (SU10) states. The states and transitions are shown in Figure 5.1-4.

- A USER DISCONNECT indication is received from the user at the user side of the PRI. The symmetrical user side sends a DISCONNECT message across the PRI to the network side, starts Timer T305, and transitions to the disconnect request (SU11) state.

  In the disconnect request (SU11) state, the system waits to receive a RELEASE message from across the PRI. When a RELEASE message is received, the channel is released and the call state transitions to the null (SU0) state.

  If Timer T305 expires (that is, no RELEASE message received in response to a DISCONNECT message), then a RELEASE message with a cause code value of 102 “recovery on timer expiration” is sent and Timer T308 is started. The call state transitions to the release request (SU19) state.

  In state SU19, if Timer T308 expires (that is, no RELEASE COMPLETE message received in response to a RELEASE message), then a second RELEASE message with a cause code value of 102 “recovery on timer expiration” is sent and Timer T308 is started for a second time. If again no RELEASE COMPLETE message is received and the second Timer T308 expires, then the channel allocated for the call is cleared by sending a RESTART message (see “RESTART,” Section 4.2.11, and “RESTART ACKNOWLEDGE PROCEDURES,” Section 4.2.12). The restart procedure results in the call state returning to the null (SU0) state.

- A DISCONNECT message is received from the network side of the PRI at the symmetrical user side of the PRI. Upon receipt of the DISCONNECT message, a USER DISCONNECT message is sent to the user and the call state transitions to the disconnect indication (SU12) state. The channel is disconnected, a RELEASE message is sent to the user side of the PRI, Timer T308 is started, and the call state transitions to the release request (SU19) state. In the release request (SU19) state, a RELEASE COMPLETE message from the network results in a transition to the null (SU0) state. Transitions to the null (SU0) state also occur upon a second expiry of Timer T308.

5.1.7.1 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 (N12) state, the network shall stop Timer T305 or T306 (whichever is running), disconnect the B-channel (if not disconnected), send a RELEASE message, start Timer T308, and enter the release request (N19) state. Similarly, when the user receives a DISCONNECT message while in the disconnect request (SU11) state, the user shall stop Timer T305, send a RELEASE message, start Timer T308, and enter the release request (SU19) 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 (SU19) state shall stop Timer T308, release the call reference and B-channel if appropriate, send a RELEASE COMPLETE message, and enter the null (SU0) state.

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5.2 TOPICS RELATED TO PRI CIRCUIT-SWITCHED CALL CONTROL

5.2.1 CALL ACTIVITY CHECKS (STATUS ENQUIRY PROCEDURES)

STATUS ENQUIRY messages are sent to audit the status of calls (this action is known as a call activity check) either periodically, or immediately following a D-channel recovery or switch. STATUS ENQUIRY messages are sent for only calls in nonclearing states where no Layer 3 timer is running. These states, from which a STATUS ENQUIRY message is sent, include:

N3 outgoing call proceeding state

N4 call delivered state

N7 call received state

N10 call active state

U4 call delivered state

U7 call received state

U9 incoming call proceeding state

U10 call active state

A STATUS message is sent by the distant system in response to the STATUS ENQUIRY message. The STATUS message includes a cause code value and the current call state of the distant system that is sending the STATUS message (see “STATUS,” Section 4.2.14). Typically the cause code value is 30 “response to STATUS ENQUIRY.” Call state matching is done to determine the action to be taken. If the call state returned in the received STATUS message is incompatible with the state from which the STATUS ENQUIRY message was sent, the call is cleared; otherwise, no action is taken.

For any of the call states from which the STATUS ENQUIRY message is sent (that is, N3, N4, N7, N10, U4, U7, U9, or U10), if the call state that is returned in the received STATUS message is null or a call clearing state, the states are considered incompatible, and the call is cleared. The following call states in the received STATUS message result in clearing the call:

0 null state

N11 disconnect request state

N12 disconnect indication state

N19 release request state

U11 disconnect request state

U12 disconnect indication state

U19 release request state

If no STATUS message is received in response to STATUS ENQUIRY messages, then the call may be cleared either because Timer T322 has expired or because a threshold for no response to STATUS ENQUIRY messages has been exceeded. Timer T322 applies to active calls for the call activity check after a D-channel recovery or switch, and the threshold counter applies to the periodic call activity checks during normal operations.

5.2.2 RESTART/RESTART ACKNOWLEDGE PROCEDURES

The *5ESS*® switch initiates restart procedures on individual channels (that is, restart indicator class "000") when Timer T308 expires for the second time (that is, no response to the second RELEASE message). When a RESTART message is sent, Timer T316 is started. If no RESTART ACKNOWLEDGE message is received and Timer T316 expires, then a second RESTART message is sent and Timer T316 is started for a second time. If again no RESTART ACKNOWLEDGE message is received and the second Timer T316 expires, then the channel being restarted is taken out of service (OOS).

Additional restart procedures apply for maintenance operations on the National ISDN PRI (see "National ISDN PRI Maintenance Procedures," Section 9.3).

The *5ESS* switch uses restart procedures to return SWF-DS1, also known as NxDS0, channels to an idle condition when call clearing fails. Call clearing fails when Timer T308 has expired twice and the *5ESS* switch has not received a response to the RELEASE message for an NxDS0 call.

A RESTART message originating from the *5ESS* switch references the lowest channel number (channel with the smallest time slot number) of an NxDS0 call in the channel identification IE by using the channel number (not a slot map). If a valid RESTART ACKNOWLEDGE message is received from the far end, then all B-channels involved in the NxDS0 call are idled. If the far end sends a RESTART message with any channel number (not particularly the lowest channel number) of an NxDS0 call, a RESTART ACKNOWLEDGE message is sent with the same channel number in the channel identification IE as in the RESTART message and all B-channels involved in the NxDS0 call are idled.

5.2.3 CUT-THROUGH PROCEDURES

The PRI cut-through procedures refer to the voice or data path through the *5ESS* switch. In cutting through a path, the forward direction is from the originating end-user to the terminating end-user and backward direction is from the terminating end-user to the originating end-user. In general, the cut-through procedures are controlled by the termination (that is, a duplex path is set up immediately for an origination, however, until the path is cut-through at the termination, no path exits). The following options are assignable to a PRI and apply to the PRI termination.

EARLY Cut-Through. The path is cut through when the call originates. Cut through on a PRI call will take place in both directions on the receipt of the first valid response, that is, CALL PROCEEDING, ALERTING, PROGRESS, or CONNECT.

NORMAL Cut-Through. The path in the backward direction is cut through when the call originates. For a PRI call, cut-through will take place in the backward direction on the receipt of the ALERTING or PROGRESS message. Cut-through in the forward direction takes place when the terminating end answers and all appropriate protocol messages have been received at the originating end. For a PRI call, cut-through in the forward direction takes place on the receipt of the CONNECT message (see Figure 5.1-5).

DELAYED Cut-Through. The path is cut through in both directions after the terminating end answers and all appropriate protocol messages have been received at the originating end. For a PRI call, cut-through will take place in both directions on the receipt of the CONNECT message (see Figure 5.1-5).

For voice calls NORMAL and EARLY cut-through are allowed. For narrowband (64-kbps information transfer rate) data calls, all three options are allowed. For wide-band data calls (384-kbps, 1536-kbps, and multirate information transfer rates), only DELAYED cut-through is employed. Note that DELAYED cut-through is alwayed employed for wide-band data calls regardless of the way cut-through may be provisioned on the trunk group. For example, if both narrowband and wide-band calls are handled on a trunk group, and NORMAL cut-through is provisioned, the narrowband calls will be given NORMAL cut-through and the wide-band calls will be given DELAYED cut-through.

NORMAL and DELAYED cut-through are mainly intended for the central office (CO) case, whereas EARLY cut-through is intended for the *5ESS* switch PBX case. The *5ESS* switch PBX procedures are also the recommended procedures for any PBX that interfaces with a *5ESS* switch.

5.2.4 SETUP GLARE

SETUP glare occurs when both the user side and the network side of a PRI simultaneously attempt to seize the same channel on the PRI (that is, a SETUP message in each direction requesting the same channel). For wide-band calls, glare can occur when both sides simultaneously attempt to seize one or more of the same channels. When this happens, the network side call takes precedence. The glare condition is resolved by the network side releasing the incoming user side call with a RELEASE COMPLETE containing a cause code value of 44 “requested channel unavailable,” and the user side allowing the incoming network side call to continue.

5.2.5 B-CHANNEL REHUNT PROCEDURE

Without B-channel Availability Signaling (BCAS) Procedures, situations may occur in which a B-channel appears to be in-service and available at the switch side of the PRI, while it is OOS or busy at the other side of the PRI. In this case, a call attempt for this B-channel fails and if the B-channel is the first channel of the B-channel hunt group, a potential lockout situation occurs. To reduce the probability of lockout and to address certain glare situations, the switch invokes a B-channel rehunt procedure. The rehunt procedure is invoked on both the National ISDN PRI and the Custom PRI. It is not, however, invoked on switched fractional-DS1 calls.

The rehunt procedure is invoked when the initial attempt to terminate a call on a PRI B-channel fails and the first response to the SETUP message is a RELEASE COMPLETE message that contains either a cause code value of 34 “no circuit or channel available” or a cause code value of 44 “requested channel not available.” The rehunt procedure makes a second attempt by sending another SETUP message requesting the next available B-channel in the B-channel hunt group. Unless the next available B-channel also is OOS or busy at the opposite end of the PRI, the attempt to obtain a B-channel will succeed. Several hunt types are available on the PRI: linear, uniform call distribution (UCD), backward circular sequential (BGUCD), and forward circular sequential (GUCD). By using one of the hunt types other than linear, one can prevent lockout in cases in which two consecutive B-channels are busy or OOS at the far end of the PRI.

5.2.6 PRI TIMERS

Layer 3 call control timers supported on the network side include T301, T303, T305, T308, T309, T310, T316, T321 (which is a noncall related Layer 3 timer) and T322. The timer values and conditions for starting and stopping them are shown in Table 5.2-1.

The timers for the user side are shown in Table 5.2-2. The Timer T313 is employed on the user side. Layer 3 call control timers supported on the user side include T303, T305, T308, T309, T310, T313, T316, T317, T321, T322, and TSERV.

Table 5.2-1 — Timers in the PRI Network Side

TIMER	DEFAULT TIME-OUT VALUE	STATE OF CALL	CAUSE FOR START	NORMAL STOP	AT THE FIRST EXPIRY	AT THE SECOND EXPIRY	CROSS-REFERENCE
T301	5 minutes	Call Received	ALERT received	CONNECT	Sends REL	Timer is not restarted.	Mandatory.
T303	4 s [a] [b]	Call Present	SETUP sent.	ALERT, CONN, CALL, PROC or PROG received. REL COMP received if SETUP sent on point-point data link.	Retransmit SETUP restart T303. If REL COMP has been received, clear the call. [b]	Clear network connection. Enter Null state. [b]	Mandatory.
T305	4 s	Disconnect Indication	DISC	REL DISC or REL COMP received.	Network sends REL.	Timer is not restarted.	Mandatory.
T306	c	Tone Active	PROGRESS	DISC received.	Stop the tone announcement. Send DISC.	Timer is not restarted.	Mandatory when in-hand tones announcements are provided. See 5.2.7.
T308	4 s [a]	Release Request	REL sent.	REL COMP received.	Retransmit REL and restart T308.	Place B-channel in maintenance condition. REL COMP sent Release call reference. [d]	Mandatory.
T309	90 s [e]	Any stable state.	Active D-channel failure. Calls in stable states are not lost.	Data link reconnected.	See 5.2.10.	Timer is not restarted.	Mandatory.
T310	30 s [f]	Incoming Call Proceeding	CALL PROC received.	ALERT, CONN, DISC, or PROG received.	Send REL.	Timer is not restarted.	Mandatory.
T316	30 s [g]	Restart Request	REST sent	REST ACK received.	REST retransmitted. Reinitialize T316.	Channel is taken out of service.	Mandatory.
T321	50 s [h]	Any call state.	Active D-channel failure.	Response to Layer 3 message received. SERV or SERV ACK rec. on WAIT D-channel.	Send SERV on WAIT D-channel.	Timer is not restarted.	Mandatory when DCBU is provisioned.

See note(s) at end of table.

Table 5.2-1 — Timers in the PRI Network Side (Contd)

TIMER	DEFAULT TIME-OUT VALUE	STATE OF CALL	CAUSE FOR START	NORMAL STOP	AT THE FIRST EXPIRY	AT THE SECOND EXPIRY	CROSS-REFERENCE
T322	4 s	Active	STATUS ENQUIRY sent.	STATUS received.	Send REL COMP Cause #41.	Timer is not restarted.	Mandatory.

Note(s):

a. This default value assumes the use of default values at Layer 2 (that is, [N200+1] times T200).

b. See product specific documentation.

c. The value of Timer T306 may depend on the length of the announcement.

d. The restart procedures contained in Section 5.2.2 can be used on B-channels in the maintenance condition.

e. The value of this timer is an implementation option. The value shall lie in the range of 30-120 seconds.

f. The value of Timer T310 may be different in order to take into account the characteristics of a private network.

g. Timer T316 can be provisioned to be in the range 10-120 seconds.

h. While Timer T321 is running, the SERV message is sent on WAIT D-channel at 5-second intervals.

Table 5.2-2 — Timers in the PRI User Side

TIMER	DEFAULT TIME-OUT VALUE	STATE OF CALL	CAUSE FOR START	NORMAL STOP	AT THE FIRST EXPIRY	AT THE SECOND EXPIRY	CROSS-REFERENCE
T303	4 s [a]	Call Initiated	SETUP sent.	ALERT (ANNEX D), CONN (ANNEX D), CALL, PROC or REL COMP received.	Retransmit SETUP restart T303. If REL COMP has been received, clear the call (symmetrical user).	Clear network connection. Send REL COMP. Enter Null state.	Mandatory when symmetrical user is provisioned; otherwise optional.
T305	4 s	Disconnect Indication	DISC sent.	REL DISC or REL COMP received.	REL sent.	Timer is not restarted. REL COM may be sent.	Mandatory.
T308	4 s [a]	Release Request	REL sent.	REL COMP or REL received.	Retransmit REL and restart T308.	B-channel placed in maintenance condition. Call reference released. [b]	Mandatory.
T309	90 s [a]	Any stable state.	Active D-channel failure. Calls in stable states are not lost.	Data link reconnected.	See 5.2.10.	Timer is not restarted.	Optional.
T310	Implementation dependent. 30 s [c]	Outgoing Call Proceeding	CALL PROC received.	ALERT, CONN, DISC, or PROC received.	Send REL.	Timer is not restarted.	Mandatory when symmetrical user is provisioned.
T313	4 s [a]	Connect Request	CONN sent.	CONN ACK received.	Send CONN	Timer is not restarted. Send.	Mandatory. See Section 5.1.5.
T316	30 s [d]	Restart Request	REST sent.	REST ACK received.	REST retransmitted. Reinitialize T316.	Channel is taken out of service.	Mandatory.
T317	120 s	Not associated with call state.	SERV sent on B-channel, waiting for SERV ACK.	Receive SERV ACK on B-channel.	Place B-channel OOS-blocked.	Timer is not restarted.	Custom PRI only.
T321	50 s [e]	Any call state.	Active D-channel failure.	Response to Layer 3 message received. SERV or SERV ACK rec. on WAIT D-channel.	Send SERV on WAIT D-channel.	Timer is not restarted.	Mandatory when DCBU is provisioned.
T322	4 s	Active.	STATUS ENQUIRY sent. [f]	STATUS received.	Send REL COMP Cause #41.	Timer is not restarted.	Mandatory.
TSERV	5 min.	Independent of call state.	SERV ACK sent on DCBU active D-channel, waiting for SERV ACK.	Receive SERV ACK on active D-channel.	Switch active and STBY D-channels; place STBY D-channel OOS.	Timer is not restarted.	See Section 10.9.1.

Note(s):

a. This default value assumes the use of default values at Layer 2 (that is, [N200+1] times T200).

Table 5.2-2 — Timers in the PRI User Side (Contd)

Note(s): (Contd)
b. The restart procedures contained in Section 5.2.2 may be used on B-channels in the maintenance condition.
c. T310 is not started if PROGRESS message has been delivered. If T310 is implemented, it is recommended that the value selected be sufficiently large to insure against premature disconnect on international calls due to delays encountered in some foreign networks.
d. Timer T316 can be provisioned to be in the range of 10-120 seconds.
e. While T321 is running, the SERV message is sent on WAIT D-channel at 5 second intervals.
f. T322 is used for CAC after a Layer 2 recovery, after a D-channel switch, and after a SETUP message is received for an active call.

5.2.7 IN-BAND TONES AND ANNOUNCEMENTS

Methods for providing ringback[1], user busy, reorder (network busy) tones and network intercept announcements are essential to preserving the traditional human interface for telephony calls. 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. The following subsections will deal with the PBX/network procedures for providing/responding to in-band tones and announcements for circuit-switched calls. “Pure ISDN Network Call with Successful Completion to an Endpoint,” Section 5.2.7.1, “Pure ISDN Network Call—End User/Terminal Busy,” Section 5.2.7.2, and “Pure ISDN Network Call—Congestion and Intercept Treatment,” Section 5.2.7.3, deal with calls that route through a pure ISDN path from an originating to terminating PBX.

5.2.7.1 Pure ISDN Network Call with Successful Completion to an Endpoint

The procedures for originating, terminating, and network nodes are described in “At the Originating PBX/Network,” Section 5.2.7.1.1, and “At the Terminating PBX,” Section 5.2.7.1.2. The message flow that corresponds to these procedures is found in Figure 5.2-1.

Figure 5.2-1 shows the messages flowing across the PRI interfaces for an end-to-end ISDN call originated at a PBX (PBX A, configured as a user side of a PRI), carried over a PRI to a switch (switch X, configured as a network side of the PRI). The messages flowing across the network are indicated as SS7 messages that pass from switch Y where the call terminates on a PRI to PBX B. The end-users are ISDN customers that are interfaced to the two PBXs.

5.2.7.1.1 At the Originating PBX/Network

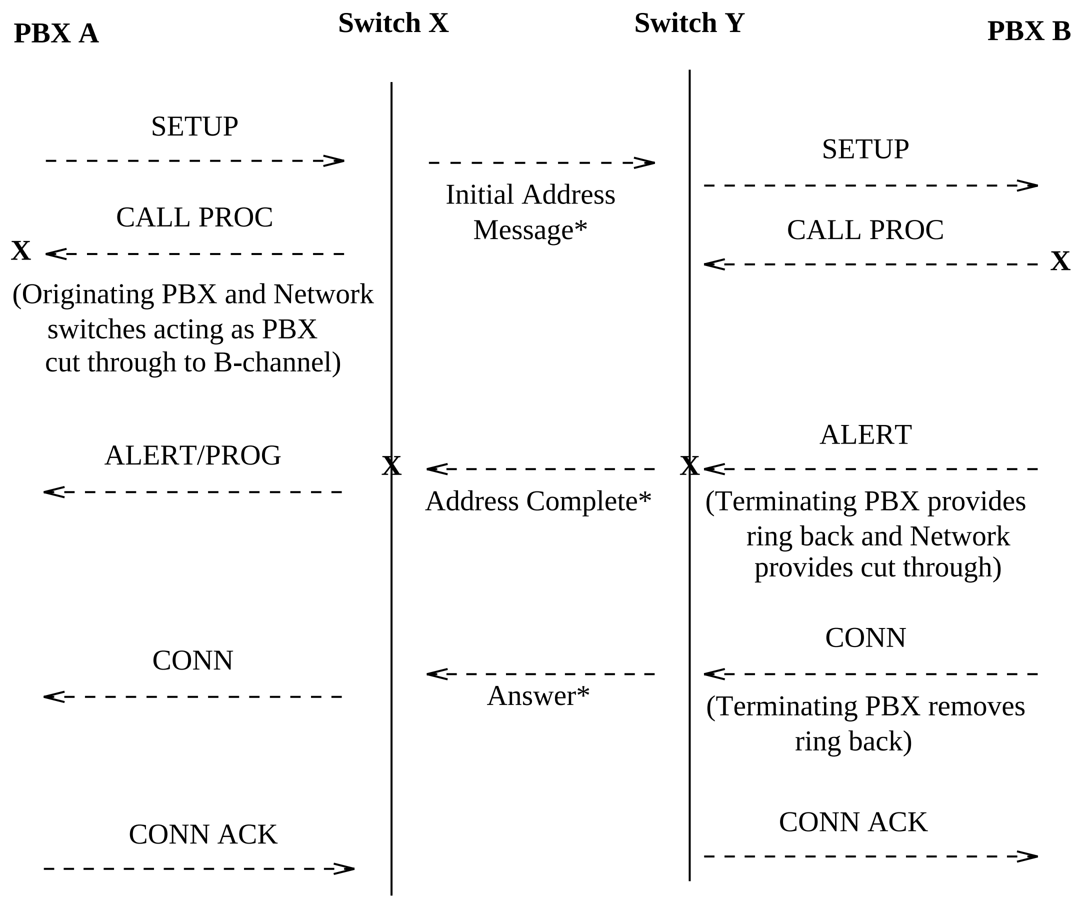
When a call that originates from a PBX/network uses ISDN-PRI facilities, it will send a SETUP message and cut through to the designated B-channel using the procedures described in “In-Band Tones and Announcements,” Section 5.2.7. If the call completes end-to-end successfully, no in-band feedback will be provided to the user by the origination PBX/network. In order to remain consistent with pre-ISDN implementations, the ringback will be provided by the terminating PBX/network. This will provide a more uniform implementation of ISDN services as the protocol evolves.

1. For PBXs, ringback refers to the ringback tone always provided to the originator of a call. For network switches, this term is synonymous with “audible ringing.”

5.2.7.1.2 At the Terminating PBX

If the calls proceeds through the network and is successful, the terminating PBX will:

- respond to a SETUP message with a CALL PROCEEDING and cut-through to the designated B-channel
- determine whether the endpoint terminal designated by the called party number is available
- respond to the other end of the ISDN-PRI interface, if the endpoint terminal is available, with an ALERTING message and provide in-band ringback tone. (The network node will cut-through to the designated B-channel upon receipt of the ALERTING message and propagate ALERTING back toward the originating PBX/network.)
- remove ringback when the terminal at the terminating PBX answers the call
- send a CONNECT message when the terminal at the terminating PBX answers the call (The CONNECT message is propagated back toward the originating PBX/network.)



Note: X denotes B-channel cut-through

* The call flows to the network, indicated as an SS7 network to Switch Y, where the call terminates on a PRI to PBX B.

Figure 5.2-1 — Pure ISDN Network/PBX Call with End-to-End Completion

5.2.7.2 Pure ISDN Network Call—End User/Terminal Busy

The procedures for originating, terminating, and network nodes are described in "Originating Node Transmittal of SETUP," Section 5.2.7.2.1, "At the Terminating PBX," Section 5.2.7.2.2, and "Originating Node Action on Indication of Clearing," Section 5.2.7.2.3. The message flow that corresponds to these procedures is found in Figure 5.2-2.

5.2.7.2.1 Originating Node Transmittal of SETUP

When a call that originates from a PBX/network uses ISDN-PRI facilities, it will send a SETUP message and cut through to the designated B-channel using the procedures described in "In-Band Tones and Announcements," Section 5.2.7.

5.2.7.2.2 At the Terminating PBX

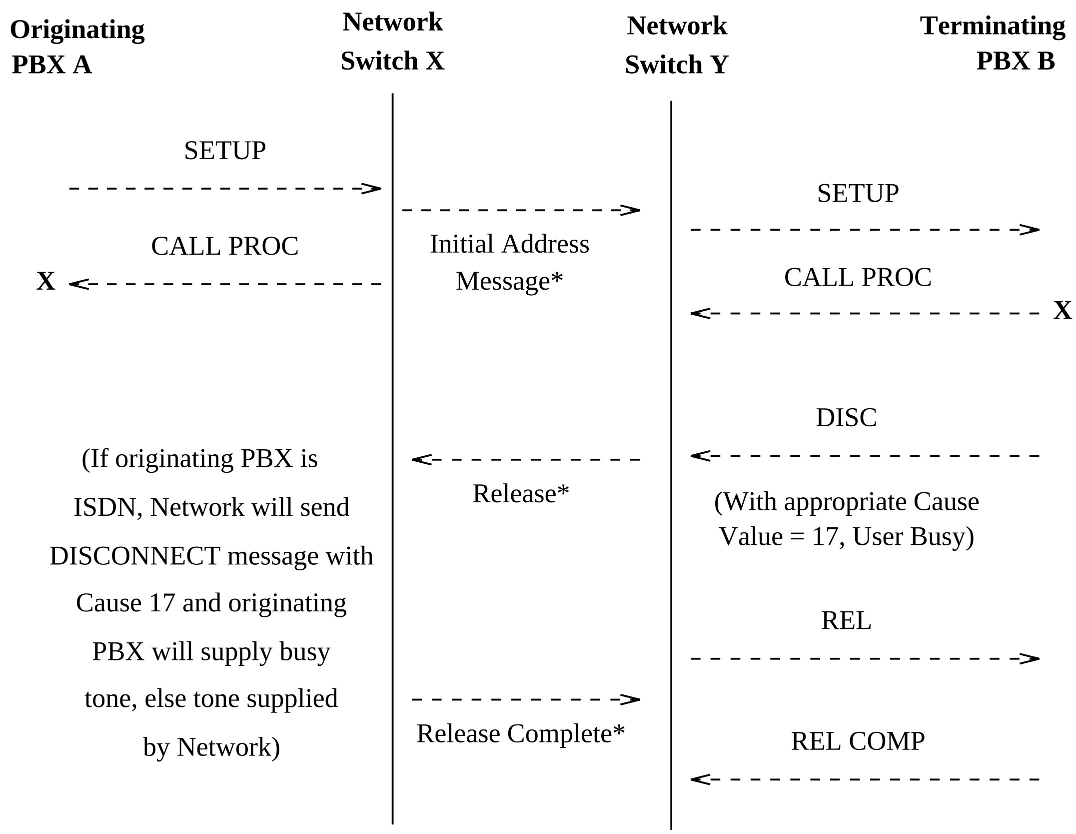
The call will proceed through the network and arrive at the terminating PBX, which will:

- Respond to a SETUP message with a CALL PROCEEDING and cut-through to the designated B-channel
- Distinguish whether the endpoint terminal designated by the destination address is available
- Respond to the other end of the ISDN-PRI interface, if the endpoint terminal, coverage points, and alternative destinations are all unavailable, by sending a DISCONNECT message with a cause code value of 17 “user busy”
- Propagate the DISCONNECT message as far back toward the originating PBX/network as possible (that is, the propagation may stop at an interworking node[2]) where the in-band user busy tone will be provided.

5.2.7.2.3 Originating Node Action on Indication of Clearing

If the originating PBX/network receives a DISCONNECT message with a cause code value of 17 “user busy,” it will disconnect the designated B-channel and provide in-band user busy tone.

2. It is also possible for the response to a SETUP message to be RELEASE COMPLETE with a cause code value of 17 “user busy.” In this case, the switch that originates the SETUP request will propagate the message as far back as possible. Either the originating PBX/network or interworking node will provide the user busy tone. This provides for the most efficient usage of the public or private network.



Note: X denotes B-channel cut-through.

* The call flows to the network, indicated as an SS7 network to Switch Y, where the call terminates on a PRI to PBX B.

Figure 5.2-2 — Pure ISDN Network/PBX Call with End User/Terminal Busy

5.2.7.3 Pure ISDN Network Call—Congestion and Intercept Treatment

The procedures for originating, network, and terminating nodes are described in “At the Originating PBX/Network,” Section 5.2.7.3.1, “At a Network Node,” Section 5.2.7.3.2, and “Network Congestion at a Terminating PBX,” Section 5.2.7.3.3. The message flow that corresponds to these procedures is found in Figure 5.2-3.

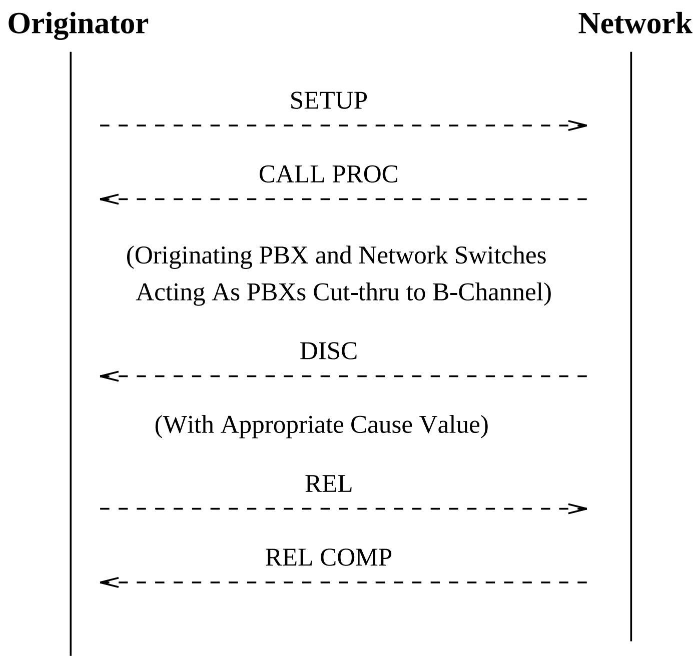


Figure 5.2-3 — Pure ISDN Network/PBX Call with Network Congestion

5.2.7.3.1 At the Originating PBX/Network

When a call originates from a PBX/network that uses ISDN-PRI facilities, it will send a SETUP message and cut through to the designated B-channel using the procedures described in “Cut-Through Procedures,” Section 5.2.3.

5.2.7.3.2 At a Network Node

Once the originating network switch has determined that the SETUP message contains valid information, the following sequence occurs:

- a CALL PROCEEDING message is returned to the originating PBX
- the designated B-channel is cut through
- the call will proceed through the network.

If network congestion is detected by the network, the network will determine the source of this congestion. If for network congestion the cause code value is 34 “no circuit or channel available,” the network will play the appropriate announcement.

Other cause code values indicate no circuit, reorder, or vacant code intercept tones and announcements. The originating PBX/network will not be required to provide tones locally in these cases. Instead, the node that detects the congestion condition will send a PROGRESS message (which will force cut-through throughout the network) and play the appropriate tones and announcements[3]. A PBX might detect any of the causes

3. If Channel Negotiation is not active, and a SETUP message is received from the user side of the interface for a busy B-channel, the response is RELEASE COMPLETE with a cause code value of 34 “channel not available.” An alternate channel may be selected by the originating (user) end of the interface. The appropriate tone would not be provided until alternate choices for an idle B-channel are exhausted. A terminating node may, as an implementation option, choose to map other cause code values to locally provided tones and disconnect the channel. Section 11.14, “PRI B-channel Negotiation,” describes the codings and the errors that are sent when PRI B-channel negotiation is active.

previously mentioned that initiate network announcements. The PBX initiated feedback, however, will usually be in the form of tones (reorder/fast, busy, or intercept).

Table 5.2-3 contains cause code values that initiate tones and announcements for interworking with a basic rate interface (BRI).

5.2.7.3.3 Network Congestion at a Terminating PBX

Network congestion can also occur at a switch in a private network. A PBX could be configured to provide its own congestion announcements that correspond to those provided by the public network. A PBX, however, handles announcements differently than the network. If a call terminates to an announcement in a PBX, the PBX would respond by sending a CONNECT message when the announcement answers. In this case, no DISCONNECT message would be sent by the PBX until the announcement is completed. To the originating PBX/network (in terms of ISDN message flow), the call would look like a normally answered call.

5.2.8 PROCEDURES FOR INTERWORKING WITH ISDN BASIC RATE INTERFACES

COs and PBXs that implement PRIs will support several types of terminal interfaces. This section documents the interworking required by these switches to support the ISDN BRI. Table 5.2-3 defines the procedures required of a switch for such interworking.

Interworking problems arise, such as call rejection, if the BRI receives the bearer capability IE with Octet 5 missing for voice and 3.1-kHz audio calls. Therefore, when a call arrives at the BRI through a PRI, the bearer capability IE in the SETUP message shall include Octet 5 indicating ITU-T Recommendation G.711 μ-law for speech and 3.1-kHz audio calls. In some instances, however, this may not be the case. Therefore, the switch performing the interworking between the BRI and the PRI should check the bearer capability IE in the SETUP message for the presence of Octet 5. If Octet 5 is not present for speech and 3.1 kHz audio calls, the switch shall generate it, indicating μ-law, and include it in the bearer capability IE conveyed within the SETUP message delivered to the BRI endpoint to avoid the rejection of the call.

Table 5.2-3 — Actions to be Taken by BRI/PRI Interworking Node

ORIGINATING INTERFACE (O.I.)	TERMINATING INTERFACE (T.I.)	CALL STATE (ORIGINATING INTERFACE)	INTERWORKING NODE MESSAGE OR STIMULUS RECEIVED	ACTION TAKEN BY INTERWORKING NODE (O.I.)	ACTION TAKEN BY INTERWORKING NODE (T.I.)	COMMENTS
BRI	PRI	3	No circuits available at terminating interface (T.I.)	PROGRESS (cause = no channel available, signal = net. congestion tone on) Apply network congestion tone	None	Wait for O.I to disconnect (Sec. 5.2.7.1)
BRI	PRI	3	Clearing (user busy) from T.I.	PROGRESS (cause = user busy signal = busy tone on). Apply busy tone	Follow normal clearing. (Sec. 5.2.7.1)	Wait for user to disconnect.
BRI	PRI	3	REL COMP (due to error condition) from T.I.	PROGRESS (cause and signal determined from REL COMP). Apply appropriate tone	None	
BRI	PRI	3	T303 expires first time at T.I.	None	Retransmit SETUP	
BRI	PRI	3	Second T303 expiration, or T310 expiration at T.I.	PROGRESS (cause = no user responding, signal = audible ringing tone on) Apply audible ringing	None	Wait for user to disconnect
PRI	BRI	3	T303 expires first time at T.I.	PROGRESS (cause = no user responding) Apply in-band audible ringing	Retransmit SETUP	
PRI	BRI	3	Second T303 expiry at T.I.	Continue to apply in-band audible ringing	RELease COMplete cause = no user responding) Normal clearing	
PRI	BRI	3	T310 expiration at T.I.	DISCONNECT (Cause = no user responding). Apply appropriate tones	RELease COMplete (cause = no user responding). Normal clearing	
PRI	BRI	3	Clearing Message from T.I.	PROGRESS (Cause determined from clearing message)	None	Tone determined from cause in clearing message. Apply appropriate tone
PRI	BRI	3	No circuits available at T.I.	DISCONNECT (cause = user busy) Normal clearing	None	Originating switch applies busy tone to O.I.
PRI	BRI	3	Clearing (cause = user busy) from T.I.	PROGRESS (cause = user busy). Apply audible ringing	None	Wait for user to disconnect

Table 5.2-3 — Actions to be Taken by BRI/PRI Interworking Node (Contd)

ORIGINATING INTERFACE (O.I.)	TERMINATING INTERFACE (T.I.)	CALL STATE (ORIGINATING INTERFACE)	INTERWORKING NODE MESSAGE OR STIMULUS RECEIVED	ACTION TAKEN BY INTERWORKING NODE (O.I.)	ACTION TAKEN BY INTERWORKING NODE (T.I.)	COMMENTS
PRI	BRI	4	Clearing (cause = user busy) from T.I.	None (In-band audible ringing already being provided)	Continue clearing	Continue waiting for O.I. to disconnect

5.2.9 NOTIFICATION OF EXCESSIVE CALL SETUP DELAY

For calls that originate on a *5ESS* switch PRI and terminate using end-to-end ISDN to an interface that supports the National ISDN procedures for excessive call setup delay, the following procedures may apply.

a. For circuit-switched speech/3.1-kHz audio call, if Timer T303 expires for the first time at the terminating BRI, the switch will send the originating PRI a PROGRESS message containing two progress indicator IEs: a progress descriptor set to 8 “in-band information or appropriate pattern now available” and progress descriptor set to 10 “delay in response at the called interface” (Progress Descriptor 10 is a national coding standard). If Timer T303 expires for the second time or T310 expires at the terminating BRI, the switch will send the originating PRI a PROGRESS message containing a progress descriptor in the progress indicator IE set to 8 “in-band information or appropriate pattern now available” with a cause code value of 18 “no user responding.”

b. For circuit-switched data call, if Timer T303 expires for the first time at the terminating BRI, the switch will send the originating PRI a PROGRESS message containing a progress descriptor in the progress indicator IE set to 10 “delay in response at the called interface” (in-band audible ringing will not be provided for CSD calls). If Timer T303 expires for the second time or T310 expires, the switch will send the originating PRI a DISCONNECT message containing a cause code value of 18 “no user responding.”

5.2.10 LOSS OF SIGNALING LINK

In the case of malfunction of the signaling link (Layer 2) on the D-channel, there is a loss of Q.931 call control messages on Layer 3. When this occurs the following actions are taken:

- Timer T309 (90 seconds) is started.
- Depending on whether the PRI is National ISDN or Custom PRI:
  - — If National ISDN PRI, transient calls (that is, those calls not in Q.931 State 10) are cleared.
  - — If Custom PRI, no calls are cleared.
- If the signaling link recovers before the expiration of T309 timer, a STATUS ENQUIRY message is sent. Calls may or may not be affected depending on the results of the STATUS message received in response to the STATUS ENQUIRY message.

- If T309 timer expires before the signaling link recovers, then all calls are cleared and all B-channels are removed.

5.2.11 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 that pass the checks described in the following sections.

The sections that follow are listed in order of precedence.

5.2.11.1 Protocol Discrimination Error

When a message is received with a protocol discriminator coded other than “Q.931 user-network call control message” or “Q.931(I.451) maintenance messages,” that message shall be ignored. Ignore means to do nothing, as if the message had never been received.

5.2.11.2 Message Too Short

When a message is received that is too short (less than 4 octets) to contain a complete message type IE, that message shall be ignored.

5.2.11.3 Call Reference Error

5.2.11.3.1 Invalid Call Reference Format

If the call reference IE Octet 1, Bits 5 through 8 do not equal 0000, then the message shall be ignored.

If the call reference IE Octet 1, Bits 1 through 4 indicate a length greater than the maximum length agreed upon for the interface (see “Call Reference,” Section 4.3.1.2), then the message shall be ignored.

5.2.11.3.2 Call Reference Procedural Errors

Whenever any message except SETUP, RELEASE COMPLETE, STATUS, or STATUS ENQUIRY is received specifying a call reference that is not recognized as relating to an active call or to a call in progress, clearing is initiated by sending a RELEASE COMPLETE message with a cause code value of 81 “invalid call reference value” and remains in the null state.

When a RELEASE message is received specifying a call reference not recognized as relating to an active call or to a call in progress, a RELEASE COMPLETE message with a cause code value of 81 “invalid call reference value” is returned specifying the call reference in the received message.

When a RELEASE COMPLETE message is received specifying a call reference that is not recognized as relating to an active call or to a call in progress, no action should be taken.

When a SETUP message is received specifying a call reference that 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”, this message shall be ignored or a RELEASE COMPLETE is sent to the user.

When a SETUP message is received specifying a call reference that is recognized as relating to an active call or to a call in progress, this SETUP message may be ignored, or a STATUS message is sent with a cause code value of 98 “message incompatible with call state.”

When any message except RESTART, RESTART ACKNOWLEDGE, SERVICE, SERVICE ACKNOWLEDGMENT, or STATUS is received using the global call reference, no action should be taken on this message and 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 code value of 81 “invalid call reference” shall be returned.

When a STATUS message is received specifying a call reference that is not recognized as relating to an active call or to a call in progress, the procedures of “Call Activity Checks (STATUS ENQUIRY Procedures),” Section 5.2.1, shall apply.

The receiver of a STATUS ENQUIRY message specifying a call reference that is not recognized as in use shall return a STATUS message with a cause code value of 30 “response to STATUS ENQUIRY” indicating call State 0 (null state).

5.2.11.4 Message Type or Message Sequence Errors

On the Custom PRI, whenever an unexpected message other than a RELEASE, a RELEASE COMPLETE, or an unrecognized message is received in any state other than the null state, a STATUS message may be returned with a cause code value of 98 “message not compatible with the call state” and the corresponding diagnostic as described in this section.

On the National ISDN PRI, whenever an unexpected message other than a RELEASE, a RELEASE COMPLETE, or an unrecognized message is received in any state other than the null state, a STATUS message may be returned with a cause code value of 101 “message not compatible with the call state” and the corresponding diagnostic as described in this section.

If a network or user can distinguish between unimplemented (or non-existent) message types and implemented message types that are incompatible with the call state, then a STATUS message may be sent with the following cause:

- a cause code value of 97 “message type non-existent or not implemented”

Alternatively, a STATUS ENQUIRY message may be sent requesting the call state of the entity (see “Call Activity Checks (STATUS ENQUIRY Procedures),” Section 5.2.1). No change in state shall be made in either case at this time.

However, two exceptions to this procedure exist. The first exception is when the network or the user receives an unexpected RELEASE message (such as, if the DISCONNECT message was corrupted by undetected transmission errors). In this case no STATUS or STATUS ENQUIRY message is sent. Whenever the network receives an unexpected RELEASE message, the network shall disconnect and release the B-channel; clear the network connection and the call to the remote user with the cause of the RELEASE message sent by the user or, if this cause was not included, a cause code value of 31 “normal, unspecified”; return a RELEASE COMPLETE message to the user; release the call reference; stop all timers; and enter the null state. Whenever the user receives an unexpected RELEASE message, the user shall disconnect and release the B-channel, return a RELEASE COMPLETE message to the network, release the call reference, stop all timers, and enter the null state.

The second exception is when the network or the user receives an unexpected RELEASE COMPLETE message. Whenever the network receives an unexpected RELEASE COMPLETE message, the network shall disconnect and release the B-channel, clear the network connection and the call to the remote user with the cause indicated by the user, release the call reference, stop all timers, and enter the null state. Whenever the user receives an unexpected RELEASE COMPLETE message, the user shall disconnect and release the B-channel, release the call reference, stop all timers, and enter the null state.

When a message arrives with an active call reference value for which a response is not prescribed in the current state of the call, the message is considered to be unexpected. Error conditions due to such unexpected messages are classified into three degrees and the actions that need to be taken for each degree are as follows:

Ignorable — By ignoring this message, the state machine can still operate in a trouble free manner.

Tolerable — Receipt of an unexpected clearing message.

Violent — Receipt of an unexpected message that is at odds with the current state of the call. In this case, some kind of query needs to be issued to the other end.

For ignorable errors, the receiver may ignore the arrival of this message or return a status with an appropriate cause. For tolerable errors, the receiver may assume that it is allowable to receive this message and take the appropriate action. For example, if the network receives a RELEASE message in states other than N0, N12, and N19, it shall RELEASE the information channel, the call reference value, send a RELEASE COMPLETE to the user, and move to N0. For violent errors, the receiver of an unexpected message must send a STATUS message to the other end specifying the state of the call at the receiver's side, a cause code value of 98 "message not compatible with call state," and a diagnostics field containing the message type.

Figures 5.2-4 and 5.2-5 summarize all possible messages and states, and the types of responses.

The disconnect request, disconnect indication and release request states are defined to be clearing states and the DISCONNECT, RELEASE, and RELEASE COMPLETE messages are defined to be clearing messages.

When an unexpected non-clearing message is received when the call is perceived to be in

i. a non-clearing state, then the receiver shall send a STATUS message (if the received message is a late-arriving or duplicated message, then the receiver shall ignore the receipt of the message), the cause IE shall specify the cause code value of 98 "message not compatible with the call state," the location being the user or the local network (as is appropriate), and the diagnostics field shall specify the message type that was received.

ii. a clearing state, then the receiver shall ignore the receipt of the message.

When an unexpected DISCONNECT message is received when the call is perceived to be in

i. a clearing state, then the receiver shall ignore the receipt of the message in states N11, SU12, N19, or SU19, except for recording a protocol error record. If a DISCONNECT message is received in states N12 or SU11, a RELEASE message is sent in response and the call state transitions to the release request (N19 or SU19) state.

ii. a nonclearing state, then the usual clearing procedures as described in “Call Clearing—Network Side Treatment,” Section 5.1.4, or “Call Clearing—Symmetrical User Side Treatment,” Section 5.1.7, shall be followed.

When a RELEASE message is received unexpectedly in a state other than release request state, the receiver shall release the information channel and the call reference; furthermore the receiver also shall send a RELEASE COMPLETE message to the sender and move the call to the null state.

When a RELEASE COMPLETE message is received unexpectedly, the receiver shall release the information channel and the call reference; furthermore the receiver shall move the call to the null state.

Table 5.2-4 — Network Response on Receipt of a Message for a Non-Global CRV and Non-Dummy Call Reference

Network’s state	Message received by the network											
	SETUP	**CONN ACK**	**CALL PROC**	**ALERT**	**CONNECT**	**DISC**	**RELEASE**	**REL COM**	**RESTART**	**REST ACK**	**PROGRESS**	**FACILITY**
0	*	CR DNE	CR DNE	CR DNE	CR DNE	CR DNE	CR DNE	I	CR DNE	CR DNE	CR DNE	CR DNE
3	VE	VE	VE	VE	VE	*	TE	TE	VE	VE	VE	I
4	VE	VE	VE	VE	VE	*	TE	TE	VE	VE	VE	I
6	VE	VE	*	*	*	TE	TE	*	VE	VE	VE	I
7	VE	VE	VE	*	*	*	TE	TE	VE	VE	VE/*	I
8	VE	I	VE	VE	VE	*	TE	TE	VE	VE	VE	I
9	VE	VE	VE	*	*	*	TE	TE	VE	VE	*	I
10	VE	I	VE	VE	VE	*	TE	TE	VE	VE	VE	*
11	***	I	I	I	I	I	TE	TE	VE	VE	I	I
12	***	I	I	I	I	*	*	TE	VE	VE	I	I
19	*	*	*	*	*	*	*	*	VE	VE	*	I

*	: This Specification specifies the procedure
***	: RELEASE COMPLETE sent
CR DNE	: Call reference does not exist (see Section 5.2.11.3).
I	: Ignorable error
TE	: Tolerable error
VE	: Violent error

Table 5.2-5 — User Response on Receipt of a Message for a Non-Global CRV and Non-Dummy Call Reference

User's state	Message received by the user											
	SETUP	CONN ACK	CALL PROC	ALERT	CONNECT	DISC	RELEASE	REL COM	RESTART	REST ACK	PROGRESS	FACILITY
0	*	CR DNE	CR DNE	CR DNE	CR DNE	CR DNE	CR DNE	I	CR DNE	CR DNE	CR DNE	CR DNE
1	I	VE	*	*	*	TE	TE	*	VE	VE	*	I
3	I	VE	I	*	*	*	*	TE	VE	VE	*	I
4	I	VE	I	*	*	*	*	TE	VE	VE	*	I
7	I	VE	VE	VE	VE	*	*	TE	VE	VE	VE	I
8	I	*	VE	VE	VE	*	*	TE	VE	VE	VE	I
9	I	VE	VE	VE	VE	*	*	TE	VE	VE	VE	I
10	I	I	VE	VE	VE	*	*	TE	VE	VE	VE	*
11	I	I	I	I	I	*	*	TE	VE	VE	I	I
12	I	I	I	I	I	I	*	TE	VE	VE	I	I
19	I	I	I	I	I	I	*	*	VE	VE	I	I

* : This Specification specifies the procedure

CR DNE : Call reference does not exist (see Section 5.2.11.3)

I : Ignorable error

TE : Tolerable error

VE : Violent error

5.2.11.5 General Information Element Errors

The general IE error procedures may also apply to IEs in codesets other than 0.

5.2.11.5.1 Information Element Out of Sequence

An IE that has a code value lower than the code value of the variable length IE preceding it shall be considered as an out of sequence IE.

If the network or user receives a message containing an out of sequence IE, it may ignore this IE and continue to process the message. If this information is mandatory and the network or user chooses to ignore the out of sequence IE, then the error handling procedure for missing mandatory IEs as described in “Mandatory Information Element Errors,” Section 5.2.11.6, shall be followed. If the ignored IE is non-mandatory, the receiver continues to process the message.

5.2.11.5.2 Duplicated Information Elements

If an IE is repeated in a message in which repetition of the IE is not permitted, only the contents of the IE appearing first shall be handled and all subsequent repetitions of the IE shall be ignored. When repetition of IEs is permitted, only the contents of permitted IEs shall be handled. If the limit on repetition of IEs is exceeded, the contents of IEs appearing first up to the limit of repetitions shall be handled and all subsequent repetitions of the IE shall be ignored.

5.2.11.6 Mandatory Information Element Errors

5.2.11.6.1 Mandatory Information Element Missing

When a message other than SETUP, DISCONNECT, RELEASE, or RELEASE COMPLETE is received that has one or more mandatory IEs missing, no action should be taken on the message and no state change should occur. A STATUS message is then returned with a cause code value of 96 “mandatory information element is missing.”

When a SETUP or RELEASE message is received that has one or more mandatory IEs missing, a RELEASE COMPLETE message with a cause code value of 96 “mandatory information element is missing” shall be returned.

When a DISCONNECT message is received with the cause IE missing, the actions taken shall be the same as if a DISCONNECT message with a cause code value of 31 “normal, unspecified” was received (see “Call Clearing—Network Side Treatment,” Section 5.1.4, and “Call Clearing—Symmetrical User Side Treatment,” Section 5.1.7).

When a RELEASE, RELEASE COMPLETE message is received with a cause IE missing, it will be assumed that a RELEASE COMPLETE message was received with a cause code value of 31 “normal, unspecified.”

5.2.11.6.2 Mandatory Information Element Content Error

When a message other than SETUP, DISCONNECT, RELEASE, or RELEASE COMPLETE is received that has one or more mandatory IEs with invalid content, no action should be taken on the message and no state change should occur. A STATUS message is then returned with a cause code value of 100 “invalid information element contents.”

When a SETUP or RELEASE message is received that has one or more mandatory IEs with invalid content, a RELEASE COMPLETE message with a cause code value of 100 “invalid information element contents” shall be returned.

When a DISCONNECT message is received with invalid content of the cause IE, the actions taken shall be the same as if a DISCONNECT message with a cause code value of 31 “normal, unspecified” was received (see “Call Clearing—Symmetrical User Side Treatment,” Section 5.1.7).

When a RELEASE COMPLETE message is received with invalid content of the cause IE, it will be assumed that a RELEASE COMPLETE message was received with a cause code value of 31 “normal, unspecified.”

IE with a length exceeding the maximum length (given in “Information Element Layouts,” Section 4.3.3) will be treated as an IE with content error.

5.2.11.7 Nonmandatory Information Element Errors

The following sections identify actions on IEs not recognized as mandatory.

5.2.11.7.1 Unrecognized Information Element

When a message is received that has one or more unrecognized IEs, the receiving entity shall proceed as follows:

Action shall be taken on the message and those IEs that are recognized and have valid content.

No validity checks are performed on the contents of Codeset 7. The only check is on the length of the sum of the user-related IEs. See individual sections on IEs for more information.

5.2.11.7.2 Nonmandatory Information Element Content Error

When a message is received that has one or more nonmandatory IEs with invalid content, action shall be taken on the message and those IEs that are recognized and have valid content.

IE with a length exceeding the maximum length (given in “Information Element Layouts,” Section 4.3.3) will be treated as an IE with content error except for nonmandatory IEs that are part of Message-associated User-to-User Information (see “User-to-User Signaling Service,” Section 11.6). The *5ESS* switch will not support more than the maximum length shown in “Information Element Layouts,” Section 4.3.3. For access IEs such as user-user IE (see “User-to-User Signaling Service,” Section 11.6), a STATUS with a cause code value of 43 “access information discarded” may be returned.

5.2.12 TRANSIT NETWORK SELECTION

Some networks may not support transit network selection (TNS). In this case, when a TNS IE is received, that IE is processed according to the rules for unimplemented nonmandatory IEs (see “Nonmandatory Information Element Content Error,” Section 5.2.11.7.2). When TNS is supported, the user identifies the selected transit network(s) in the SETUP message. One TNS IE is used to convey a single network identification.

As the call is delivered to each selected network, the corresponding transit selection may be stripped from the call establishment signaling in accordance with the relevant internetwork signaling arrangement. The TNS IE(s) is/are not delivered to the destination user.

When a network cannot route the call because the route is busy, the network shall initiate call clearing in accordance with “Call Clearing—Symmetrical User Side Treatment,” Section 5.1.7, with a cause code value of 34 “no circuit/channel available.”

If a network does not recognize the specified transit network, the network shall initiate call clearing in accordance with “Call Clearing—Symmetrical User Side Treatment,” Section 5.1.7, with a cause code value of 2 “no route to specified transit network.” The diagnostic field shall contain a copy of the contents of the TNS IE identifying the unreachable network.

A network may screen all remaining transit network selection IEs to:

- avoid routing loops
- ensure an appropriate business relationship exists between selected networks
- ensure compliance with national and local regulations.

If the TNS is of an incorrect format or fails to meet the previously mentioned criteria, the network shall initiate call clearing in accordance with “Call Clearing—Symmetrical User Side Treatment,” Section 5.1.7, with the appropriate cause code value.

When a user includes the TNS IE, pre-subscribed default interexchange carrier information (if any) is overridden.

The network specific facilities (NSF) IE may also be used and specifies the transit network from which a service is requested. If both NSF and TNS IEs are supplied in a message, the transit network supplied in the NSF IE takes precedence.

For inter-LATA calls directed to a network switch, if there is no transit network selected in the NSF IE, then the message will be examined for the presence of a transit network selection IE. If no TNS IE is found, the call will be routed to the presubscribed carrier.

5.2.13 NETWORK SPECIFIC FACILITY SELECTION

The purpose of this IE is to indicate which network facilities are being invoked.

5.2.13.1 Default Provider

When the length of the network identification field is set to zero in the NSF IE, then the services identified in this IE are to be provided by the network side of the interface receiving the IE (default provider), if the interexchange carrier is needed. If the NSF IE is recognized but the network facilities are not understood, then this IE is processed according to rules for nonmandatory IE content error (see “Nonmandatory Information Element Content Error,” Section 5.2.11.7.2).

5.2.13.2 Routing Not Supported

Some networks may not support the routing to the remote network of the contents of the NSF IE. In this case, when a NSF IE is received, that IE is processed according to the rules for unimplemented nonmandatory IEs (see “Nonmandatory Information Element Content Error,” Section 5.2.11.7.2).

5.2.13.3 Routing Supported

When NSF IE routing is supported, the user identifies the network provider in this IE in the Q.931 SETUP message. One NSF IE is used to identify a network provider.

The user may specify more than one network provider by repeating the NSF IE. Each identification is placed in a separate IE. The information is routed to the indicated network provider as long as the call is also handled by the network provider. For example, if the user lists network providers A and B in separate NSF IEs, there must be corresponding TNS IEs in the SETUP message identifying those networks (or default call routing using A and B that was established prior to call establishment).

As the signaling messages containing NSF IEs are delivered to the indicated remote network, they may be stripped from the signaling messages, in accordance with the relevant interworking signaling arrangement. The NSF IEs may be delivered to the identified user.

No more than two NSF IEs may be used in a SETUP message. Further, there does not have to be a one-to-one correspondence between NSF IEs and TNS IEs.

If a network cannot pass the information to the indicated network provider because either the network indicated is not part of the call path or no mechanism exists for passing the information to identified network, the network shall initiate call clearing in accordance with “Call Clearing—Symmetrical User Side Treatment,” Section 5.1.7, with a cause code value of 2 “no route to specified transit network.”

When a user includes the NSF IE in the SETUP message, presubscribed default service treatment (if any) is overridden.

The NSF IE may also be used and specifies the transit network from which a service is requested. If both NSF and TNS IEs are supplied in a message, the transit network supplied in the NSF IE should override that supplied in the TNS IE.

For inter-LATA calls directed to a network switch, if there is no transit network selected in the NSF IE, then the message will be examined for the presence of a transit network selection IE. If no TNS IE is found, the call will be routed to the presubscribed carrier.

5.2.14 DIALED SEQUENCES AND CODING OF SETUP MESSAGE

Table 5.2-6 shows typical dialing sequences that may be encountered by a user on a PBX or a network switch. The table represents examples in which a user on a system dials a sequence as indicated in the column “User Dialed Sequence.” The sending system interprets the user dialed sequence, encodes a SETUP message, and sends it to the receiving system over a PRI. The carrier information, if explicitly provided in the NSF IE or the TNS IE, is shown in the “NSF/TNS Carrier Selection” column. The NSF IE facility coding value, the called party number IE type of number field, and address digits field are shown in the “NSF Facility Code,” “CdPN Type of Number,” and “CdPN Address Digits” columns, respectively.

Where the column “*5ESS* Switch Receiving” is marked and the “*5ESS*0 Switch Sending” is blank, it indicates that the *5ESS* switch receives the SETUP message and expects it to be coded as shown in the four columns showing NSF/TNS, NSF, and CdPN IEs. In general (exceptions follow), the system receiving is the *5ESS* switch serving as a CO. Where the system receiving is labeled “PBX,” the *5ESS* switch is operating as a PBX. The system sending is an arbitrary system that is interfaced to the *5ESS* switch over a PRI and converts the user dialed sequence into a SETUP message.

Where the column “*5ESS* Switch Sending” is marked and the “*5ESS* Switch Receiving” column is blank, it indicates that the *5ESS* switch is the system at which the “User Dialed Sequence” is interpreted and converted to a SETUP message that is sent to the “System Receiving.” The information in the SETUP message is coded by the *5ESS* switch as indicated in the remaining columns. The receiving system is an arbitrary system interfaced to the *5ESS* switch over a PRI.

The rows of the table are separated into the following subgroups, separated by double lines.

- operator access calls (Lines 1-9)
- direct-dialed local and national calls (Lines 10-14)
- international direct-dialed calls (Lines 15-16)
- calls that are coded for services as indicated in the NSF IE (Lines 17-30)

In Table 5.2-6, under the “NSF Facility Code” column:

OP	means operator
OP/P	means presubscribed (or default) transit network operator
MSB	means maximal subscribed WATS band
SDS	means *ACCUNET*[4] switched digital service

4. Registered servicemark of AT&T.

ILDS means international long distance service

NSF/TNS carrier selection denotes that the carrier XXX (or XXXX) is provided in the NSF, the TNS IE, or in both. The switch treatment is as previously described. (If the carrier is coded in the NSF IE, that carrier is used. If no carrier is coded in the NSF IE, the carrier coded in the TNS IE is used.) “XXX” stands for a three-digit carrier ID. Not shown but implied is “XXXX,” which denotes a four-digit carrier ID whenever XXX is indicated. When not specified in this column, the carrier ID is not applicable or is not specified in the message. In the user dialed sequences, whenever 10XXX is shown, it also implies that the case 101XXXX is also allowed.

For the “CdPN Type of Number” column:

N is national

I is international

!I is other than international

U is unknown

S is subscriber (or local)

5.2.14.1 Operator Access

For access to the local operator, Octet 4 of the NSF IE (see “Network Specific Facilities,” Section 4.3.3.15) in the SETUP message is coded for “Operator (TELCo),” and the called party number contains either:

- Seven or ten digits for zero plus; in this case, the called party number may be coded as a national number.
- No digits for zero minus; in this case, the called party number may be coded as a national number or an unknown number.

These cases are shown in Lines 1 and 2 of Table 5.2-6.

For access to the operator for an international call, the NSF in the SETUP message is coded for “Operator (TELCo)” and the type of number in the called party number IE is coded as international. The called party number IE may contain no digits for a 010 call (see Line 3), or it may contain digits for a 01+CC+NN call (see Line 4).

For access to the operator in a particular transit network, Octet 4 of the NSF IE (see “Network Specific Facilities,” Section 4.3.3.15) in the SETUP message is coded for “Operator (TELCo),” Octet 3 of the NSF IE is coded as XXX (or XXXX), or alternatively, the carrier ID is coded in the TNS IE. The called party number IE either contains no digits for 10XXX0 (or 101XXXX0), or contains digits for 10XXX0 plus (or 101XXXX0 plus). The called party number is expected to be coded as follows:

- As a national number, if it contains digits
- As either a national or an unknown number, if it contains no digits.

These codings are illustrated in Table 5.2-6, Lines 5 and 6.

For access to the presubscribed common carrier operator, the NSF in the SETUP message is coded for “Operator (default common carrier)” and the called party number contains no digits (see Line 7). This is equivalent to dialing 00-. If the carrier is specified in the TNS (or NSF) and the SETUP message is coded for “Operator (default common carrier),” and no calling party number (CgPN) digits are included, the call will be treated as a 10XXX+00- call, where XXX is the carrier specified in the TNS/NSF (see Line 8). If CgPN digits are included, the call will be rejected.

The cases in which the user dials 10XXX# (and 101XXXX#) are shown in Line 9. These cases are properly handled if the NSF is not coded for an operator feature, the carrier is specified, and the dialed digits contain a "#" sign. These cases are routed as if the dialed digits were 10XXX- (and 101XXXX-).

Table 5.2-6 — Dialing Sequences and Information Element Coding

Information Element Coding Interaction							
#	*5ESS*-2000 SWITCH SENDING	*5ESS*-2000 SWITCH RECEIVING	USER DIALED SEQUENCE	NSF/TNS CARRIER SELECTION	NSF FACILITY CODE	CdPN TYPE OF NUMBER	CdPN ADDRESS DIGITS
1		CO	0-	-	OP	N,U	-
2		CO	0+7D/10D	-	OP	N	7D/10D
3		CO	010	-	OP	I,U	-
4		CO	01+CC+NN	-	OP	I	CC+NN
5		CO	10XXX+0	XXX	OP	N,U	-
6		CO	10XXX+0+7D/10D	XXX	OP	N	7D/10D
7		CO	00-	-	OP/P	N,U	-
8		CO	10XXX+00-	XXX	OP/P	N,U	-
9		CO	10XXX#	XXX	-	N,U	#
10		CO	3D/7D/1+10D	-	-	!I	3D/7D/10D
11		CO	3D/7D/1+10D	XXX	-	!I	3D/7D/10D
12		CO	10XXX+3D/7D/1+10D	XXX	-	!I	3/7/10D
13		CO	1+7D/1+10D	-	-	!I	7D/10D
14	CO		1+7D/1+10D	-	-	S/N	7D/10D
15		CO	011+CC+NN	-	-	I	CC+NN
16		CO	10XXX+011+CC+NN	XXX	-	I	CC+NN
17	CO		INWATS 7D-10D	-	INWATS	S/N	7D/10D
18		CO	WATS 7D/1+10D	-	OUTWATS band or MSB	N	7D/10D
19		CO	WATS 1+7D/1+10D	-	OUTWATS band or MSB	N	7D/10D
20		CO	SDS 011+CC+NN	-	SDS	I	CC+NN
21		CO	ILDS 011+CC+NN	-	ILDS	I	CC+NN
22		PBX/CO	ETN 4D-7D	-	ETN	U	“Private” 4D-7D
23		PBX/CO	ETN 7D	-	ETN	S/N	7D/10D
24		CO	7D/1+10D	-	Tie(Senderized)	S,U	7D/10D
25		CO	1+7D/1+10D	-	Tie(Senderized)	S,U	1+7D/10D
26		CO	7D/1+10D	-	Tie(Cut-through)	S,U	-
27	CO		7D/1+10D	-	Tie(Cut-through)	U	-
28		CO	7D/1+10D	-	FX	I,N,S,U	7D/10D
29		CO	1+7D/10D	-	FX	I,N,S,U	1+7D/10D
30	CO		7D/1+10D	-	FX	U	-

5.2.14.2 Direct Dialed Calls

Translation of the dialed sequence and interpretation of digits received in the CdPN IE depend on the office dialing plan and whether the digit analysis tables are provisioned as lines or trunks. Typically, PRIs are provisioned as lines to allow for prefix resolution.

5.2.14.2.1 Other than International Calls (Local, National, or Unknown CdPN Type)

Lines 10 to 13 show the codings for local and national numbers with and without carriers specified in the NSF/TNS. A local or national call must not be coded as *international* type of number, or the call will fail. In the incoming SETUP message, the switch does not require the type of number to be *local* for 7-digit CdPNs or *national* for 10-digit CdPNs. However, such a number will be recoded in the terminating outgoing SETUP message. Line 14 shows the coding of the SETUP message sent by the switch CO in the case in which the switch is the sending office.

The switch CO or PBX sends:

- A 7-digit called party number as a *subscriber* number.
- A 10-digit called party number as a *national* number.
- Any called party number for other than a 7-digit, 10-digit, or international call as an *unknown* number. The *unknown* called party number type is coded; for example, when prefix digits are included.

5.2.14.2.2 International Calls

Lines 15 and 16 show the expected codings for international calls. When the *5ESS* switch receives a called party number type of *international*, the switch prepends “011” to the called party number before performing digit analysis. If the received called party number already contained a “011” prefix, the switch’s prepending action yields a called party number of “011011CCNN” for digit analysis. This will cause the call to fail.

The *5ESS* switch requires the digits to be translated through the office dialing plan to code the outgoing SETUP message with a type of number *international*. The *5ESS* switch *does not* code the type of number as *international* if the digits are translated through a private numbering plan.

5.2.14.3 Calls Invoking Services

The remainder of the case illustrated in Table 5.2-6 deal with calls in which services are indicated or requested by coding the facility coding value in the NSF IE. In the cases in which the switch is the sending system (Lines 17, 27, and 30), the table represents the form of the information that is sent out by the switch. In other cases, the table indicates the form of information that is expected to be received by the switch. Electronic tandem network (ETN) calls (Lines 22 and 23) represent codings for a *5ESS* switch PBX in a network of PBXs, or as a CO interface to a PBX network. For ETN or SDN on-net calls (where access code = 8, for example) the numbering plan identification field of the CdPN is set to “Private.” Off-net calls (where access code = 9, for example) will have numbering plan identification set to “E.164.”

Cases illustrate the FX and tie codings for both origination and termination. Lines 24 to 27 show tie originations and coding that are expected by the switch. In the cut-through case, no digits are included in the CdPN IE. Line 27 shows the codings sent out by the switch for tie cut-through terminations. The coding for the FX cases are in Lines 28 and 29. Line 30 shows the FX termination case in which the sending office is the switch. Note that no digits are included in the CdPN IE. As indicated in "PRI Call-by-Call Service Selection," Section 11.3, the NSF carriers facility number information in the service parameters field, which identifies the FX or tie facility for these calls.

5.2.15 CAUSE CODES AND LOCATION INDICATORS

For call clearing messages, either the *5ESS* switch or the customer premises equipment (CPE) can send information about the disposition of a call by populating the cause information element (IE). The cause IE is mandatory in the DISCONNECT message, and optional in the RELEASE and RELEASE COMPLETE call clearing messages. For other types of messages, the cause IE is mandatory in the STATUS message, and optional in the PROGRESS message.

The cause IE includes a cause value that provides information about conditions that result in the clearing of the call, the sending of the STATUS message, or the sending of the PROGRESS message. The cause IE also includes a location indicator (LI) to indicate the location that generated the condition and, in some cases, a diagnostic field to provide additional information.

Beginning with the 5E13 software release, modifications have been made to the population of cause codes and location indicators on the National ISDN PRI, in order to better align the *5ESS* switch treatment with Bellcore's recommendations to standardize cause codes and location indicators. With this change, customers are provided an option to toggle this capability to off and use instead their previous cause values and location indicators.

5.2.15.1 Cause Code Definitions

This section provides expanded definitions for the causes in "Cause," Section 4.3.3.8. A table is provided in Appendix I of ITU-T Recommendation Q.931 (I.451) to indicate how these causes are used in the call control procedures.

Note: See "Cause," Section 4.3.3.8, to determine which cause code values are supported by *5ESS* switch implementations.

5.2.15.1.1 Normal Class

5.2.15.1.1.1 Cause Code Value 1 "Unallocated (Unassigned) Number"

This cause indicated that the destination requested by the calling user cannot be reached because although the number is in a valid format, it is not currently assigned (allocated).

5.2.15.1.1.2 Cause Code Value 2 "No Route to Specified Transit Network"

This cause indicates that the equipment sending this cause has received a request to route the call through a particular transit network that it does not recognize. The equipment sending this cause does not recognize the transit network because either the transit network does not exist or it does not serve the equipment that is sending this cause.

This cause is supported on a network-dependent basis.

5.2.15.1.1.3 Cause Code Value 3 "No Route to Destination"

This cause indicates that the called user cannot be reached because the network through which the call has been routed does not serve the destination desired.

This cause is supported on a network-dependent basis.

5.2.15.1.1.4 Cause Code Value 6 “Channel Unacceptable”

This cause indicates that the channel most recently identified by the called user is not acceptable for use in the call.

5.2.15.1.1.5 Cause Code Value 8 “Preemption”

This cause indicates that a call is being cleared because the B-channel is being preempted for a call of higher priority. The network does not need the B-channel for the preempting call. The preempted B-channel is returned to the pool of available resources.

5.2.15.1.1.6 Cause Code Value 9 “Preemption—Circuit Reserved for Reuse”

This cause indicates that a call is being cleared because the B-channel is being preempted for a call of higher priority. The B-channel is dedicated for the preempting call.

5.2.15.1.1.7 Cause Code Value 16 “Normal Call Clearing”

This cause indicates that the call is being cleared because one of the users involved in the call has requested that the call be cleared.

Under normal circumstances, the source of this cause is not the network.

5.2.15.1.1.8 Cause Code Value 17 “User Busy”

This cause is used when the called user has indicated the inability to accept another call.

It is noted that the user equipment is compatible with the call.

5.2.15.1.1.9 Cause Code Value 18 “No User Responding”

This cause is used when a user does not respond to a call establishment message with either an alerting or a connect indication within the prescribed period of time allocated (defined in Q.931 by the expiry of either Timer T303 or Timer T310).

5.2.15.1.1.10 Cause Code Value 19 “No Answer from User (User Alerted)”

This cause is used when a user has provided an alerting indication but has not provided a connect indication within a prescribed period of time.

Note: This cause is not necessarily generated by Q.931 procedures, but may be generated by internal network timers.

5.2.15.1.1.11 Cause Code Value 21 “Call Rejected”

This cause indicates that the equipment sending this cause does not wish to accept this call, although it could have accepted the call because the equipment sending this cause is neither busy nor incompatible.

5.2.15.1.1.12 Cause Code Value 22 “Number Changed”

This cause is returned to a calling user when the called party number indicated by the calling user is no longer assigned. The new called party number may optionally be included in the diagnostic field. If a network does not support this capability, a cause code value of 1 “unallocated (unassigned) number” shall be used.

5.2.15.1.1.13 Cause Code Value 27 “Destination Out of Order”

This cause indicates that the destination indicated by the user cannot be reached because the interface to the destination is not functioning correctly. The term “not functioning correctly” indicates that a signaling message was unable to be delivered to the remote user. Reasons for inability to deliver to the remote user include a physical layer or data link layer failure at the remote user, or user equipment off-line.

5.2.15.1.1.14 Cause Code Value 28 “Invalid Number Format (Address Incomplete)”

This cause indicates that the called user cannot be reached because the called party number is not a valid format or is not complete.

5.2.15.1.1.15 Cause Code Value 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.

5.2.15.1.1.16 Cause Code Value 31 “Normal, Unspecified”

This cause is used to report a normal event only when no other cause in the normal class applies.

5.2.15.1.2 Resource Unavailable Class

5.2.15.1.2.1 Cause Code Value 34 “No Circuit/Channel Available”

This cause indicates that there is no appropriate circuit/channel presently available to handle the call.

5.2.15.1.2.2 Cause Code Value 35 “Call has been Queued”

This cause indicates that the call has been queued.

5.2.15.1.2.3 Cause Code Value 41 “Temporary Failure”

This cause indicates that the network is not functioning correctly and that the condition is not likely to last a long period of time. The user may wish to try another call attempt almost immediately.

5.2.15.1.2.4 Cause Code Value 42 “Switching Equipment Congestion”

This cause indicates that the switching equipment generating this cause is experiencing a period of high traffic.

5.2.15.1.2.5 Cause Code Value 43 “Access Information Discarded”

This cause indicates that the network could not deliver access information, low layer compatibility, high layer compatibility, or sub-address as indicated in the diagnostic.

It is noted that the particular type of access information discarded is optionally included in the diagnostic.

5.2.15.1.2.6 Cause Code Value 44 “Requested Circuit/Channel Not Available”

This cause is returned when the circuit or channel indicated by the requesting entity cannot be provided by the other side of the interface.

5.2.15.1.2.7 Cause Code Value 47 “Resource Unavailable, Unspecified”

This cause is used to report a resource unavailable event only when no other cause in the resource unavailable class applies.

5.2.15.1.3 Service or Option Not Available Class

5.2.15.1.3.1 Cause Code Value 50 “Requested Facility Not Subscribed”

This cause indicates that the requested supplementary service could not be provided by the network because the user has not completed the necessary administrative arrangements with its supporting network.

5.2.15.1.3.2 Cause Code Value 51 “Bearer Capability Incompatible with Service Request”

This cause indicates that the user has requested a bearer capability that is implemented by the equipment that generated this cause, but that is not compatible with the service being requested.

5.2.15.1.3.3 Cause Code Value 52 “Outgoing Calls Barred”

This cause indicates that because of Call Screening provided by the network, the calling user is not permitted to make a call.

5.2.15.1.3.4 Cause Code Value 53 “Service Operation Violated”

This National ISDN PRI specific cause code value indicates that the user has requested a supplementary service in a manner or state not supported by the sending equipment. This cause code is also returned when multiple privacy of calling name (PCN) requests are received in the same SETUP message.

5.2.15.1.3.5 Cause Code Value 54 “Incoming Calls Barred”

This cause indicates that the called user will not accept the call delivered in the SETUP message.

5.2.15.1.3.6 Cause Code Value 57 “Bearer Capability Not Authorized”

This cause indicates that the user has requested a bearer capability that is implemented by the equipment that generated this cause but the user is not authorized to use.

5.2.15.1.3.7 Cause Code Value 58 “Bearer Capability Not Presently Available”

This cause indicates that the user has requested a bearer capability that is implemented by the equipment that generated this cause, but that is not available at this time.

5.2.15.1.3.8 Cause Code Value 63 “Service or Option Not Available, Unspecified”

This cause indicates that the user has requested a service or option that is not available to the user.

5.2.15.1.4 Service or Option Not Implemented Class

5.2.15.1.4.1 Cause Code Value 65 “Bearer Capability Not Implemented”

This cause indicates that the equipment sending this cause does not support the bearer capability requested.

5.2.15.1.4.2 Cause Code Value 66 “Channel Type Not Implemented”

This cause indicates that the equipment sending this cause does not support the channel type requested.

5.2.15.1.4.3 Cause Code Value 69 “Requested Facility Not Implemented”

This cause indicates that the equipment sending this cause does not support the requested supplemental service.

5.2.15.1.4.4 Cause Code Value 70 “Only Restricted Digital Information Bearer Capability is Available”

This cause indicates that one equipment has requested an unrestricted bearer service but that the equipment sending this cause supports only the restricted version of the requested bearer capability.

5.2.15.1.4.5 Cause Code Value 79 “Service or Option Not Implemented, Unspecified”

This cause is used to report a service or option not implemented event only when no other cause in the service or option not implemented class applies.

5.2.15.1.5 Invalid Message (Such as Parameter Out of Range) Class

5.2.15.1.5.1 Cause Code Value 81 “Invalid Call Reference Value”

This cause indicates that the equipment sending this cause has received a message with a call reference that is not currently in use on the user-network interface.

5.2.15.1.5.2 Cause Code Value 82 “Identified Channel Does Not Exist”

This cause indicates that the equipment sending this cause has received a request to use a channel not activated on the interface for a call. For example, if a user has subscribed to those channels on a primary rate interface numbered from 1 to 12 and the user equipment or the network attempts to use Channels 13 through 23, this cause is generated.

5.2.15.1.5.3 Cause Code Value 83 “a Suspended Call Exists, but This Call Identity Does Not”

This cause indicates that a call resume has been attempted with a call identity that differs from that in use for any presently suspended call(s).

5.2.15.1.5.4 Cause Code Value 88 “Incompatible Destination”

This cause indicates that the equipment sending this cause has received a request to establish a call that has low layer compatibility, high layer compatibility, or other compatibility attributes (such as data rate) that cannot be accommodated.

5.2.15.1.6 Protocol Error (Such as Unknown Message) Class

5.2.15.1.6.1 Cause Code Value 96 “Mandatory Information Element Is Missing”

This cause indicates that the equipment sending this cause has received a message that is missing an IE that must be present in the message before that message can be processed.

5.2.15.1.6.2 Cause Code Value 97 “Message Type Non-Existent or Not Implemented”

This cause indicates that the equipment sending this cause has received a message with a message type it does not recognize, because the message is either not defined or not implemented by the equipment sending this cause.

5.2.15.1.6.3 Cause Code Value 98 “Message Not Compatible with Call State or Message Type Non-Existent or Not Implemented”

This cause indicates that the equipment sending this cause has received a message such that the procedures do not indicate that this is a permissible message to receive while in the call state, or a STATUS message was received indicating an incompatible call state.

5.2.15.1.6.4 Cause Code Value 99 “Information Element Non-Existent or Not Implemented”

When only a locking shift information element is included and no variable length information element follows, the codeset in the locking shift itself is not implemented.

5.2.15.1.6.5 Cause Code Value 100 "Invalid Information Element Contents"

This cause indicates that the equipment sending this cause has received an IE that it has implemented; however, one or more of the fields in the IE are coded in such a way that they have not been implemented by the equipment sending this cause.

5.2.15.1.6.6 Cause Code Value 101 "Message Not Compatible with Call State"

This cause indicates that a message has been received that is incompatible with the call state.

5.2.15.1.6.7 Cause Code Value 102 "Recovery On Timer Expiry"

This cause indicates that a procedure has been initiated by the expiry of a timer in association with Q.931 error handling procedures.

5.2.15.1.7 Interworking Class

5.2.15.1.7.1 Cause Code Value 127 "Interworking, Unspecified"

This cause indicates that there has been interworking with a network that does not provide causes for actions it takes, thus the precise cause for a message that is being sent cannot be ascertained.

5.2.15.2 Location Indicator Definitions and Usage

The location field in the cause IE is coded with one of the following values:

- User
- Private Network Serving the Local User
- Private Network Serving the Remote User
- Public Network Serving the Local User
- Public Network Serving the Remote User
- Transit Network
- International Network
- Network Beyond Interworking Point.

The following guidelines and use cases have been applied to determine the location indicator to be used in various situations:

- Public/Private Network Serving Local/Remote User
  - — Local User vs. Remote User:

    If the *5ESS* switch sends the message to the same interface about which it generated the cause code, "local user" is used in the location indicator.

    If the *5ESS* switch sends the message to an interface different from the one about which it generated the cause code, "remote user" is used in the location indicator, even if this different interface is within the same switch.

  - — Public Network vs. Private Network:

    If the *5ESS* switch serving as a public network switch generates the cause, the switch codes the location as "public network" in the location indicator in conjunction with either "local user" or "remote user."

If Class II equipment (a PBX, for example) generates the cause, this equipment codes the location as “private network” in the location indicator in conjunction with either “local user” or “remote user.”

- Mapping from Local to Remote

  The following use cases illustrate conditions that result in the *5ESS* switch mapping a “local” location indicator it receives to a “remote” location indicator before sending the cause IE to another interface.

  — If the *5ESS* switch receives the location indicator “private network serving the local user” (from a PRI, for example), the switch maps the location indicator to “private network serving the remote user” in its message to the other end of the call connection.

  — If the *5ESS* switch receives the location indicator “public network serving the local user,” the switch maps the location indicator to “public network serving the remote user” in its message to the other end of the call connection.

  — For inter-switch calls, if the *5ESS* switch receives the location indicator “local interface controlled by this signaling link” in an SS7 cause indicators parameter, the 5ESS-SS7 function codes the location indicator “public network serving the local user,” unless it received the cause code over an inter-exchange carrier (IC) link. Further, if the *5ESS* switch includes the cause code in its message to another interface (a PRI, for example), the SS7-ISDN interworking function maps the location indicator from “public network serving the local user” to “public network serving the remote user.”

- User

  The following use cases illustrate conditions that result in the *5ESS* switch coding the location as “user” when the location information is passed from the *5ESS* switch.

  — If user equipment sends to the *5ESS* switch a message with the location indicator “user,” the switch codes the location indicator as “user” when it passes cause and location information to other end of the call connection.

  — If the user equipment causes the condition but the *5ESS* switch assigns the cause value and passes it to another connection of the call (a PRI, for example), the switch codes the location indicator as “user.”

  — If the *5ESS* switch receives from Class II equipment a cause code with other than one of the following three locations, the switch codes the location indicator as “user”:

    - user
    - private network serving the local user
    - private network serving the remote user.

- Transit Network

  For inter-switch calls, if *5ESS* switch receives the location indicator “local interface controlled by this signaling link” over an IC link in an SS7 cause parameter, the switch codes the location indicator as “transit network” before sending the cause IE to an interface.

If the *5ESS* switch receives the location indicator “transit network,” it passes this location value.

- International Network

  If the *5ESS* switch receives, for an interoffice trunk in the call connection, a cause generated by an international carrier and the location indicator “international network” is included in the SS7 message, the switch passes this location value.

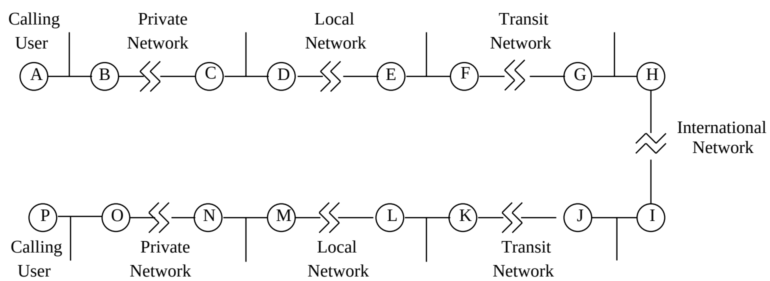
- Network Beyond Interworking Point

  If the *5ESS* switch cannot identify (because of interworking with a non-ISDN trunk) the cause for releasing a call, it sends a cause code value of 127 “Interworking, unspecified” with location indicator “network beyond interworking point.” The switch does not use this location indicator with any other cause code.

5.2.15.3 Examples of Cause Values and Locations for Busy Conditions

This section gives examples on the detailed cause code value and location to be sent in a cause IE for the busy condition.

Figure 5.2-4 shows the reference configuration that identifies nodes where busy condition may occur and therefore a cause should be generated.



Note: The interface A-B, C-D, M-N, and O-P are assumed to be Q.931.

Figure 5.2-4 — Reference Configuration for Locations of Busy Condition

Table 5.2-7 shows:

- A cause code value and location to be generated at the point where the busy condition occurs
- A cause code value and location to be delivered to the user (indicated as A) for each location (B - P) where the busy condition occurs.

As indicated in Table 5.2-7, the cause code value is not changed but the location may be changed in the receiving exchange when the cause code value crosses a network boundary.

Table 5.2-7 — Locations Where Busy Occurs and Associated Cause Values

LOCATION WHERE BUSY OCCURS		CAUSE AT THE POINT OF GENERATION		CAUSE RECEIVED BY USER "A"	
B	incoming circuit	#34 or #44	LPN	)	
B	outgoing circuit	#34	LPN	)	
C	outgoing circuit	#34	LPN	)	
				)	
D	incoming circuit	#34 or #44	LN	)	
D	outgoing circuit	#34	LN	)The same as left	
E	outgoing circuit	#34	LN	)	
				)	
F	outgoing circuit	#34	TN	)	
G	outgoing circuit	#34	TN	)	
				)	
H	outgoing circuit	#34	INTL	)	
I	outgoing circuit	#34	INTL	)	
J	outgoing circuit	#34	TN	#34	TN
K	outgoing circuit	#34	TN	#34	TN
L	outgoing circuit	#34	LN	#34	RLN
M	outgoing circuit	#17	LN	#17	RLN
N	incoming circuit	#34 or #44	LPN	#34 or #44	RPN
N	outgoing circuit	#34	LPN	#34	RPN
O	outgoing circuit	#17	LPN	#17	RPN
P	incoming circuit	#34 or #44	U	#34 or #44	U
P	call control	#17	U	#17	U

LPN : Private network serving the local user
LN : Public network serving the local user
TN : Transit network
INTL : International transit network
RLN : Public network serving the remote user
RPN : Private network serving the remote user
U : User.

5.2.16 USE OF PROGRESS INDICATORS

This section describes the use of the progress descriptor values for the progress indicator IE, whose codings are provided in "Progress Indicator," Section 4.3.3.18.

Progress Descriptor 1 indicates that interworking with a non-ISDN has occurred within the network or networks through which the call has traversed.

Progress Descriptor 2 indicates that the destination user is not ISDN.

Progress Descriptor 3 indicates that the origination user is not ISDN.

Progress Descriptor 4 indicates that a call that had left the ISDN has returned to the ISDN at the same point it had left due to redirection within the non-ISDN. This progress descriptor would be employed when a prior ITU-T Recommendation Q.931 (I.451) message resulted in a Progress Descriptor 1 “call is not end-to-end ISDN” being delivered to the calling user.

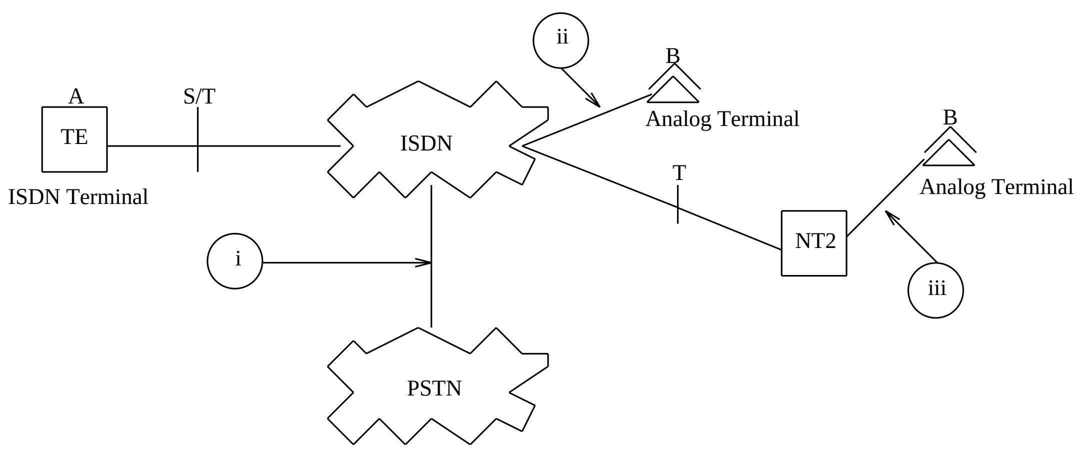
Progress Descriptor 8 indicates that in-band information or an appropriate pattern is now available.

Examples of the use of Progress Descriptors 1, 2, and 3 are provided in the following interworking situations that are depicted in Figure 5.2-5:

i. interworking with another network

ii. interworking with a non-ISDN user connected to ISDN

iii. interworking with non-ISDN equipment within the calling or called user’s premises.



For calls *from* A:

case i) -	Progress indicator IE with Progress Descriptor 1 is sent to A.
case ii) -	Progress indicator IE with Progress Descriptor 2 is sent to A.
case iii) -	Progress indicator IE with Progress Descriptor 2 is sent to A (location sub-field—private network).

For calls *toward* A:

case i) -	Progress indicator IE with Progress Descriptor 1 is sent to A.
case ii) -	Progress indicator IE with Progress Descriptor 3 is sent to A.
case iii) -	Progress indicator IE with Progress Descriptor 3 is sent to A (location sub-field—private network).

Figure 5.2-5 — Progress Descriptors Values Based on Interworking Situation

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5.3 COMMON ELEMENT PROCEDURES FOR SERVICE CONTROL

5.3.1 OVERVIEW

This section contains an overview of a subset of Layer 3 and Layer 7 protocols and the Lucent Technologies implementation of those protocols. The reader should be familiar with Bellcore document SR-3887[1] which specifies generic guidelines for CPE equipment using Layer 7 protocols.

The common element procedures provide a functional mechanism for the user and network to exchange supplementary service information for service control. There are four components defined for this control. The components are a structured sequence of octets used to carry service-specific information in both the CPE-to-network and the network-to-CPE directions. The common element procedures are defined in Bellcore SR-2823-CORE.[2]

5.3.2 COMPONENT SIGNALING PROCEDURES

5.3.2.1 Component Overview

The protocol and procedures herein are based on the services and protocol defined in ITU-T Recommendations X.219 and X.229, and ISO DIS-11582. The seven components are the following:

- Network Facilities Extension (NFE) Component (Layer 3)

  The NFE component is not used for public network PRI services. If received in a facility IE by the switch, the NFE will be ignored.

- Network Protocol Profile (NPP) Component (Layer 3)

  The NPP is not used for public network PRI services. If it is received in a facility IE by the switch, the entire facility IE will be discarded and a STATUS message indicating “invalid information element contents” will be returned to the sending CPE.

- Interpretation Component (Layer 3)

  The interpretation component is sent to indicate the expected response to receipt of an unrecognized operation value. The responses include ignore, discard and respond with a reject component, or clear call.

- Invoke Component (Layer 7)

  The Invoke component is sent to request that an operation be performed. The Invoke component begins a new component exchange or is a response to an Invoke component. The Invoke component contains a data element to identify the requested operation and any other parameters (arguments) needed to perform the requested operation.

- Return Result Component (Layer 7)

  The Return Result component indicates the successful completion of the requested operation. The Return Result component may contain service-specific parameters to be returned to the requester.

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1. The 1997 version of Bellcore, *National ISDN Primary Rate Interface Customer Premise Equipment Generic Guidelines*, Issue 1, November 1996 (SR-3887).
2. Bellcore, *PRI Common Element Procedures and Service Information Transport Generic Requirements,* Issue 1, October 1994 (GR-2823-CORE).

- Return Error Component (Layer 7)

  The Return Error component indicates the unsuccessful completion of the requested operation. The Return Error component contains the reason for failure and may also contain service-specific parameters.

- Reject Component (Layer 7)

  The Reject component is sent in response to an Invoke, Return Error, or Return Result component as an indication of a protocol error.

5.3.2.2 Receipt of a Network Facilities Extension Component

The received facility should not contain a NFE component (Octet 3b). If the *5ESS*® switch receives an NFE component in the facility IE of a SETUP message from an originating PRI, the *5ESS* switch shall discard the NFE component and continue processing the rest of the facility IE. No notification of discard of the NFE component (for example, STATUS message) will be returned to the originating PRI for this event.

5.3.2.3 Sending a Network Facilities Extension Component

The NFE component will not be sent by the *5ESS* switch.

5.3.2.4 Receipt of a Network Protocol Profile Component

The received facility IE should not contain a NPP component for privacy of calling name (PCN) invocations.

If a facility IE is received in a SETUP message with a NPP component, the *5ESS* switch shall discard the facility IE and return a STATUS message containing a cause code value of 100 “invalid information element contents,” a location of “public network serving the local user,” a diagnostic of the facility IE ID, and the appropriate call state.

5.3.2.5 Sending a Network Protocol Profile Component

This component will not be sent by the *5ESS* switch.

5.3.2.6 Receipt of an Interpretation Component

The received facility IE in a SETUP message may contain an Interpretation component as shown in Table 4.3-23. If an Interpretation component is received it must contain the interpretation value data element coded as defined in “Interpretation Value,” Section 4.4.9.

If a facility IE is received in a SETUP or FACILITY message with an interpretation value other than those specified in “Interpretation Value,” Section 4.4.9, or without an Interpretation component, the *5ESS* switch will assume a default interpretation value of 2, shall discard (that is, ignore) the Interpretation component, and continue with processing the facility IE as if no Interpretation component had been received.

If a facility IE is received in a DISCONNECT, RELEASE, or RELEASE COMPLETE with an interpretation value other than the values defined previously, the *5ESS* switch shall discard (that is, ignore) the Interpretation component and shall continue with call clearing following existing procedures.

5.3.2.7 Sending an Interpretation Component

The *5ESS* switch will include an Interpretation component in the facility IE of a SETUP or FACILITY message for networking extension operations. For example, in CNAM, an interpretation value coded as “0” is sent. The Interpretation component contains the following data elements:

- Component type

  The component type is coded as “Interpretation.”

- Interpretation value

  An interpretation value coded as “0” means discard any Invoke component containing an unrecognized operation value.

5.3.2.8 Receipt of an Invoke Component

When the switch receives an Invoke component from a CPE, it expects it to contain the following data elements coded as described in Table 4.3-24:

- Component type

  The switch expects the component type to be coded as “Invoke.”

- Invoke ID
- Operation value
- Argument(s), if defined for the operation

The switch saves the invoke ID it receives from the CPE since it may be used in a reply component sent back to the CPE.

5.3.2.9 Sending an Invoke Component

Table 4.3-24 and “Service Components,” Section 4.3.3.11.1.2, describe the coding details for the various data elements of the Invoke component. The Invoke component contains the following data elements:

- Component type

  The switch codes the component type as “Invoke.”

- Invoke ID

  The switch includes an invoke ID, chosen as described in “Invoke Identifier,” Section 4.4.2.

- Operation value

  The switch includes the operation value of the requested operation.

- Arguments

  The switch includes arguments only if defined for this particular operation.

5.3.2.10 Receipt of a Return Result Component

Table 4.3-25 and “Service Components,” Section 4.3.3.11.1.2, describe the coding details for the various data elements of the Return Result component. The Return Result component contains the following data elements:

- Component type

  The component type will be coded as “Return Result.”

- Invoke ID

  The switch expects the invoke ID to be coded to the same value as the invoke ID sent in the Invoke component.

- Sequence, Operation value, and Results

  The sequence and operation value data elements are included only if service-specific results are included.

5.3.2.11 Sending a Return Result Component

Table 4.3-25 and "Service Components," Section 4.3.3.11.1.2, describe coding for the various data elements of the Return Result component. The Return Result component contains the following data elements:

- Component type

  The switch codes the component type as "Return Result."

- Invoke ID

  The switch codes the invoke ID to the same value as the invoke ID in the Invoke component received from the CPE.

- Sequence, Operation value, and Results

  The sequence and operation value data elements are included only if service-specific results are included.

5.3.2.12 Receipt of a Return Error Component

Table 4.3-26 and "Service Components," Section 4.3.3.11.1.2, describe the coding details for the various data elements of the Return Error component. The Return Error component contains the following data elements:

- Component type

  The component type will be coded as "Return Error."

- Invoke ID

  The switch expects the invoke ID to be coded to the same value as the invoke ID sent in the Invoke component.

- Error value

  This data element is expected to carry service-specific error information.

- Parameter(s) (also known as Arguments)

  Service-specific arguments are included if any for the indicated error value are defined.

5.3.2.13 Sending a Return Error Component

Table 4.3-26 and "Service Components," Section 4.3.3.11.1.2, describe coding details for the various data elements of the Return Error component.

The switch sends a Return Error component as an indication that it can not perform the operation identified in the Invoke component received from the user. The Return Error component contains the following data elements:

- Component type

The switch codes the component type as “Return Error.”

- Invoke ID

  The switch codes the invoke ID to the same value as the invoke ID in the Invoke component received from the CPE.

- Error value

  The switch codes the error value to indicate which error has occurred.

5.3.2.14 Receipt of a Reject Component

Table 4.3-27 and “Service Components,” Section 4.3.3.11.1.2, describe coding details for the various elements of the Reject component. The Reject component contains the following data elements:

- Component type

  The component type will be coded as “Reject.”

- Invoke ID

  The switch expects the invoke ID to be coded to the same value as the invoke ID sent in the Invoke component.

- Problem value

  The problem value will indicate one of four categories of errors. A General problem is a protocol error (such as an unrecognized component, a mistyped component, or a badly structured component) that is independent of a particular component. An Invoke problem indicates protocol errors with a received Invoke component. A Return Result problem indicates protocol errors with a received Return Result component. A Return Error problem indicates protocol errors with a received Return Error component.

5.3.2.15 Sending a Reject Component

Table 4.3-27 and “Service Components,” Section 4.3.3.11.1.2, describe coding details for the various data elements of the Reject component. The switch sends a Reject component to indicate that a protocol error was detected in a received component. The Reject component contains the following data elements:

- Component type

  The switch codes the component type as “Reject.”

- Invoke ID

  The switch codes the invoke ID to the same value as the invoke ID in the received Invoke component. If the invoke ID in the Invoke component sent by the CPE is invalid, the switch uses the null ID in the Reject component.

- Problem value

  General problems are used to indicate protocol errors with a received Invoke component.

  Invoke problems are used to indicate protocol problems associated with the requested operation.

5.3.2.16 Operation Class

There is an operation class specified for each operation value. The operation class defines the allowable responses to an invoke operation. The operation class is not contained in the protocol between the switch and the CPE; however, it is expected to be known to both. There are synchronous and asynchronous operation modes. Synchronous operation mode requires a reply from the performer to the invoker before invoking another operation. Asynchronous operation mode allows continuous invocation of operations without waiting for a reply. The *5ESS* switch supports the operation classes as follows:

- Operation Class 2: Synchronous, reporting success or failure (result or error)

  The Class 2 operation is defined in both the user-to-network and network-to-user direction for the invoking of a request. The components the switch may send in response to an Invoke component are Reject, Return Error and Return Result.

- Operation Class 5: Asynchronous, outcome not reported

  Class 5 operations are defined in both the network-to-user and the user-to-network directions. The switch may send the Reject component as a response to a Class 5 Invoke component; however, the switch does not expect a response from the CPE after sending an Invoke component with a Class 5 operation.

5.3.2.17 Invoke Identifier

The invoke ID identifies the particular component exchange at the local CPE-to-network interface to which a component applies. The invoke ID is present in every ROSE component, enabling a reply to be correlated with the request.

5.3.2.17.1 Invoke IDs in Components Received by the Switch

The switch accepts an invoke ID value as being valid in an Invoke component if the value is either one octet or two octets long and within the range of –32768 to 32767, and responds using the invoke ID it received. If the switch determines that the invoke ID contained in the Invoke component is invalid, it discards the Invoke component and sends to the originating CPE a FACILITY message containing a facility IE with a null ID and a Reject component. This Reject component contains the General problem tag and a problem value of “badly-structured-component.”

5.3.2.17.2 Invoke IDs Used in Components Sent by the Switch

The switch allocates an invoke ID (one or two octets long) when it sends an Invoke component to the CPE. Invoke IDs sent by the *5ESS* switch fall within the range –32768 to 32767.

Note: An invoke ID with a value of 0 (length of 1) is not the same as a null invoke ID (length of 0).

5.3.2.18 Arguments and Parameters

The parameters included in a component (for example, the arguments in an Invoke component or the parameters in a Return Error component) are included in the service-specific definition of an operation.

5.3.3 CALL-ASSOCIATED SIGNALING PROCEDURES

5.3.3.1 Invoke Identifier Administration

When the switch receives a message from the CPE containing a facility IE coded with an Invoke component, the switch will retain the invoke ID value to be used in all facility IEs exchanged between the switch and the CPE. The invoke ID is associated with the call reference value (CRV). Multiple invoke IDs may be associated with the same CRV, and different CRVs on the interface may have identical invoke IDs.

For example, the switch may detect an error with the Invoke component and send a Reject component in the facility IE of the FACILITY message. The invoke ID will be the same as the invoke ID received in the incoming message.

5.3.3.2 Protocol Error Treatment During Call Origination or an Active Call

- Receipt of a facility IE in an incorrect message.

  If the facility IE is received in a message other than SETUP or FACILITY, the switch ignores the facility IE and proceeds with normal call processing.

- Receipt of a message without a facility IE.

  If the switch receives a FACILITY message that is missing the facility IE and the call is not in the process of being cleared, the switch discards the FACILITY message and responds with a STATUS message containing a cause code value of 96, “mandatory information element is missing” (location: public network serving the local user; diagnostic: information element identifier), and the current call state.

  If the switch receives a FACILITY message that is missing the facility IE and the call is in the process of being cleared, the switch discards the FACILITY message and continues with call clearing. The switch does not send a STATUS message.

- Receipt of a facility IE with components with invalid or inconsistent length, or a data element length inconsistent with the component length.

  If the switch receives a SETUP or FACILITY message containing a facility IE with a component that has a length inconsistent with the length of the facility IE, or a data element length inconsistent with the component length, the switch sends a FACILITY message with a facility IE containing a Reject component. The Reject component contains the General problem tag and a problem value of “badly-structured-component.”

- Receipt of a Service component with an incorrect length encoding.

  If the switch receives a SETUP or FACILITY message that contains a facility IE with a two-octet length format (long form) that encodes component data element lengths less than or equal to 127 octets, the switch discards the component and sends a FACILITY message with a Reject component. The Reject component contains the General problem tag and a problem value of “badly-structured-component.”

- Receipt of a Service component without an invoke ID.

  Upon receipt of a SETUP or FACILITY message with a facility IE containing an Invoke component but not an invoke ID, the switch discards the Invoke component and sends a FACILITY message with a Reject component that contains a problem value of “mistyped-component” and a null ID.

- Receipt of a Service component with a linked ID.

  Upon receipt of a SETUP or FACILITY message with a facility IE containing an Invoke component with a linked ID identifying an operation that does not permit linked operations, the switch discards the Invoke component and sends the CPE a FACILITY message. Since the *5ESS* switch does not support linked IDs, the FACILITY message contains a Reject component with Problem Tag 129, “Invoke-problem,” and Problem Value 6, “linked-response-unexpected.”

- Receipt of a facility IE with an unrecognized component.

  If the switch receives a SETUP or FACILITY message containing a facility IE with a ROSE component type other than Invoke, Return Result, Return Error, or Reject, the switch discards the component and sends a FACILITY message with a facility IE containing a Reject component. The Reject component contains the General problem tag and problem value of “unrecognized-component.”

- Receipt of a Service component with incorrectly coded tags, or a mandatory data element missing or out of order.

  If the switch receives a SETUP or FACILITY message with a facility IE containing a component with missing or incorrectly coded mandatory data element tags, the switch discards the component and sends a FACILITY message with a Reject component. The Reject component contains the General problem tag and a problem value of “mistyped-component.”

- Receipt of a Service component with an invalidly coded data element.

  If the switch receives a SETUP or FACILITY message with a facility IE containing an Invoke component with an invalidly coded data element, the switch discards the Return Result of Return Error component and sends a FACILITY message with a Reject component. The Reject component contains the General problem tag and a problem value of “badly-structured-component.” Examples of these invalidly coded data elements include:

  — data elements with no length specified

  — data elements with improper lengths

  — invoke ID or operation value with a length that is in long format.

- Receipt of a facility IE with an unrecognized operation value.

  Upon receipt of a SETUP or FACILITY message that contains a facility IE with a protocol profile set to networking extensions, if the switch does not receive a valid operation value, the switch discards the Invoke component and:

  — If an Interpretation component was received coded “discard any Invoke component containing an unrecognized operation value,” the *5ESS* switch does not return a Reject component to the originating PRI.

  — If an Interpretation component was received coded “discard any Invoke component containing an unrecognized operation value and return a Reject component,” the *5ESS* switch sends to the originating PRI a FACILITY message with a facility IE containing a Reject component. The Reject component contains Problem Tag 129, “Invoke-problem,” and Problem Value 1, “unrecognized-operation.”

- — If an Interpretation component was received coded “clear call if any Invoke component contains an unrecognized operation value,” the *5ESS* switch initiates call clearing and returns to the originating PRI a Reject component containing Problem Tag 129, “Invoke-problem,” and Problem Value 1, “unrecognized-operation” in the call clearing message (for example, RELEASE, RELEASE COMPLETE, or DISCONNECT). The switch codes the call clearing message with a cause code value of 31, “normal unspecified,” and a location of “public network serving the local user.”
- — If an Interpretation component was not received, the *5ESS* switch returns to the originating PRI a FACILITY message with a facility IE containing a Reject component. The Reject component will contain Problem Tag 129, “Invoke-problem,” and Problem Value 1, “unrecognized-operation.”

- Receipt of a Service component with missing mandatory arguments.

  If the Invoke component in the received facility IE of the SETUP or FACILITY message contains an argument part that is missing one or more mandatory parameters, or that contains mandatory parameters that are not in the correct order, the *5ESS* switch discards the Invoke component and sends to the originating CPE a FACILITY message with a facility IE containing a Reject component. The Reject component contains Problem Tag 129, “Invoke-problem,” and Problem Value 2, “mistyped-argument.”

  If the Invoke component in the received facility IE of the SETUP or FACILITY message contains an unexpected argument, the *5ESS* switch ignores the unexpected argument.

5.3.3.3 Protocol Error Handling During Call Clearing

If the switch receives a call clearing message (RELEASE, DISCONNECT, or RELEASE COMPLETE) containing an improperly coded facility IE, the switch will ignore the facility IE and continue call processing. No response to the protocol error (for example, facility IE containing a Reject component) is sent to the CPE.

5.3.3.4 Releasing an Invoke Identifier

The switch will release the invoke ID when:

- the switch has accepted a service request for a Class 5 operation
- the switch has received a FACILITY message with a valid Return Result, Return Error, or Reject component
- the switch has sent a DISCONNECT or RELEASE COMPLETE message with a Return Result or Return Error component
- the switch has sent (through a DISCONNECT, RELEASE COMPLETE, or FACILITY message) a Reject component other than Problem Tag 129, “Invoke-problem,” with Problem Value 0, “duplicate-invocation”
- the switch releases the CRV to which the invoke ID is currently allocated.

5.3.4 ERROR DEFINITIONS FOR SUPPLEMENTARY SERVICES

ITU-T Recommendation Q.950 defines errors that apply to supplementary services. Although not all are used by supplementary services on the *5ESS* switch, all errors that are not service-specific are provided for reference in “Definitions of

Non-service-specific Errors," Section 5.3.4.1, and all service-specific errors are provided for reference in "Definitions of Service-specific Errors," Section 5.3.4.2.[3]

5.3.4.1 Definitions of Non-service-specific Errors (Q.950 General-Error-List)

- Error Value 0, "userNotSubscribed"

  is an indication that the user has not subscribed to this service.

- Error Value 1, "rejectedByNetwork"

  is an indication that the requested service is rejected by the network.

- Error Value 2, "rejectedByUser"

  is an indication that the requested service is provided by the network but that the remote user has rejected this service request.

- Error Value 3, "notAvailable"

  is an indication that the user has subscribed to this service but the requested service is not available combined with the basic service or the other services (for example, operation).

- Error Value 5, "insufficientInformation"

  is an indication that the content of operation argument is incomplete, or absent entirely.

- Error Value 6, "invalidServedUserNumber"

  is an indication that the requested service cannot be performed because of the usage of an invalid served user number.

- Error Value 7, "invalidCallState"

  is an indication that no match exists between the service request and the valid Basic Call Control state; this applies also to invalid auxiliary states or an invalid combination of Basic call states and auxiliary states.

- Error Value 8, "basicServiceNotProvided"

  is an indication that the service provided is directed to a Basic Service that is not provided. (For example, this return error value is used in cases where a supplementary service is to be invoked with a SETUP message but indicating the wrong Basic Service.)

- Error Value 9, "notIncomingCall"

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3. These error lists from *ITU-T Recommendation Q.950*, March 1993, are reprinted by written permission of the International Telecommunication Union (ITU). Lucent Technologies has made the choice of what to excerpt from the recommendation, and ITU is not responsible in any way for this choice. The full text of this and other ITU-T recommendations may be obtained from:

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is an indication that the service request has been invoked for an outgoing call, which is not permitted for that service.

- Error Value 10, “supplementaryServiceInteractionNotAllowed”

  is an indication that the service request is not permitted in combination with either a further requested service or an active supplementary service.

- Error Value 11, “resourceUnavailable”

  is an indication that the service provider has temporarily no resource available for the provision of the requested service.

- Error Value 25, “callFailure”

  is an indication that the requested supplementary service was not executable by virtue of a Basic Call Failure. The parameter is included under circumstances where the call failure was remote from the Q.931 interface over which the error is to be sent; for example, when:

  a. No Q.931 clearing message is provided locally, or

  b. The cause information element included in the Q.931 clearing message represents only the reason for local basic call clearing.

  In these cases the parameter value represents the clearing cause included in the remote clearing procedure.

- Error Value 43, “proceduralError”

  is an indication that a transport message (a SETUP message, for example) is received containing one or more operation PDUs that have a valid content but that are not specified as valid information content of the transport message used.

5.3.4.2 Definitions of Service-specific Errors

- Error Value 12, “invalidDivertedNumber”

  is an indication that the diverted to number delivered with the service request has been determined to be invalid.

- Error Value 13, “operatorAccess”

  is an indication that the diverted to number delivered with the service request is an operator assistance number, or one that included an operator assistance number to which diversion is not allowed.

- Error Value 14, “specialServiceNumber”

  is an indication that the diverted to number delivered with the service request belongs to a special service to which diversion is not allowed.

- Error Value 15, “diversionToServedUserNumber”

  is an indication that the diverted to number delivered with the service request is the served user’s own number. Return to own number is not permitted.

- Error Value 16, “invalidOrUnregisteredCugIndex”

  is an indication delivered with a rejected call request and indicating that the CUG index does not exist at the service provider’s database.

- Error Value 17, “requestedBasicServiceViolatesCugConstrains” is an indication delivered with a rejected call request and indicating that the CUG index exists but is not appropriate to the requested basic service.

- Error Value 18, “outgoingCallsBarredWithinCug”

  is an indication delivered with a rejected call request and indicating that the CUG user is prohibited from making calls to users subscribed to the same CUG.

- Error Value 19, “incomingCallsBarredWithinCug”

  is an indication delivered with a rejected call request and indicating that the CUG user is prohibited from receiving calls from users subscribed to the same CUG.

- Error Value 20, “userNotMemberOfCug”

  is an indication that no match exists between the CUG interlock code and the CUG index at the called user side.

- Error Value 21, “inconsistencyInDesignatedFacilityAndSubscriberClass”

  is an indication delivered with a rejected call request and indicating that the attributes assigned to a CUG user do not match with the CUG information received from the calling user.

- Error Value 22, “incompatibleDestination”

  is an indication that the destination of a call is unable to provide the requested supplementary service (for example, CCBS).

- Error Value 23, “incomingCallAcceptedByOtherTerminals”

  is an indication to a CFB user, for example, that the incoming call has been accepted by another terminal at the same access.

- Error Value 24, “numberOfDiversionCounterExceeded”

  is an indication from the service provider delivered with a service request rejection and indicating that the allowed maximum number of diverted connections is exceeded.

- Error Value 26, “noChargingInfoAvailable”

  is an indication that the charging information cannot be sent to the served user due to a fault situation in the network.

- Error Value 28, “illegalConferenceId”

  is an indication that the Conference ID used by the served user is not associated with a conference.

- Error Value 29, “illegalPartyId”

  is an indication that the Party ID used by the served user is not associated with a conference party.

- Error Value 30, “numberOfPartiesHaveExceeded”

  is an indication that the conference bridge cannot accept this additional party since the maximum number of parties has already been reached.

- Error Value 31, “notActive”

is an indication that the conference bridge cannot accept the service request because the conference has not successfully been established.

- Error Value 32, “notAllowed”

  is an indication that the conference bridge cannot accept the service request because the call to be added has not been routed via the conference bridge, or cannot be routed via the conference bridge.

- Error Value 33, “maximumNumberOfReservationsReached”

  is an indication that the network is unable to provide the requested reservation since the allowed maximum number of reservations has already been reached for the Connection Endpoint Identifier (CEI).

- Error Value 34, “noExplicitReservationExistsOrInvalidReservationIndicator”

  is an indication that the network is unable to provide the requested reservation function (for example, creation or cancellation of a reservation) since no explicit reservation is in use or the reservation indicator used is not valid.

- Error Value 35, “unwantedReservationCreated”

  is an indication that the network has created a reservation either explicit or implicit in case that no reservation management request was included in a call control message.

- Error Value 36, “implicitReservationUsed”

  is an indication that the network uses an existing implicit reservation in case that no explicit reservation request was included in a call control message.

- Error Value 44, “unauthorizedPrecedenceLevel”

  is an indication that the calling user has exceeded the authorized maximum precedence level.

- Error Value 45, “userIgnored”

  is an indication that the remote user has ignored the service request (neither explicit acceptance nor rejection by the remote user).

- Error Value 46, “notActivated”

  is an indication of a call diversion failure due to the fact that the supplementary service has not been activated.

- Error Value 47, “uusReqAsEssential”

  is an indication of a call diversion failure due to the fact that the user-to-user supplementary service has been requested as essential.

- Error Value 61, “linkIDNotAssignedByNetwork”

  is an indication that the remote user has requested transfer of a call from an unassigned interface.

ISDN Primary Rate Interface Specification

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6. USER SIDE PROTOCOL CONTROL SDL DIAGRAMS

6.1 INTRODUCTION

The following set of Specification and Description Language (SDL) disgrams represents the protocol control for the user side of the PRI interface. Figure 6-1 shows the Layer 3 interfaces among the user side protocol function and the user side call control and channel control functions, which consist of primitives and procedure calls. The interface between the user side call control and the user side CPE is not shown, however signals between the user side and the CPE may result from the primitives. Typically the procedure calls consist of channel control procedures such as selecting, releasing, and disconnecting a B-channel.

Messages passing between the network side of the PRI and the user side of the PRI pass through the user side-network side interface and are transmitted through the physical layer and data link layer to the Layer 3 user side protocol control function. The messages exchanged at the user side protocol function as Layer 3 messages as defined in “Layer 3: The PRI Network Interface Layer,” Section 4.

Also shown in Figure 6-1 are the symbols used in the SDL diagrams, which represent the protocol control. The diagrams are arranged in order according to ascending state number from State U1 (Null State) to U19 (Release Request State). Some diagrams are continuations of previous state diagrams, and some diagrams represent actions that are common to several states.

Explanatory notes have been indicated on the diagrams, and the accompanying notes are included in “User Side SDL Diagrams,” Section 6.2.

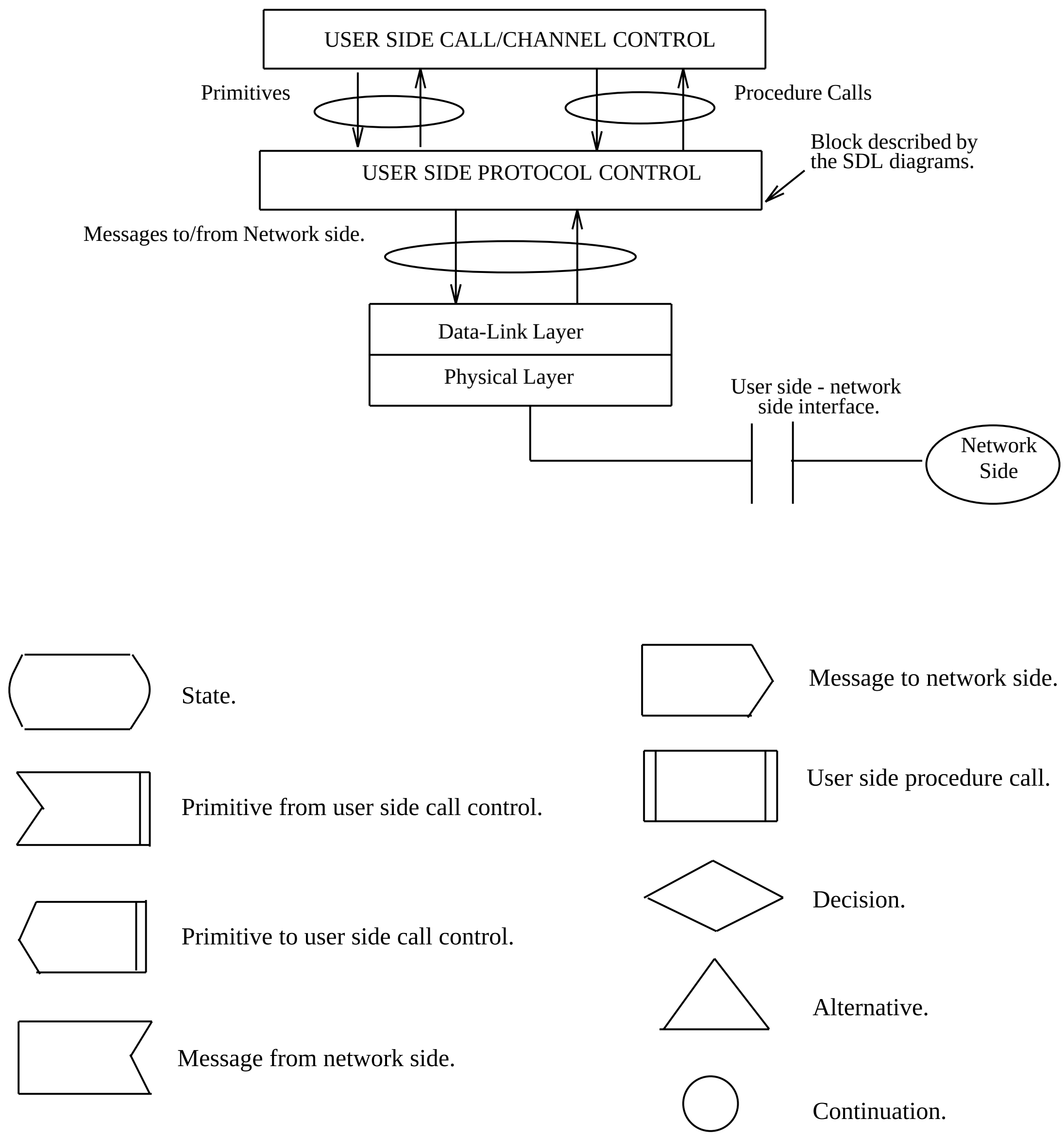

Figure 6-1 — Legend for User Side Protocol Control SDL Diagrams

6.2 USER SIDE SDL DIAGRAMS

6.2.1 U0, NULL STATE

See Figure 6-2.

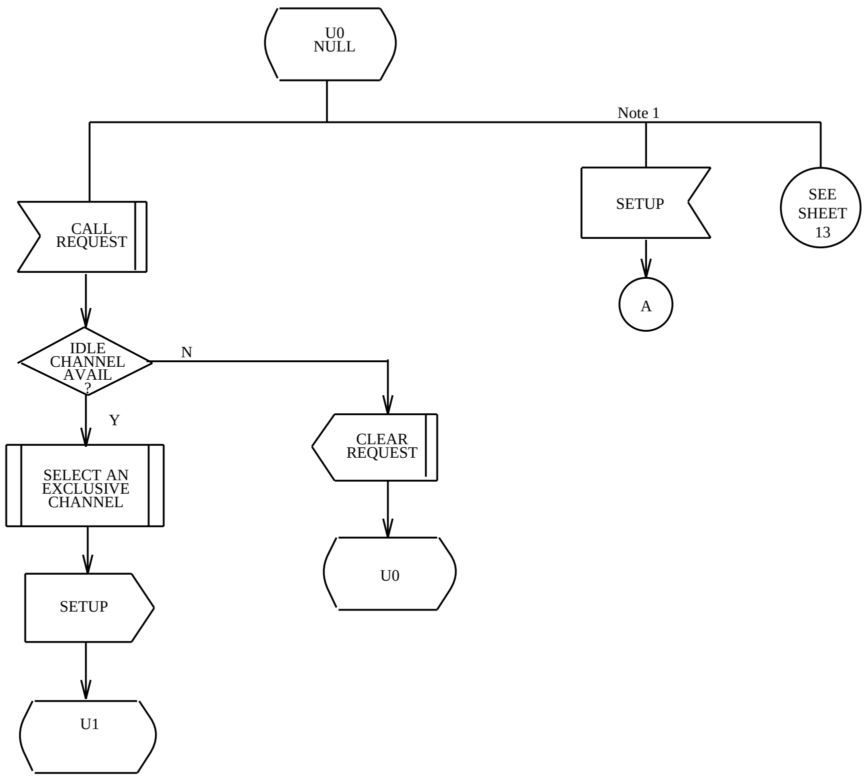

Figure 6-2 — User Side: U0, Null State (1 of 2)

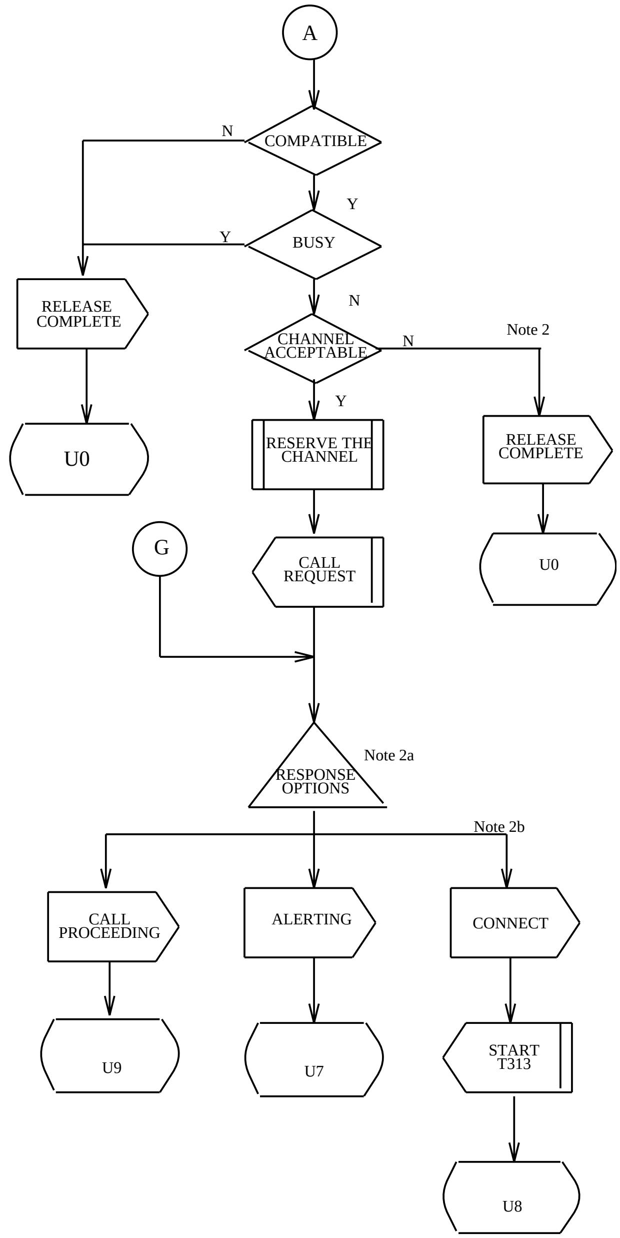

Figure 6-2 — User Side: U0, Null State (2 of 2)

6.2.1.1 Note 1

After sending the SETUP message, the network starts Timer T303 and enters into the Call Initiated state.

If no response to the SETUP message is received by the network before the first expiry of Timer T303, the SETUP message will be retransmitted and Timer T303 restarted.

If the network does not receive any response to the retransmitted SETUP message prior to the expiration of Timer T303, then the network shall initiate clearing procedures toward the calling user with a cause code value of 18 “no user responding.”

6.2.1.2 Note 2

PRI B-channel Negotiation occurs here.

6.2.1.3 Note 2a

When the user determines that sufficient call setup information has been received and compatibility requirements (see Annex B/Q.931) have been satisfied, the user responds with a CALL PROCEEDING, ALERTING, or CONNECT message and enters the Incoming Call Proceeding, Call Received, or Connect Request state, respectively.

6.2.1.4 Note 2b

A user indicates acceptance of an incoming call by sending a CONNECT message to the network. Upon sending the CONNECT message, the user shall start Timer T313.

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.

6.2.2 U1, CALL INITIATED STATE

See Figure 6-3.

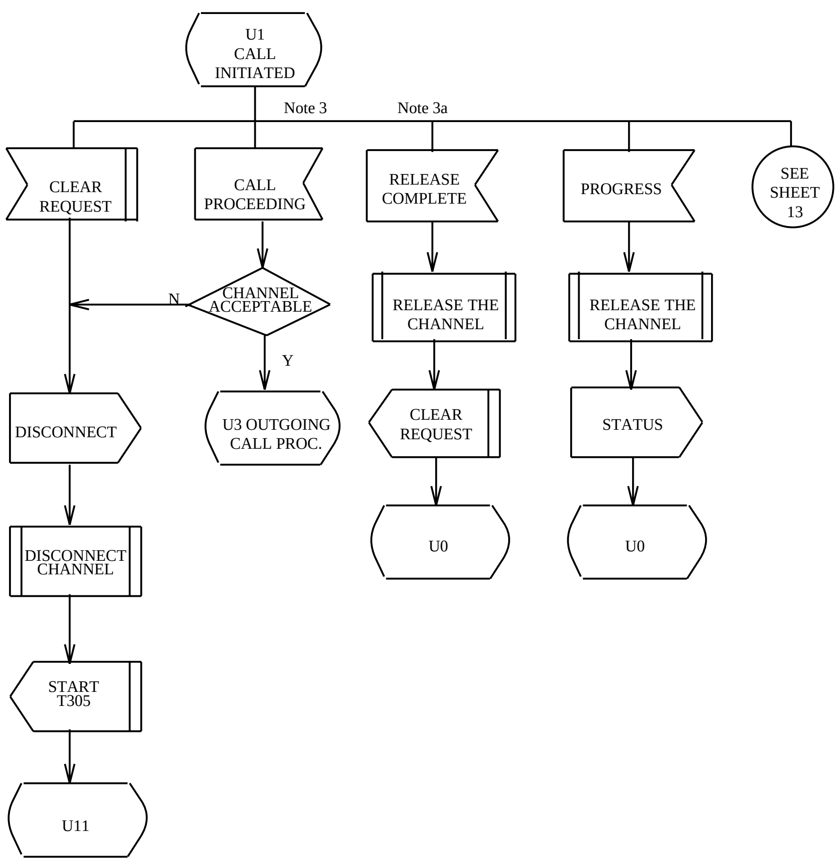

Figure 6-3 — User Side: U1, Call Initiated State

6.2.2.1 Note 3

If the network can determine that access to the requested service is authorized and available the network shall: send a CALL PROCEEDING message to the user to acknowledge the SETUP message and to indicate that the call is being processed; and enter the Outgoing Call Proceeding state.

6.2.2.2 Note 3a

If the network determines that a requested service is not authorized or is not available, the network shall respond with a RELEASE COMPLETE message with one of the following causes:

1. Cause code value of 58 “bearer capability not presently available,”
2. Cause code value of 65 “bearer service not implemented.”

6.2.3 U3, OUTGOING CALL PROCEEDING STATE

See Figure 6-4.

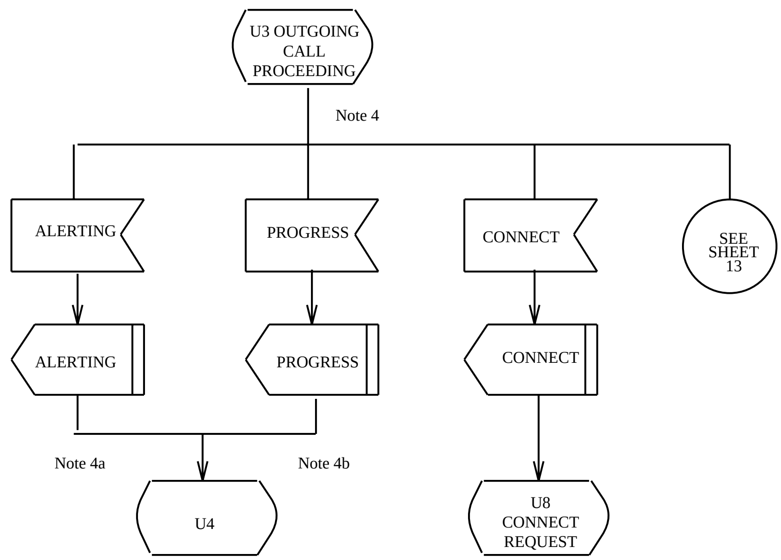

Figure 6-4 — User Side: U3, Outgoing Call Proceeding State

6.2.3.1 Note 4

If the call leaves an ISDN environment (for example, because of interworking with another network, with a non-ISDN user, or with non-ISDN equipment within the calling or called user’s premises), a Progress Indicator information element (IE) shall be returned to the calling user in the ALERTING, CONNECT, or PROGRESS message.

One of the following progress description values shall be included in the progress indicator IE:

- Progress Descriptor 1 “call is not end-to-end ISDN; further call progress information may be available in-band.”
- Progress Descriptor 2 “destination address is non-ISDN.”
- Progress Descriptor 4 “call has returned to the ISDN.” (Call is now end-to-end ISDN.)

- Progress Descriptor 8 “in-band information or appropriate pattern now available.”

One or more PROGRESS messages may be received by the user between receipts of CALL PROCEEDING and ALERTING or CONNECT messages. Receipt of a PROGRESS message does not necessarily indicate that an end-to-end connection exists at that time.

6.2.3.2 Note 4a

Upon receiving an indication that user alerting has been initiated at the called address, the network shall: send an ALERTING message across the user-network interface of the calling address; and enter the Call Delivered state.

6.2.3.3 Note 4b

If the network or the called user is unable to accept the call, and the network desires to play an announcement before the call is cleared, it shall send a PROGRESS message to the user. On receipt of this message the user enters the Call Delivered state and monitors the information channel. At this time the network can play the announcement on the information channel.

6.2.4 U4, CALL DELIVERED STATE

See Figure 6-5.

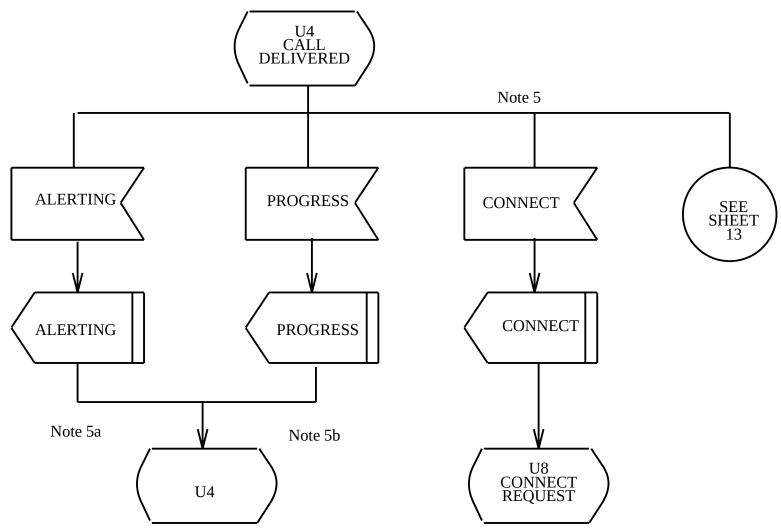

Figure 6-5 — User Side: U4, Call Delivered State

6.2.4.1 Note 5

Upon receiving an indication that the call has been accepted, the network shall: send a CONNECT message across the user-network interface to the calling user; and enter the Active state.

6.2.4.2 Note 5a

See “Note 4a,” Section 6.2.3.2.

6.2.4.3 Note 5b

See “Note 4b,” Section 6.2.3.3.

6.2.5 U7, CALL RECEIVED STATE

See Figure 6-6.

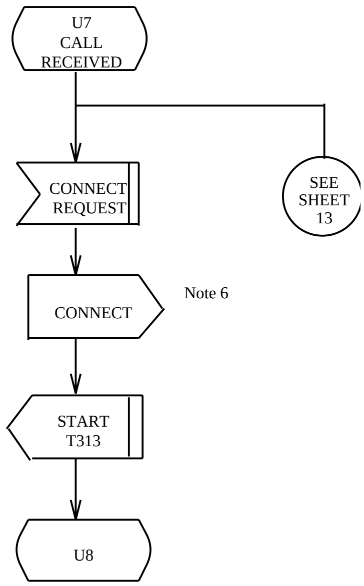

Figure 6-6 — User Side: U7, Call Received State

6.2.5.1 Note 6

A user indicates acceptance of an incoming call by sending a CONNECT message to the network. Upon sending the CONNECT message.

6.2.6 U8, CONNECT REQUEST STATE

See Figure 6-7.

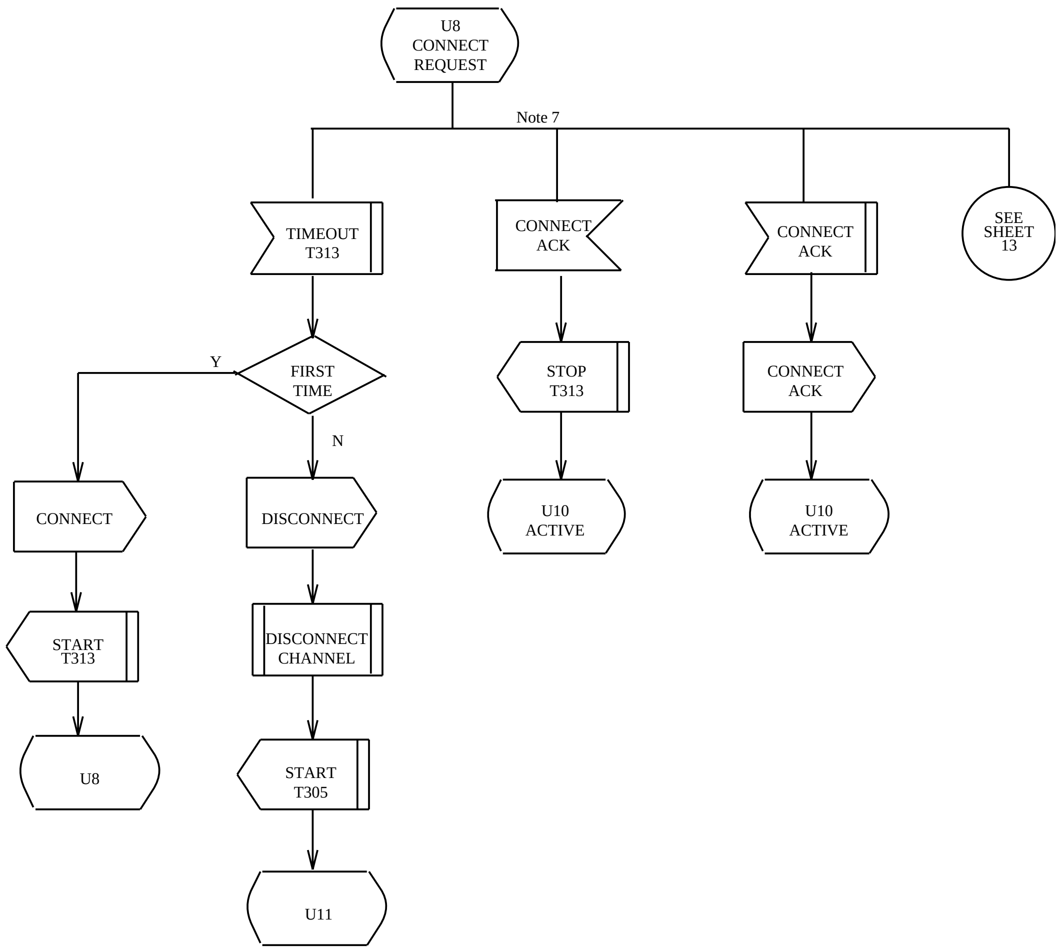

Figure 6-7 — User Side: U8, Connect Request State

6.2.6.1 Note 7

When the network sends a CONNECT ACKNOWLEDGE message to the called user, it shall initiate procedures to send a CONNECT message toward the calling user, and enter 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 a calling user. Upon receipt of the CONNECT ACKNOWLEDGE message the user shall: stop Timer T313 and enter the Active state.

6.2.7 U9, INCOMING CALL PROCEEDING STATE

See Figure 6-8.

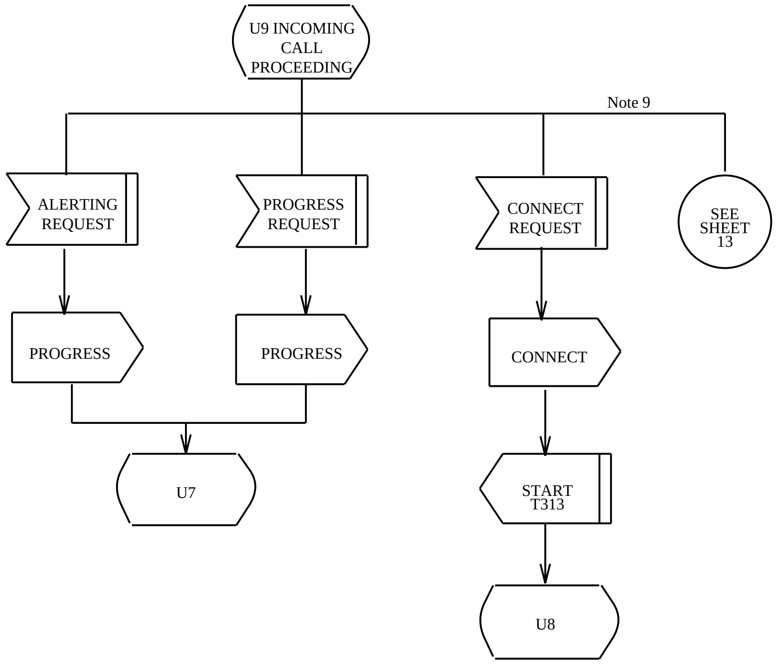

Figure 6-8 — User Side: U9, Incoming Call Proceeding State

6.2.7.1 Note 8

See “Note 6,” Section 6.2.5.1.

6.2.8 U10, ACTIVE STATE

See Figure 6-9.

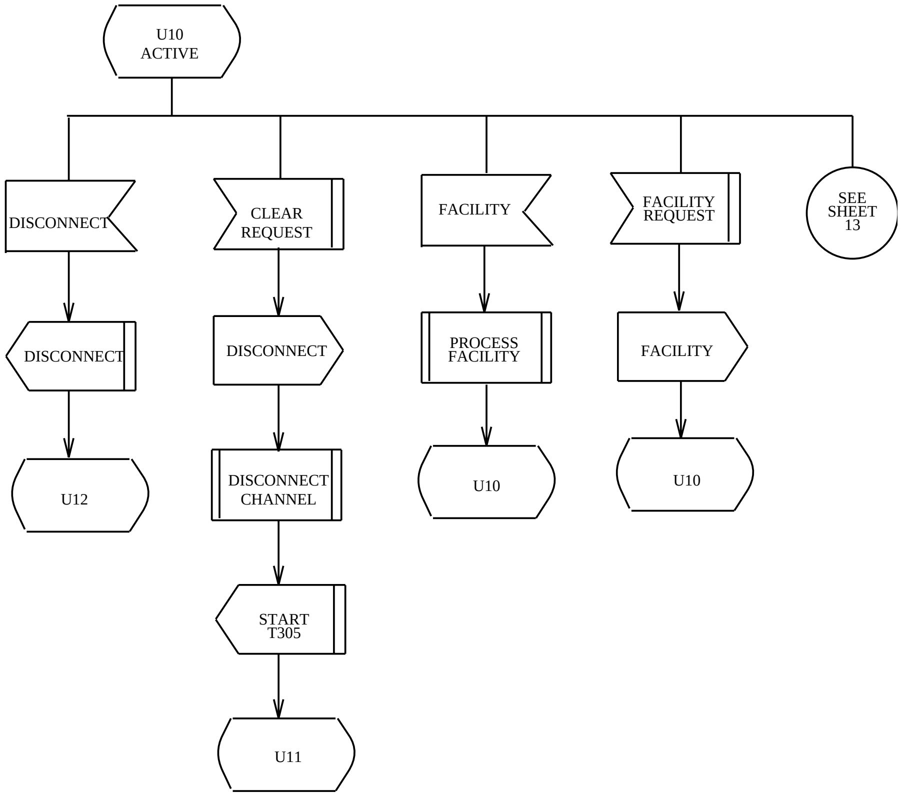

Figure 6-9 — User Side: U10, Active State

6.2.9 U11, DISCONNECT REQUEST STATE

See Figure 6-10.

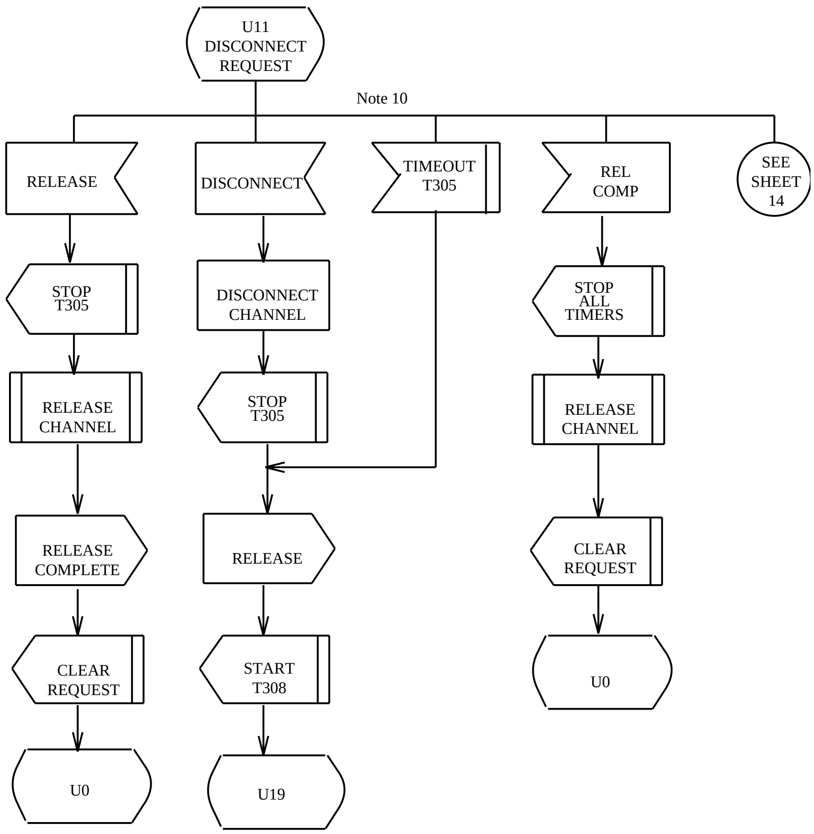

Figure 6-10 — User Side: U11, Disconnect Request State

6.2.9.1 Note 10

If Timer T305 expires, the user shall: send a RELEASE message to the network with the cause number originally contained in the DISC message; start Timer T308; and enter the Release Request state. In addition, the user may indicate a second cause information element with a cause code value of 102 “recovery on timer expiry.”

6.2.10 U12, DISCONNECT INDICATION STATE

See Figure 6-11.

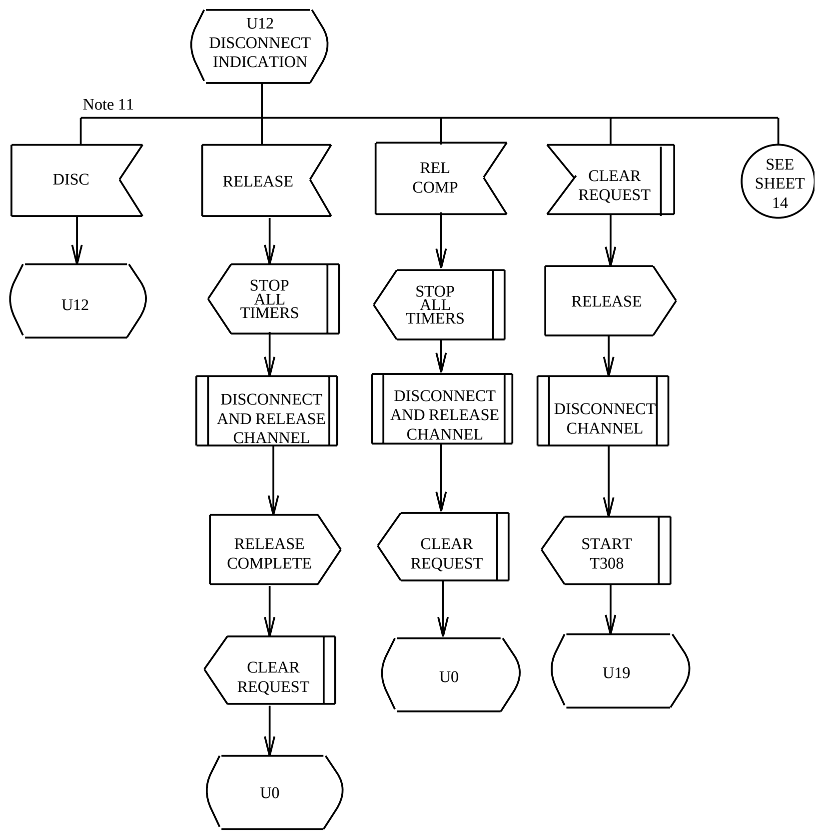

Figure 6-11 — User Side: U12, Disconnect Indication State

6.2.10.1 Note 11

Ignorable error.

6.2.11 U19, RELEASE REQUEST STATE

See Figure 6-12.

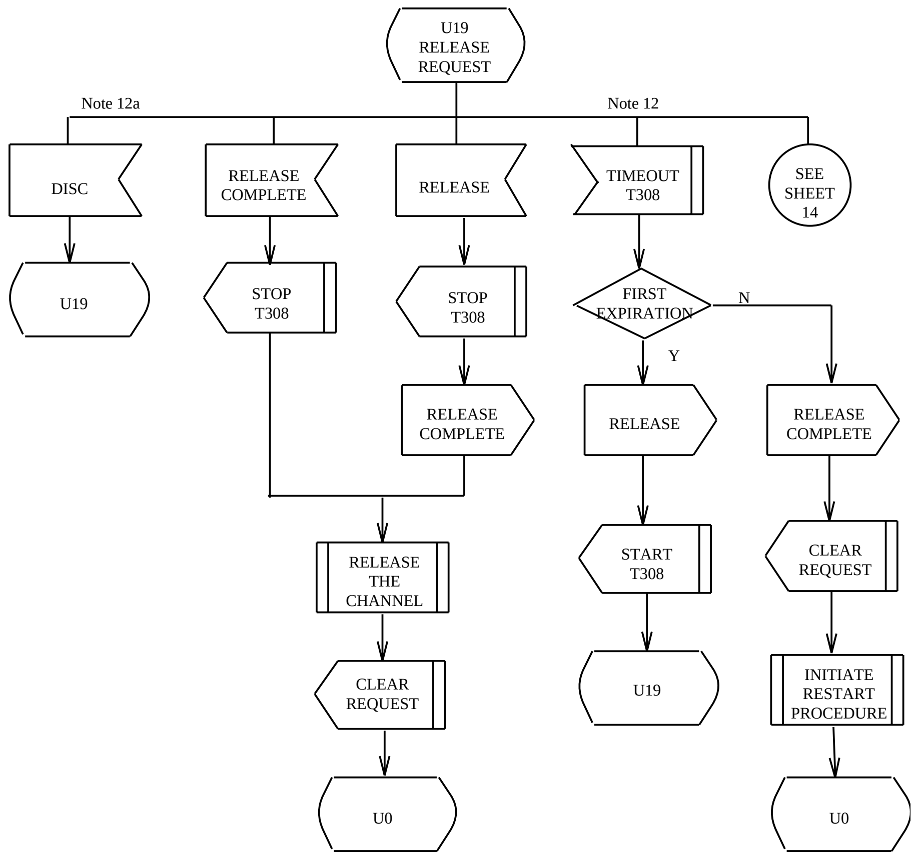

Figure 6-12 — User Side: U19, Release Request State

6.2.11.1 Note 12

If Timer T308 expires for the first time, the user shall: retransmit the RELEASE message and Timer T308 shall be restarted. In addition, the user may indicate the cause IE with a cause code value of 102 “recovery on timer expiry.” If no RELEASE COMPLETE message is received from the user before Timer T308 expires a second time, the user shall: place the B-channel in a maintenance condition, release the call reference, and return to the Null state.

6.2.11.2 Note 12a

Ignorable error.

6.2.12 MULTIPLE STATES

See Figure 6-13.

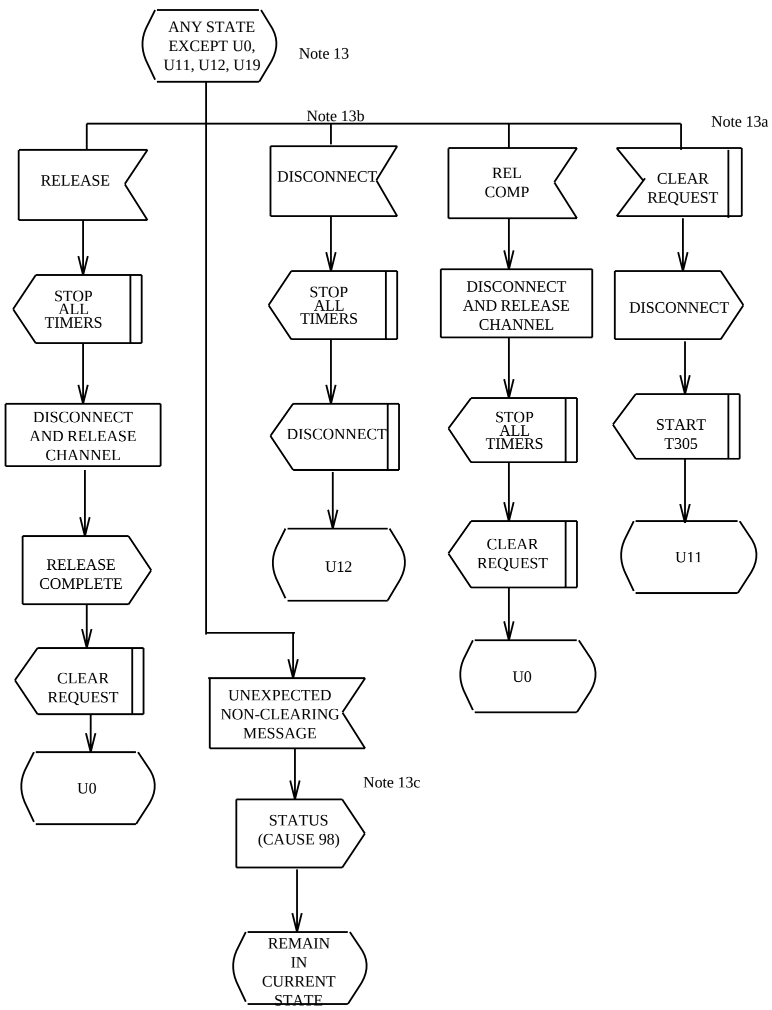

Figure 6-13 — User Side: Any State Except U11, U12, U19 (1 of 2)

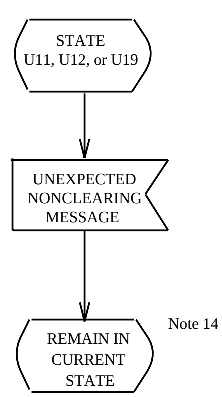

Figure 6-13 — User Side: Any State Except U11, U12, U19 (2 of 2)

6.2.12.1 Note 13

Under normal conditions, call clearing is usually initiated when the user or the network sends a DISCONNECT message. The only exceptions to the above rule are as follows:

1. 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.
2. Unsuccessful termination of the B-channel selection procedure by the side offering the call is indicated by sending a RELEASE, DISCONNECT or RELEASE COMPLETE message. The RELEASE message shall contain a cause code value of 6 “channel unacceptable.”

6.2.12.2 Note 13a

The user initiates clearing by sending a DISCONNECT message upon receipt of a user clear request. The user state transitions to the Disconnect Request state to wait for a RELEASE message from the network side.

6.2.12.3 Note 13b

Apart from the exception conditions identified in Note 13, the network shall initiate clearing by: sending a DISCONNECT message; and entering the Disconnect Indication state. The DISCONNECT message is a local invitation to clear and does not imply that the B-channel has been disconnected at the user-network interface. The user state transitions to the Disconnect Indication state to wait for RELEASE or RELEASE COMPLETE message from the network.

6.2.12.4 Note 13c

This is treated as a violent error.

6.2.12.5 Note 14

These are considered ignorable errors.

ISDN Primary Rate Interface Specification

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7. NETWORK SIDE PROTOCOL CONTROL SDL DIAGRAMS

7.1 INTRODUCTION

The following set of specification and description language (SDL) diagrams represents the protocol control for the network side of the primary rate interface (PRI). Figure 7-1 shows the Layer 3 interfaces between the network side protocol function and the network side call control and channel control functions, which consist of primitives and procedure calls. The interface between the network side call control and the network side customer premises equipment (CPE) is not shown, however signals between the network side and the other network elements may result from the primitives. Typically the procedure calls consist of channel control procedures such as selecting, releasing, and disconnecting a B-channel.

Messages passing between the user side of the PRI and the network side of the PRI pass through the user side-network side interface and are transmitted through the physical layer and data link layer to the Layer 3 network side protocol control function. The messages exchanged at the network side protocol function as Layer 3 messages as defined in “Layer 3: The PRI Network Interface Layer,” Section 4.

Also shown in Figure 7-1 are the symbols used in the SDL diagrams, which represent the protocol control. The SDL diagrams are arranged according to ascending state number from State N1 (null state) to N19 (release request state). Some diagrams are continuations of previous state diagrams and some represent actions that are common to several states.

Explanatory notes have been indicated on the diagrams and the accompanying notes are included in “Network Side SDL Diagrams,” Section 7.2.

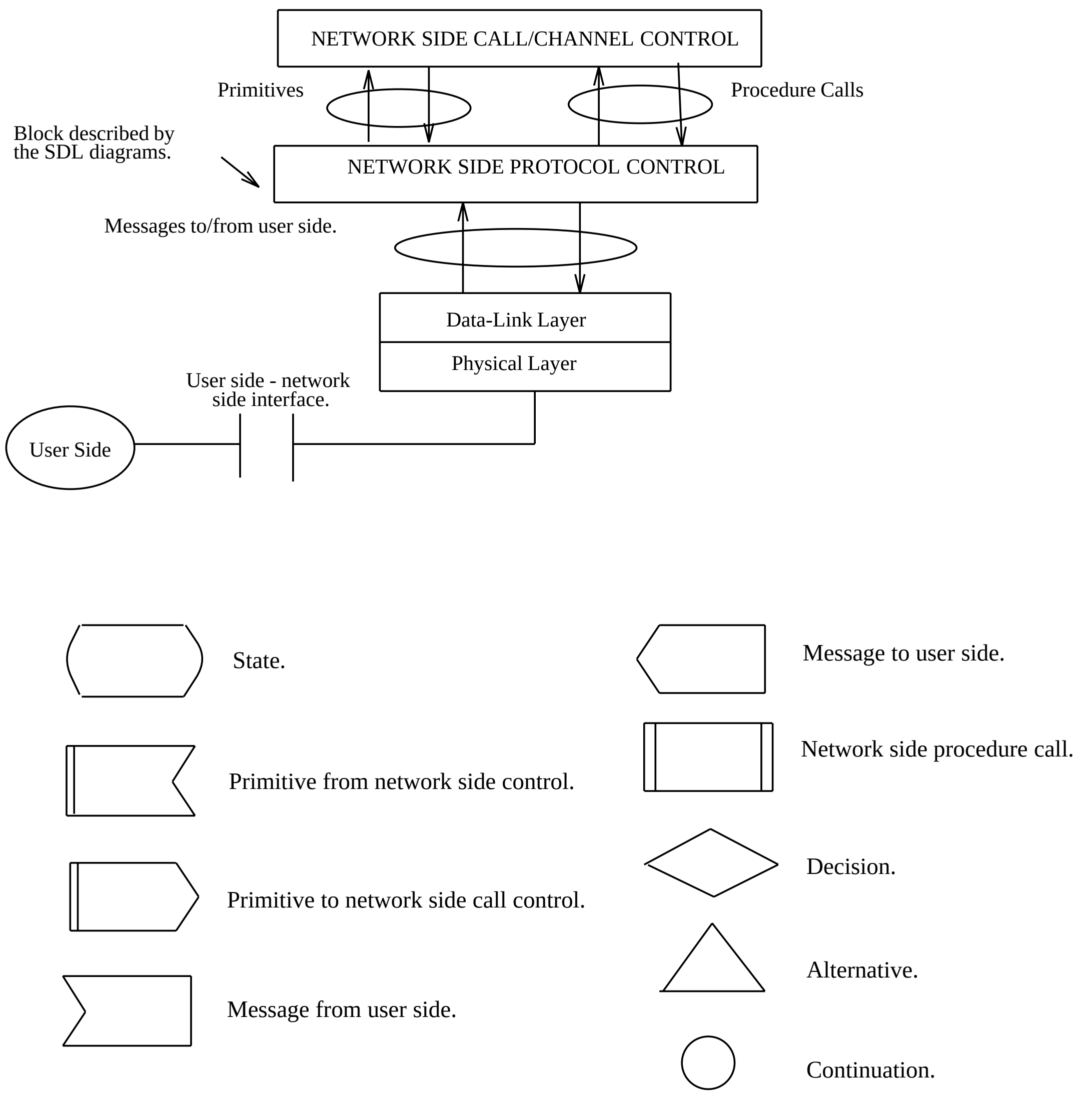


Figure 7-1 — Legend for Network Side Protocol Control SDL Diagrams

7.2 NETWORK SIDE SDL DIAGRAMS

7.2.1 N0, NULL STATE

See Figure 7-2.

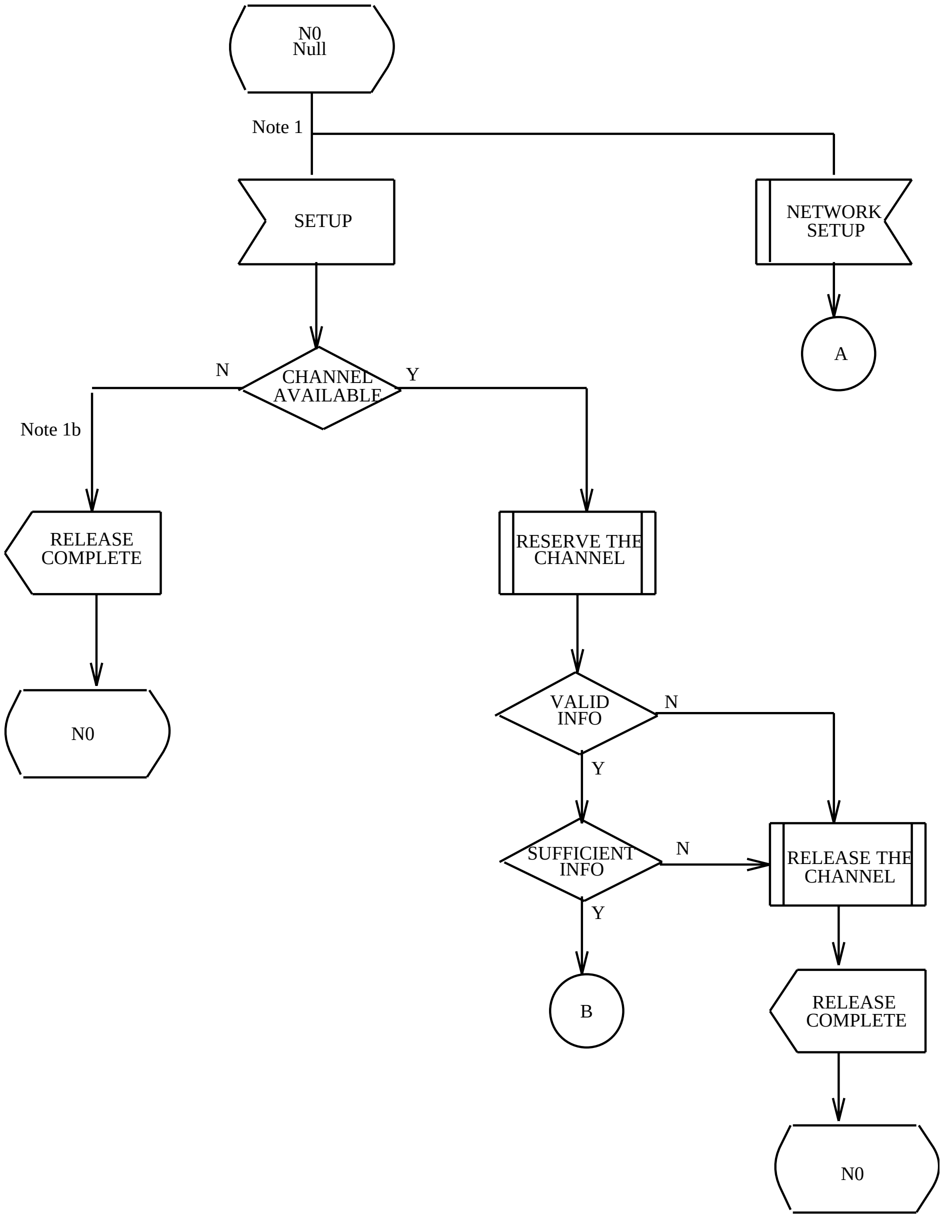


Figure 7-2 — Network Side: N0, Null State (1 of 2)

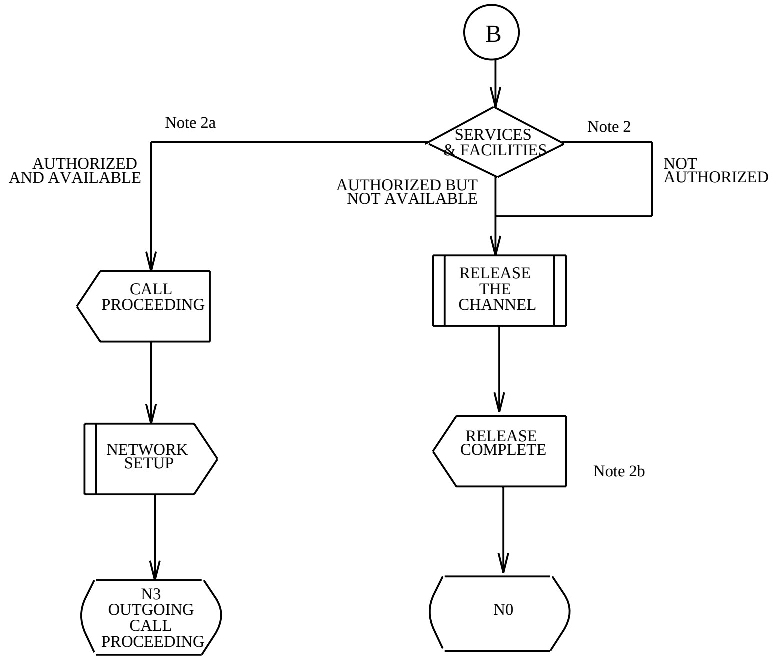


Figure 7-2 — Network Side: N0, Null State (2 of 2)

7.2.1.1 Note 1

A user initiates call establishment by transferring a SETUP message across the user-network interface. Following the transmission of the SETUP message, the call shall be considered by the user to be in the call initiated state. The message shall always contain a call reference, selected according to the procedures given in “Call Reference,” Section 4.3.1.2. In selecting a call reference, the dummy call reference value shall not be used. The bearer capability information element (IE) is mandatory in the SETUP message.

7.2.1.2 Note 1a

When the requested channel is unavailable the RELEASE COMPLETE message carries a cause code value of 44 “requested channel unavailable.” If no channels are available, the cause code value is 34, “no channels available.”

7.2.1.3 Note 2

Service and facility availability applies to the originating switch and not to the entire network.

7.2.1.4 Note 2a

If the network determines that access to the requested service is authorized and available, the network shall send a CALL PROCEEDING message to the user to acknowledge the SETUP message and to indicate that the call is being processed, and enter the outgoing call proceeding state. When the user receives the CALL PROCEEDING message, the user shall enter the outgoing call proceeding state.

7.2.1.5 Note 2b

If the network determines that a requested service is not authorized or is not available, the network shall initiate call clearing with one of the following causes.

- Cause code value of 58 “bearer capability not presently available”

- Cause code value of 65 “bearer service not implemented”

7.2.2 N3, OUTGOING CALL PROCEEDING STATE

See Figure 7-3.

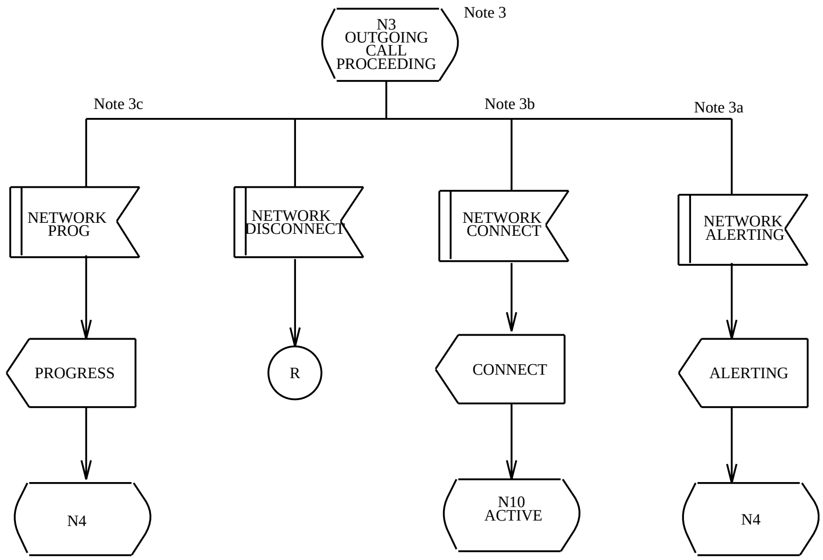


Figure 7-3 — Network Side: N3, Outgoing Call Proceeding State (1 of 2)

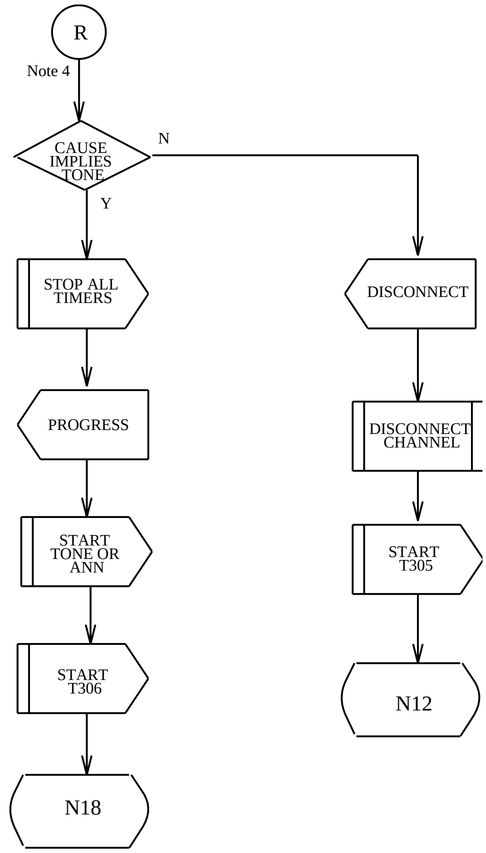


Figure 7-3 — Network Side: N3, Outgoing Call Proceeding State (2 of 2)

7.2.2.1 Note 3

During call establishment, the call may leave an ISDN environment; for example, because of interworking with another network, with a non-ISDN user, or with non-ISDN equipment within the calling or called user's premises. When such situations occur, a progress indicator IE shall be returned to the calling user in the ALERTING, CONNECT, or PROGRESS message.

One of the following progress description values shall be included in the progress indicator IE in the message sent to the user:

- Progress Descriptor 1 "call is not end-to-end ISDN; further call progress information may be available in-band."
- Progress Descriptor 2 "destination address is non-ISDN."
- Progress Descriptor 4 "call has returned to the ISDN." (Call is now end-to-end ISDN.)
- Progress Descriptor 8 "in-band information or appropriate pattern now available."

7.2.2.2 Note 3a

Upon receiving an indication that user alerting has been initiated at the called address, the network shall send an ALERTING message across the user-network interface of the calling address and enter the call delivered state. When the user receives the ALERTING message, the user shall enter the call delivered state.

7.2.2.3 Note 3b

Upon receiving an indication that the call has been accepted, the network shall send a CONNECT message across the user-network interface to the calling user and enter the active state.

This message indicates to the calling user that a connection has been established through the network and stops a possible local indication of alerting.

On receipt of the CONNECT message, the calling user shall stop any user-generated alerting indications, may optionally send a CONNECT ACKNOWLEDGE message, and shall enter the active state. The network shall not take any action on receipt of a CONNECT ACKNOWLEDGE message when it perceives the call to be in the active state.

7.2.2.4 Note 3c

One or more PROGRESS messages may be received by the user between receipts of CALL PROCEEDING and ALERTING or CONNECT messages. Receipt of a PROGRESS message does not necessarily indicate that an end-to-end connection exists at that time.

7.2.2.5 Note 4:

Upon receiving an indication that the network or the called user is unable to accept the call, the network shall initiate call clearing at the originating user-network interface using the cause provided by the terminating network or the called user. However, if the network desires to play an announcement before the call is cleared, it shall send a PROGRESS message to the user. On receipt of this message, the user enters the call delivered state and monitors the information channel. At this time the network can play the announcement on the information channel.

7.2.3 N18, TONE ACTIVE STATE

See Figure 7-4.

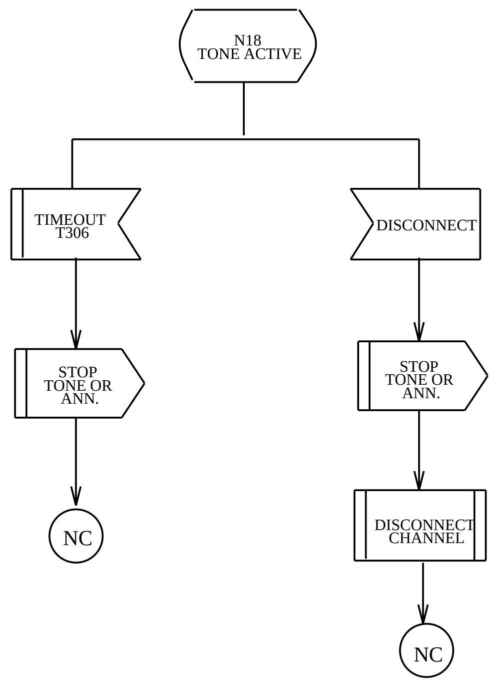


Figure 7-4 — Network Side: N18, Tone Active State

7.2.4 N4, CALL DELIVERED STATE

See Figure 7-5.

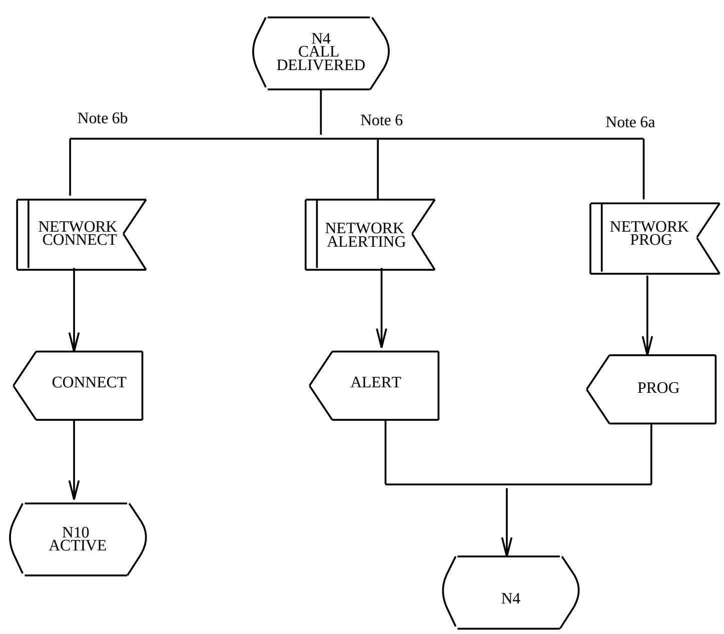


Figure 7-5 — Network Side: N4, Call Delivered State

7.2.4.1 Note 6

See “Note 3a,” Section 7.2.2.2.

7.2.4.2 Note 6a

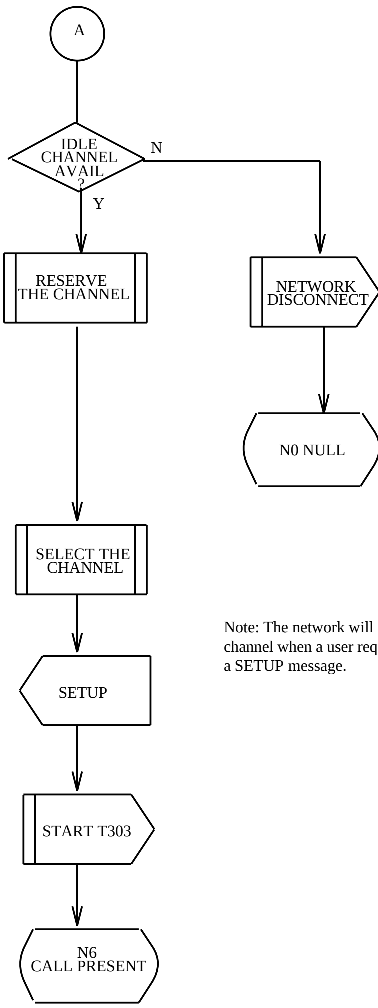
See “Note 3b,” Section 7.2.2.3.

7.2.4.3 Note 6b

See “Note 3c,” Section 7.2.2.4.

7.2.5 N0, NULL STATE, CONTINUED

See Figure 7-6.



Note: The network will request release of the channel when a user requests that channel in a SETUP message.

Figure 7-6 — Network Side: N0, Null State, Continued

7.2.6 N6, CALL PRESENT STATE

See Figure 7-7.

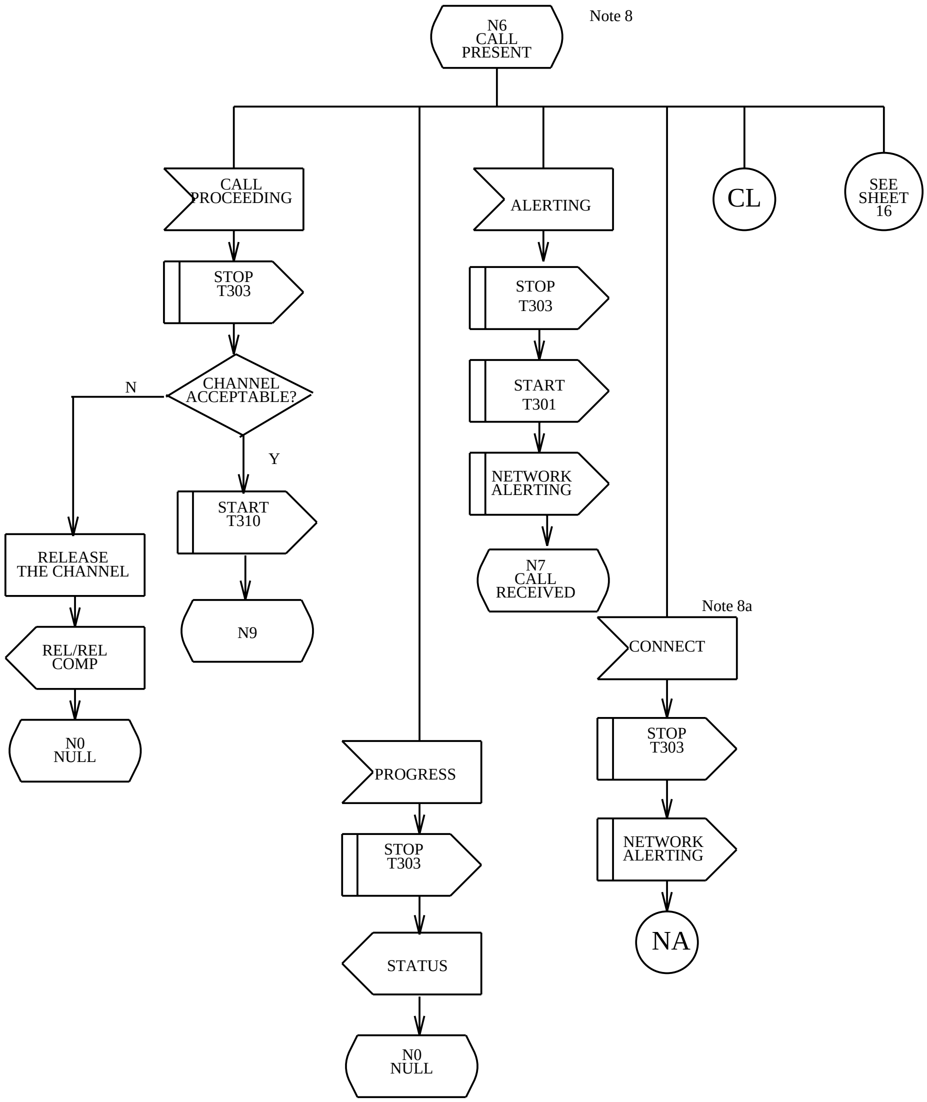


Figure 7-7 — Network Side: N6, Call Present State (1 of 2)

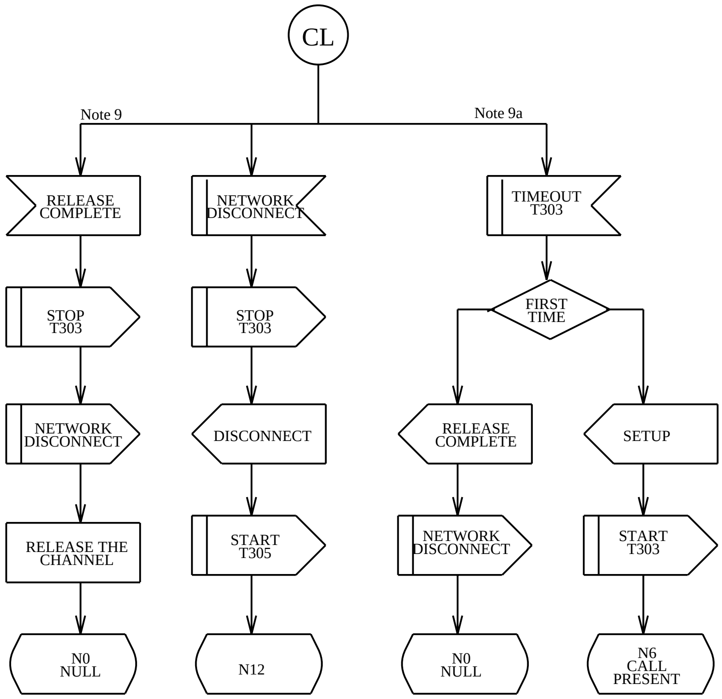


Figure 7-7 — Network Side: N6, Call Present State (2 of 2)

7.2.6.1 Note 8

When the user determines that sufficient call setup information has been received and compatibility requirements (see Annex B/Q.931) have been satisfied, the user responds with a CALL PROCEEDING, ALERTING, or CONNECT message.

7.2.6.2 Note 8a

A user indicates acceptance of an incoming call by sending a CONNECT message to the network. 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.

7.2.6.3 Note 9

When the SETUP message was delivered through a point-to-point data link, an incompatible user shall respond by sending a RELEASE COMPLETE message with a cause code value of 88 “incompatible destination.”

A busy user that satisfies the compatibility requirements indicated in the SETUP message shall normally respond with a RELEASE COMPLETE message with a cause code value of 17 “user busy.”

If the user wishes to refuse the call, a RELEASE COMPLETE message shall be sent with the a cause code value of 21 “call rejected” and the user returns to the null state.

7.2.6.4 Note 9a

If the network does not receive any response to the retransmitted SETUP message prior to the second expiration of Timer T303, then the network shall initiate clearing procedures toward the calling user with a cause code value of 18 “no user responding.”

7.2.7 N7, CALL RECEIVED STATE and N8, CONNECT REQUEST STATE

See Figure 7-8.

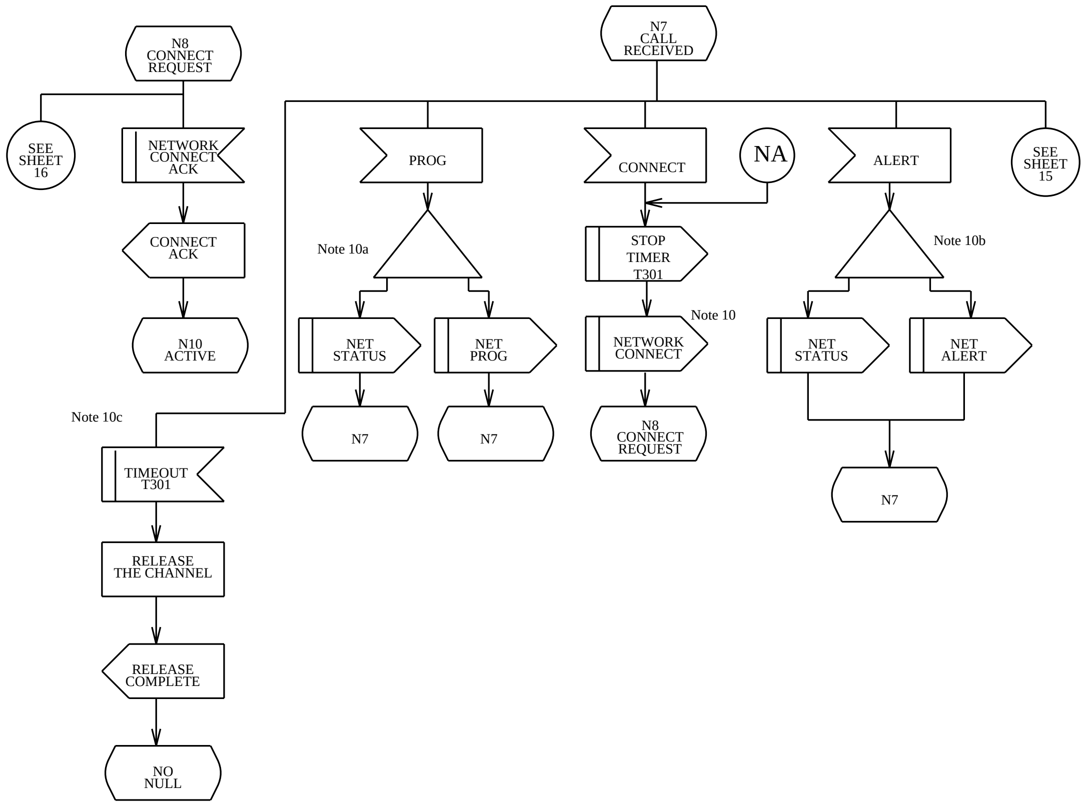


Figure 7-8 — Network Side: N7, Call Received State and N8, Connect Request State

7.2.7.1 Note 10

Timer T301 is stopped upon receipt of a CONNECT message from the user. A CONNECT message is the usual way to advance to the connect request state.

7.2.7.2 Note 10a

A PROGRESS message from the user side may indicate interworking with a non-ISDN environment at the user side. This information is forwarded to the network side.

7.2.7.3 Note 10b

An ALERTING message indicates that the user side is waiting for a response after having issued called party alerting. This information is forwarded to the network side. Only one ALERTING message will be accepted by the network switch.

7.2.7.4 Note 10c

Timer T301 governs the time by which the user must respond.

7.2.8 N9, INCOMING CALL PROCEEDING STATE

See Figure 7-9.

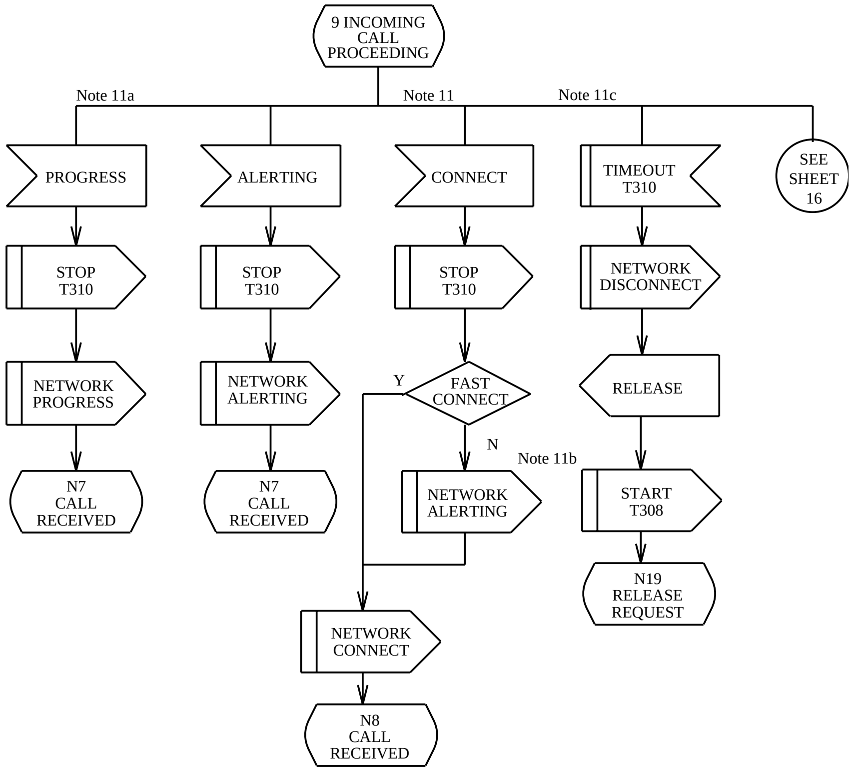


Figure 7-9 — Network Side: N9, Incoming Call Proceeding State

7.2.8.1 Note 11

A user indicates acceptance of an incoming call by sending a CONNECT message to the network. Upon sending the CONNECT message, the user shall start Timer T313.

7.2.8.2 Note 11a

The user shall notify the calling party if the call has left the ISDN environment within the called user’s premises or upon the availability of in-band information/patterns. When such situations occur, a progress indication shall be sent by the user to the network in the PROGRESS, ALERT, or CONNECT message.

One of the following progress description values shall be included in the progress indicator IE in the message sent to the network (for further information, see Annex I/Q.931):

- Progress Descriptor 1 “call is not end-to-end ISDN; further call progress information may be available in-band.”
- Progress Descriptor 2 “destination address is non-ISDN.”
- Progress Descriptor 4 “call has returned to the ISDN.” (Call is now end-to-end ISDN.)
- Progress Descriptor 8 “in-band information or appropriate pattern now available.”

7.2.8.3 Note 11b

See “Note 11a,” Section 7.2.8.2, for action on receiving a PROGRESS indicator in a CONNECT message.

7.2.8.4 Note 11c

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, then the network shall initiate clearing procedures toward the calling user with a cause code value of 18 “no user responding” and initiate clearing procedures toward the called user.

7.2.9 N10, ACTIVE STATE

See Figure 7-10.

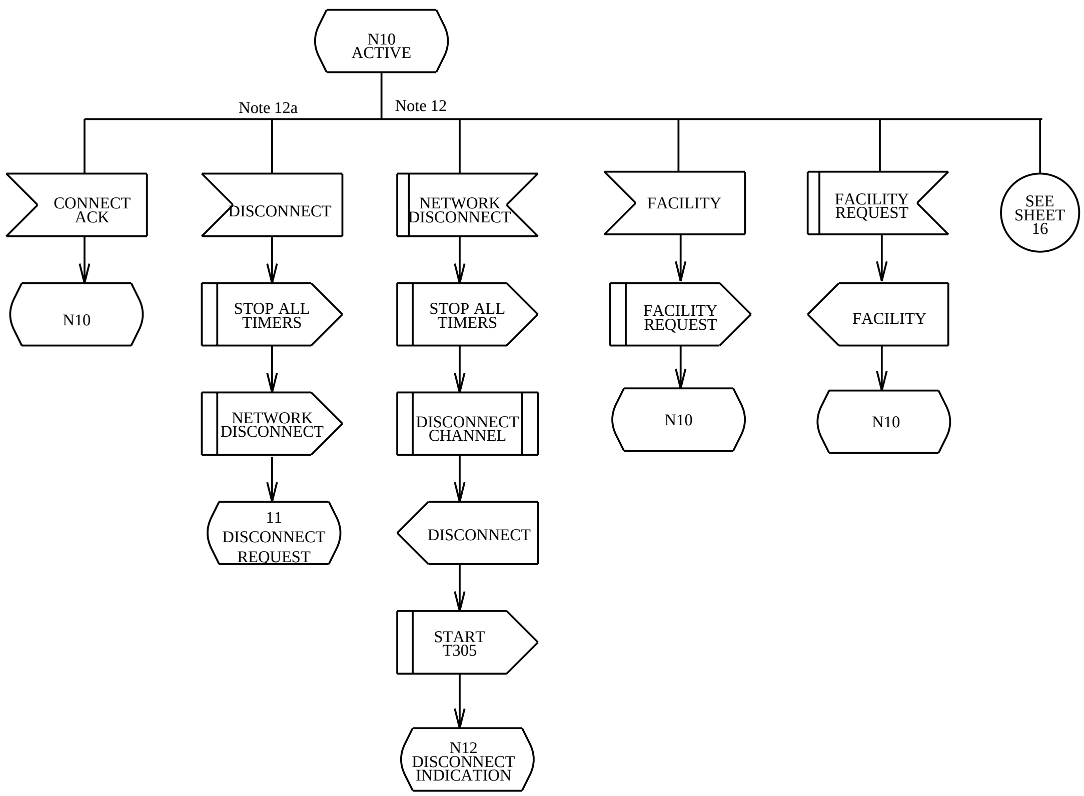


Figure 7-10 — Network Side: N10, Active State

7.2.9.1 Note 12

Under normal conditions the network shall initiate clearing by sending a DISCONNECT message and entering the disconnect indication state. The DISCONNECT message is a local invitation to clear and does not imply that the B-channel has been disconnected at the user-network interface.

When in-band tones/announcements are not provided, the DISCONNECT message does not contain a progress indicator IE with Progress Descriptor 8 “in-band information or appropriate pattern now available.”

On the receipt of the DISCONNECT message without Progress Descriptor 8, the user shall disconnect the B-channel, send a RELEASE message, start Timer T308, and enter the release request state.

7.2.9.2 Note 12a

Under normal conditions the user shall initiate clearing by sending a DISCONNECT message, starting Timer T305, disconnecting the B-channel, and entering the disconnect request state.

7.2.10 N12, DISCONNECT INDICATION STATE

See Figure 7-11.

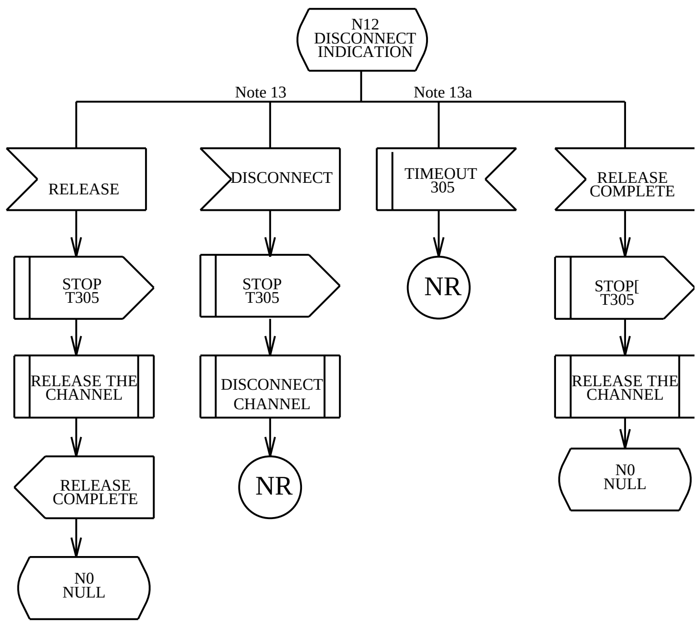


Figure 7-11 — Network Side: N12, Disconnect Indication State

7.2.10.1 Note 13

A 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 shall stop Timer T305 or T306 (whichever is running), disconnect the B-channel (if not disconnected), send a RELEASE message, start Timer T308, and enter the release request state.

7.2.10.2 Note 13a

If Timer T305 expires, the network shall send a RELEASE message to the user with the cause code value originally contained in the DISCONNECT message or a cause code value of 102 “recovery on timer expiry,” start Timer T308, and enter the release request state.

7.2.11 MULTIPLE STATES

See Figure 7-12.

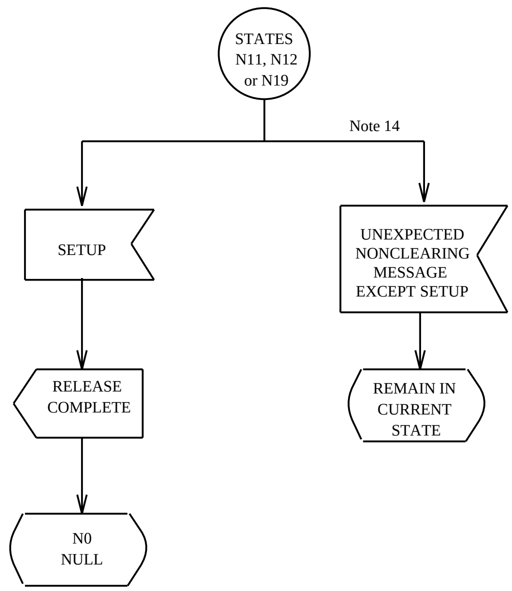


Figure 7-12 — Network Side: States N11, N12 or N19

7.2.11.1 Note 14

Ignorable error.

7.2.12 N19, RELEASE REQUEST STATE

See Figure 7-13.

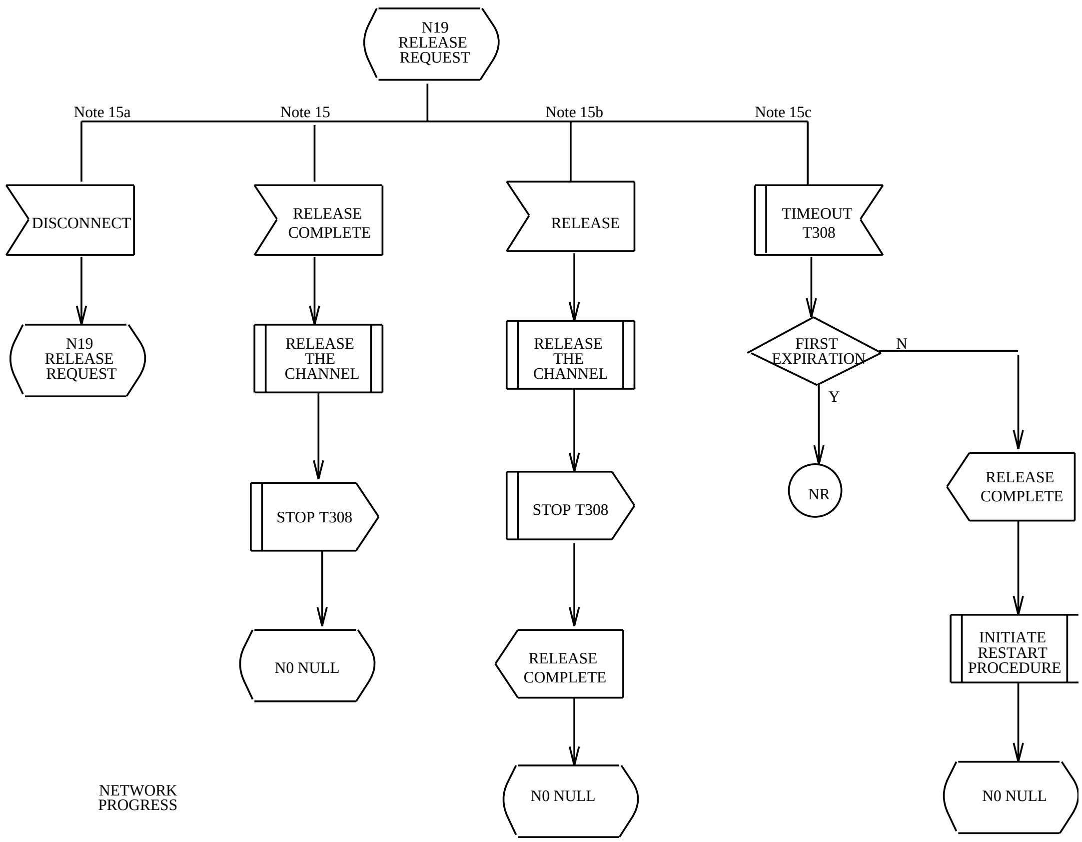


Figure 7-13 — Network Side: States N19, Release Request State

7.2.12.1 Note 15

The release request state is normally reached after the network side receives a DISCONNECT message from the user. When the network receives a RELEASE COMPLETE message from the user, the network shall release the channel.

7.2.12.2 Note 15a

Receipt of a DISCONNECT from the user, following a previous DISCONNECT message, is an ignorable error.

7.2.12.3 Note 15b

Receiving a RELEASE message following a DISCONNECT from the user is a clear collision condition. This can 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 shall stop Timer T308, release the call reference and B-channel if appropriate, send a RELEASE COMPLETE message, and enter the null state.

7.2.12.4 Note 15c

If the network does not receive a response from the user by the time T308 expires once, a RELEASE message is sent to the user and T308 is restarted. If T308 expires again, a RELEASE COMPLETE is sent to the user and restart procedures are begun.

7.2.13 MULTIPLE STATES, CONTINUED

See Figure 7-14.

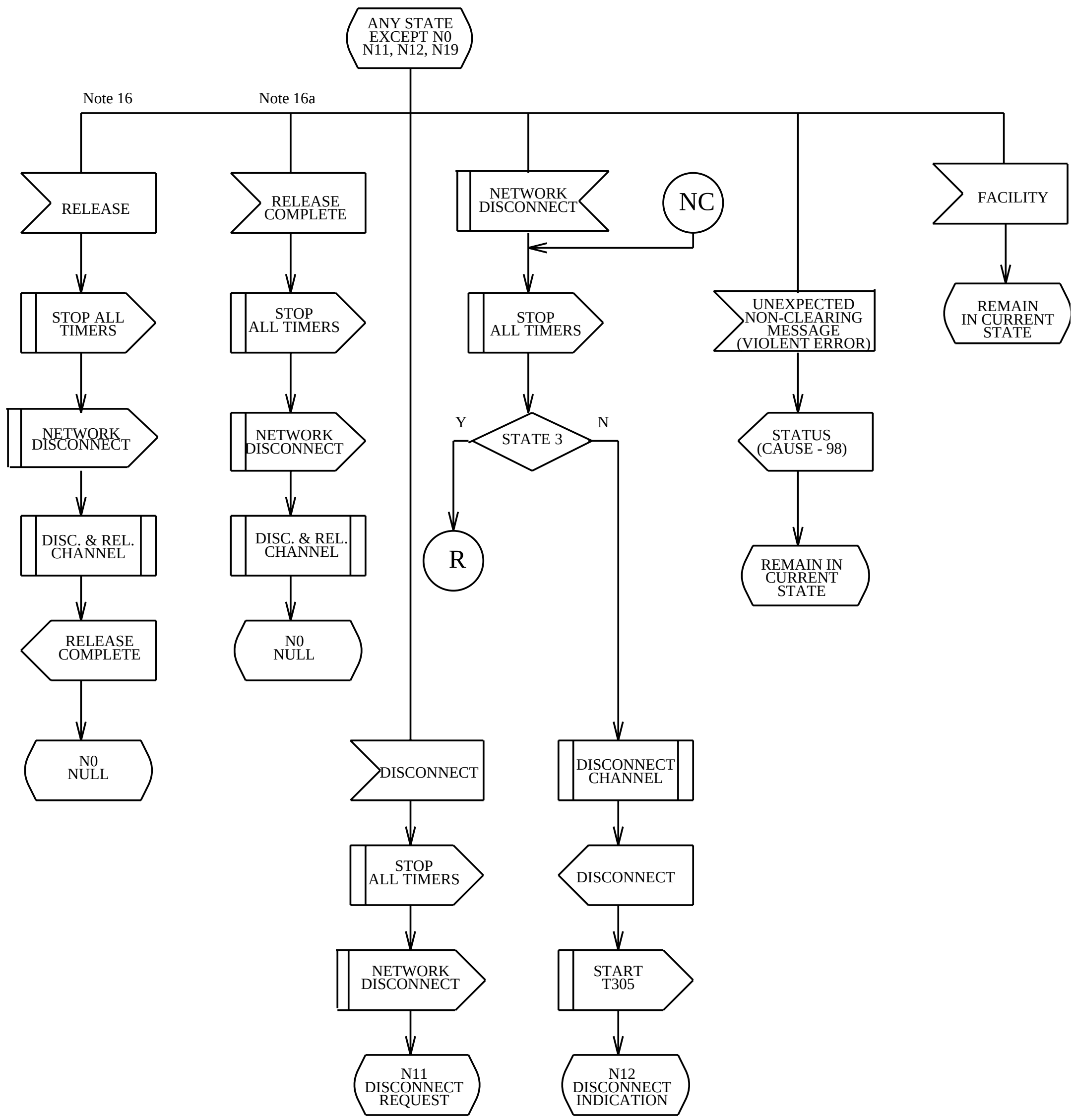


Figure 7-14 — Network Side: All States Except N11, N12, N19

7.2.13.1 Note 16

On receipt of the RELEASE message from the user, the network shall stop Timer T305, release the B-channel, send a RELEASE COMPLETE message to the user, release the call reference, and return to the null state.

7.2.13.2 Note 16a

Following the receipt of a RELEASE COMPLETE message from the user, the network shall stop Timer T308, release both the B-channel and the call reference, and return to the null state.

7.2.14 N11, DISCONNECT REQUEST STATE

See Figure 7-15.

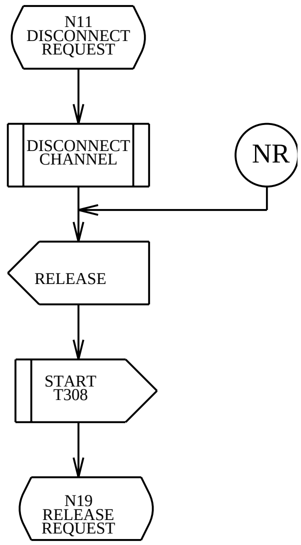


Figure 7-15 — Network Side: N11, Disconnect Request State

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8. SYMMETRICAL USER SDL DIAGRAMS

8.1 EXTENSIONS FOR SYMMETRIC CALL OPERATION

8.1.1 ADDITIONAL MESSAGE HANDLING

In symmetric applications, the SETUP message will contain a Channel Identification information element (IE) indicating a particular B-channel to be used for the call. A point-to-point data link shall be used to carry the SETUP message.

The procedure described in “Call Control Procedures,” Section 5, for the user side should normally be followed. Where additional procedures are required, they are detailed below.

8.1.1.1 Call Confirmation

Upon receipt of a SETUP message, the equipment enters the Incoming call proceeding state. Valid responses to the SETUP message are an ALERTING, a CALL PROCEEDING, a CONNECT, or a RELEASE COMPLETE message.

If the indicated channel is acceptable to the initiator of the call, the initiator shall attach to the indicated B-channel.

Table 8-1 summarizes “Error Handling,” Section 5.2.11, for symmetric signaling.

Table 8-1 — Symmetrical User Response on Receipt of Message

	Message received by the symmetrical user											
Receiver's state	SETUP	CONN ACK	CALL PROC	ALERT	CONNECT	DISC	RELEASE	REL COM	RESTART	REST ACK	PROGRESS	FACILITY
0	*	CR DNE	CR DNE	CR DNE	CR DNE	CR DNE	CR DNE	I	*	I	CR DNE	CR DNE
1	VE	VE	*	*	*	*	*	*	*	*	*	I
3	VE	VE	I	*	*	*	*	TE	*	*	*	I
4	VE	VE	I	*	*	*	*	TE	*	*	*	I
7	VE	VE	VE	VE	VE	*	*	TE	*	*	VE	I
8	VE	*	VE	VE	VE	*	*	TE	*	*	VE	I
9	VE	VE	VE	VE	VE	*	*	TE	*	*	VE	I
10	VE	I	VE	VE	**	*	*	TE	*	*	VE	*
11	I	I	I	I	I	*	*	TE	*	*	I	I
12	I	I	I	I	I	I	*	TE	*	*	I	I
19	I	I	I	I	I	I	*	*	*	*	I	I

*	: This Specification specifies the procedure.
**	: This is a tolerable error when received by the calling user (who should respond with CONN ACK); however, it is a violent error for the called user.
CR DNE	: Call Reference does not exist (see Section 5.2.11)
I	: Ignorable error
TE	: Tolerable Error
VE	: Violent Error

8.1.1.2 Clearing by the Called User Employing User-Provided Tones/Announcements

In addition to the procedures described in "Call Clearing—Symmetrical User Side Treatment," Section 5.1.7, if the bearer capability is either audio or speech, the called user or private network may apply in-band tones/announcements in the clearing phase. When in-band tones/announcements are provided, the called user or private network proceeds similarly as stipulated in "In-Band Tones and Announcements," Section 5.2.7, for the network.

8.1.1.3 Active Indication

Upon receipt of a CONNECT message, the initiator of the call shall respond with a CONNECT ACKNOWLEDGE message and enter the Active State.

8.1.1.4 Receiving a STATUS Message

On receipt of a STATUS message reporting an incompatible state, the receiving entity shall:

a. clear the call by sending the appropriate clearing message or,

b. take other actions that attempt to recover from a mismatch and that are implementation options. Refer to Table 8-2 for the details. It is an implementation option to decide which of the matchable states will be considered so. Any decision will have little impact on the protocol. The table gives the logical maximum.

Table 8-2 — User's Action on Receipt of STATUS

CURRENT STATE	RECEIVED STATE	
	MATCHING	MATCHABLE (USER'S ACTION)
1	none	none
3	9	none
4	7	none
7	4	1 and 9 (ALERTING)
8	8	1, 7, and 9 (CONNECT)
9	9	1 (CALL PROCEEDING)
10	10	8 if outgoing (CONNECT ACKNOWLEDGE)
19	19	none

8.1.2 CALL COLLISIONS

In symmetric arrangements, call collisions can occur when both sides simultaneously transfer a SETUP message indicating the same channel. In the absence administrative procedures for assignment of channels to each side of the interface, the following procedure is employed.

One side of the interface will be designated the "network" and the other side of the interface will be designated the "user." The *5ESS*® switch has implemented only "exclusive" procedures. Channel identification is allowed in both directions for ALERTING and CONNECT.

8.2 SYMMETRICAL USER SIDE SDL DIAGRAMS

8.2.1 SU0, NULL STATE

See Figure 8-1.

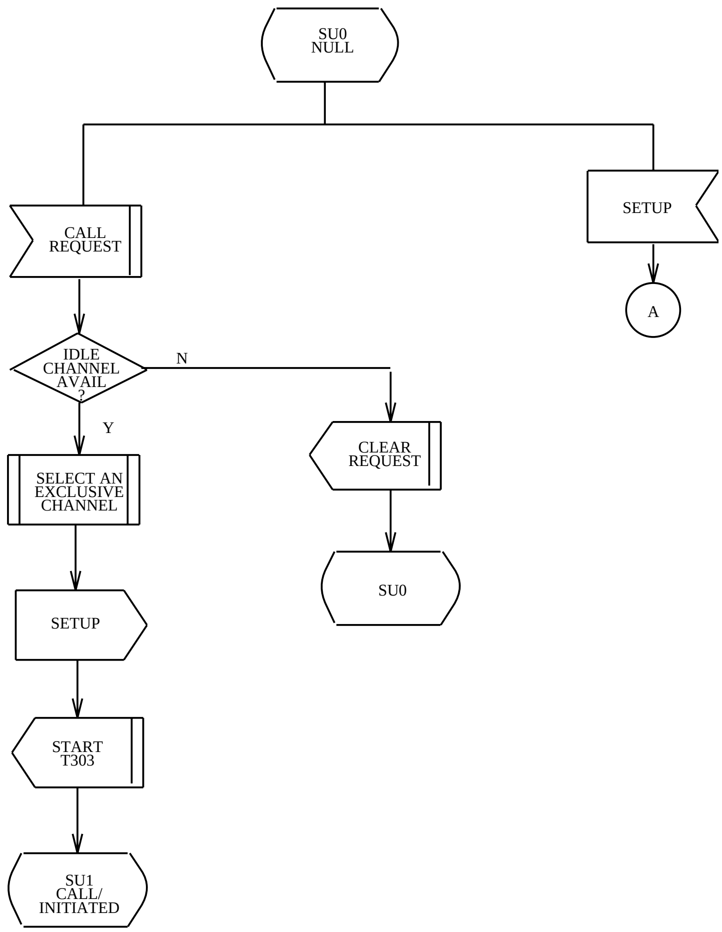
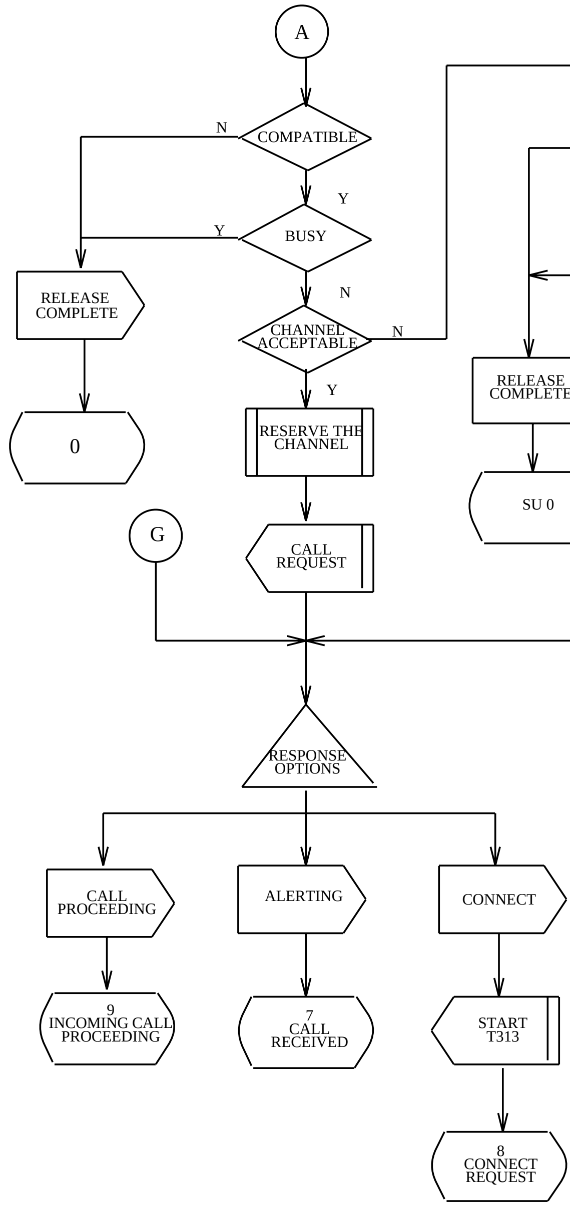


Figure 8-1 — Symmetrical User: SU0, Null State (1 of 2)



Note 1: This refers to the contending outgoing call on the requested channel. "Y" implies glare.

Note 2: This refers to the signaling channel. "Y" implies the outgoing call abandons the requested channel.

Figure 8-1 — Symmetrical User: SU0, Null State (2 of 2)

8.2.2 SU1, CALL INITIATED STATE

See Figure 8-2.

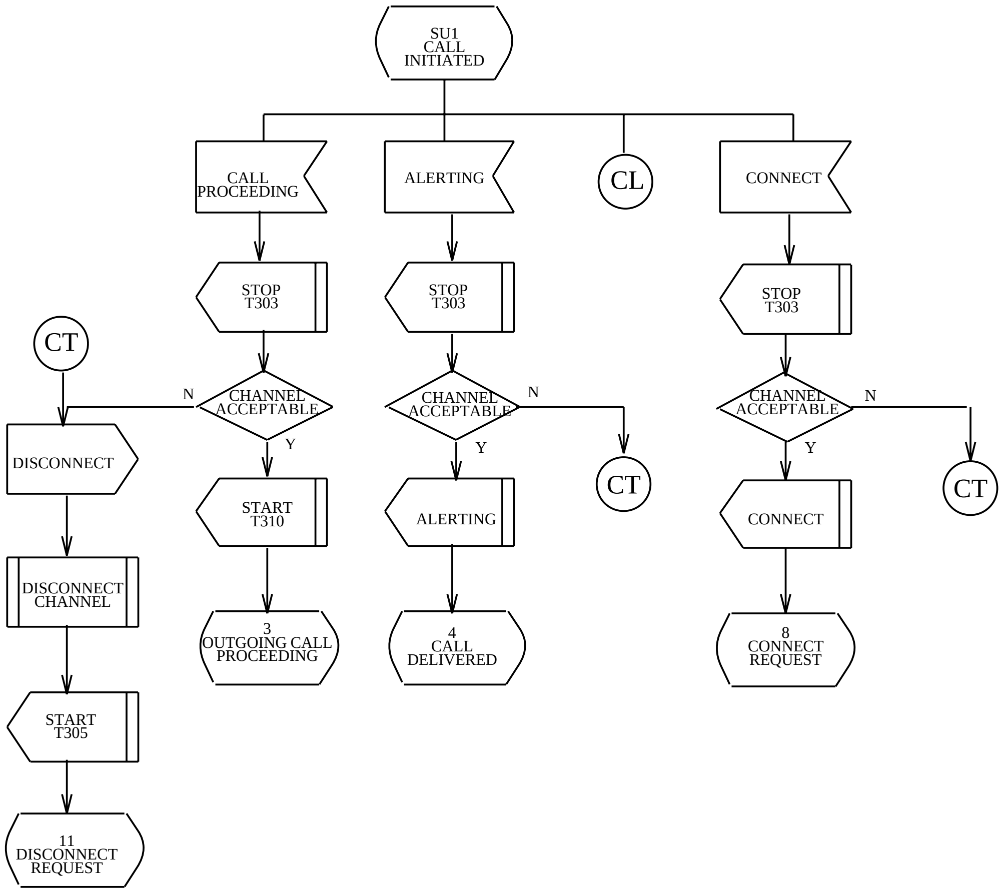


Figure 8-2 — Symmetrical User: SU1, Call Initiated State (1 of 2)

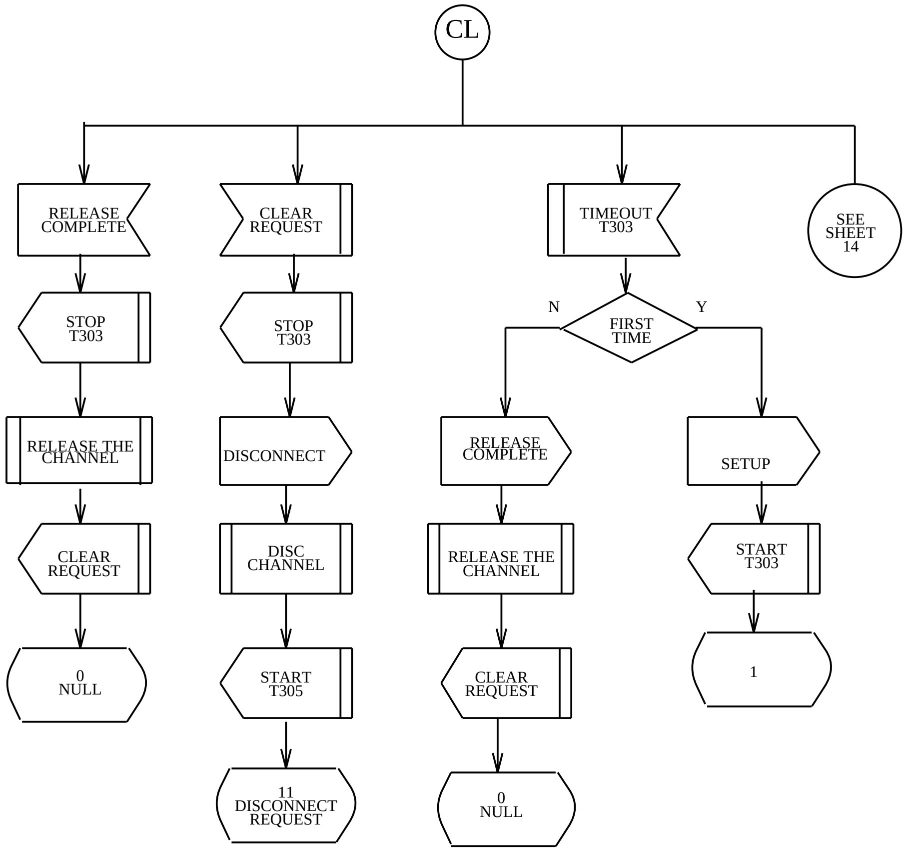


Figure 8-2 — Symmetrical User: SU1, Call Initiated State (2 of 2)

8.2.3 SU3, OUTGOING CALL PROCEEDING STATE

See Figure 8-3.

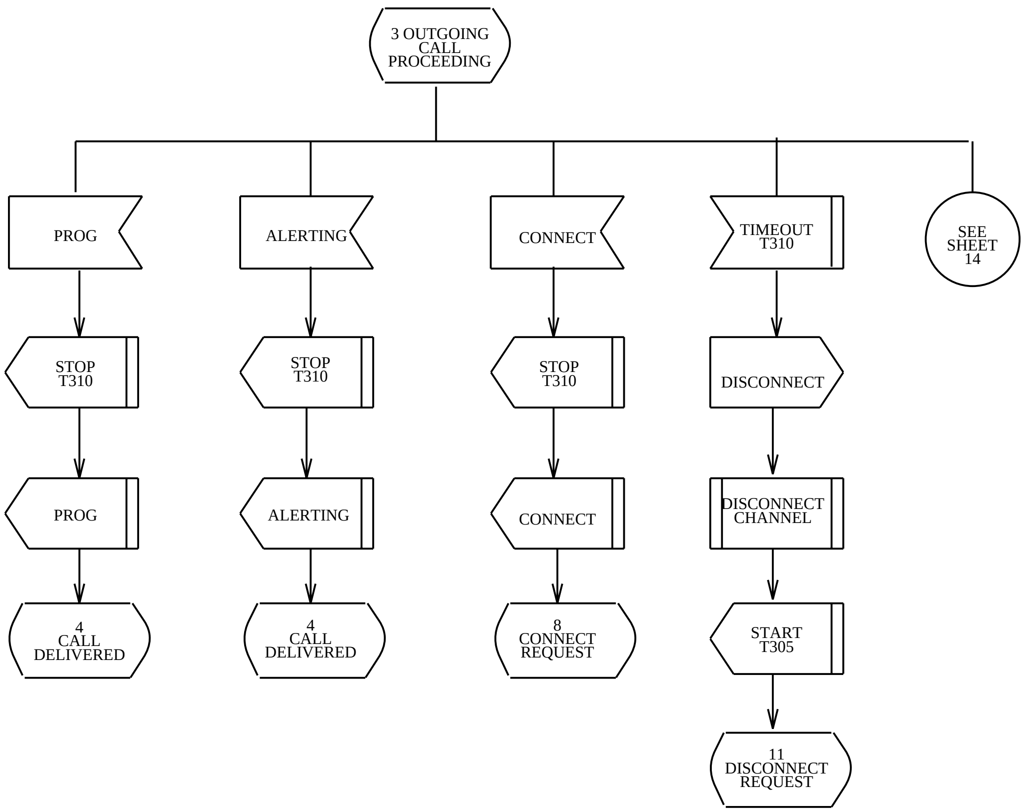


Figure 8-3 — Symmetrical User: SU3, Outgoing Call Proceeding State

8.2.4 SU4, CALL DELIVERED STATE

See Figure 8-4.

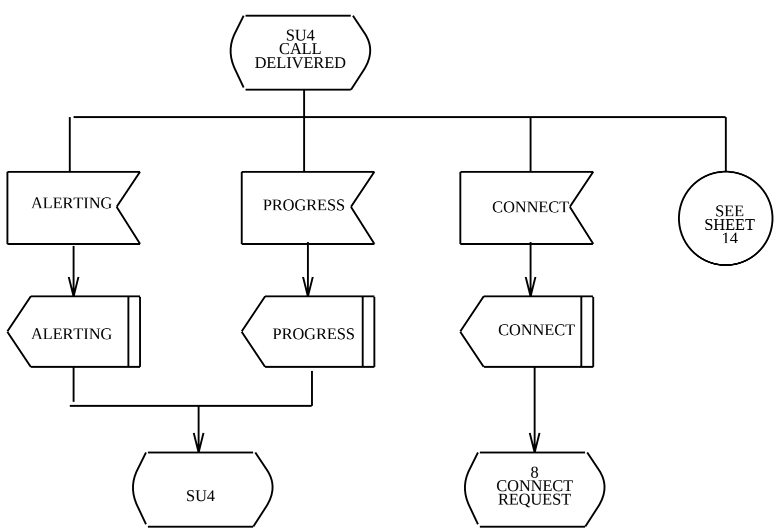


Figure 8-4 — Symmetrical User: SU4, Call Delivered State

8.2.5 SU7, CALL RECEIVED STATE

See Figure 8-5.

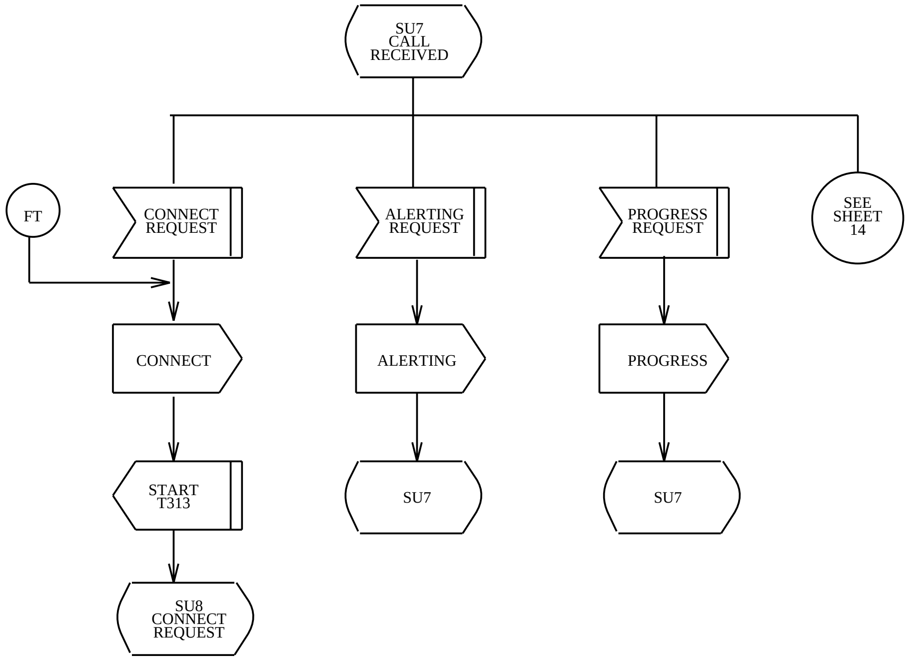


Figure 8-5 — Symmetrical User: SU7, Call Received State

8.2.6 SU8, CONNECT REQUEST STATE

See Figure 8-6.

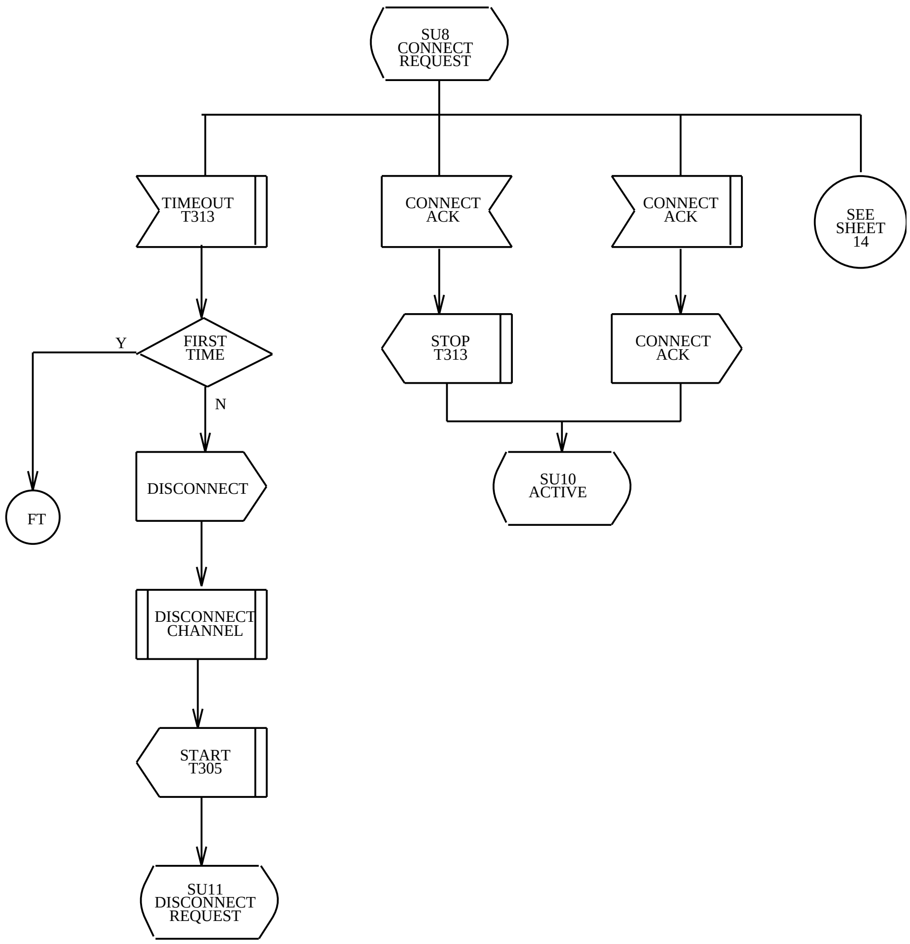


Figure 8-6 — Symmetrical User: SU8, Connect Request State

8.2.7 SU9, INCOMING CALL PROCEEDING STATE

See Figure 8-7.

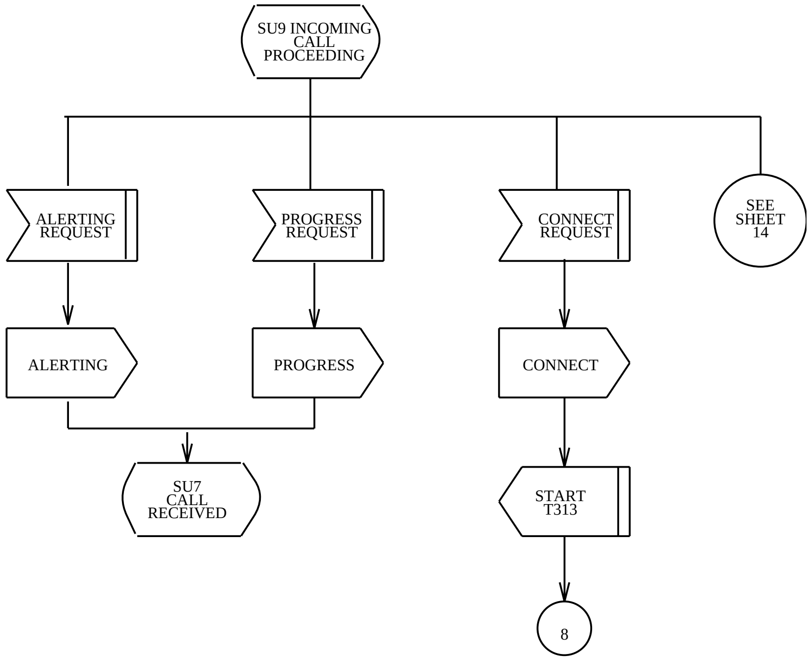


Figure 8-7 — Symmetrical User: SU9, Incoming Call Proceeding State

8.2.8 SU10, ACTIVE STATE

See Figure 8-8.

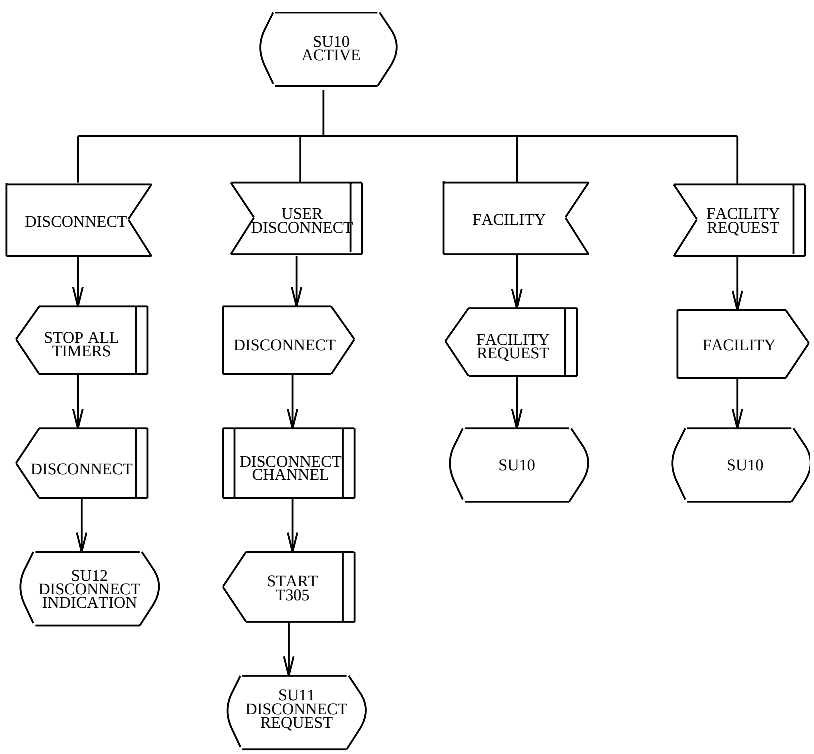


Figure 8-8 — Symmetrical User: SU10, Active State

8.2.9 SU11, DISCONNECT REQUEST STATE

See Figure 8-9.

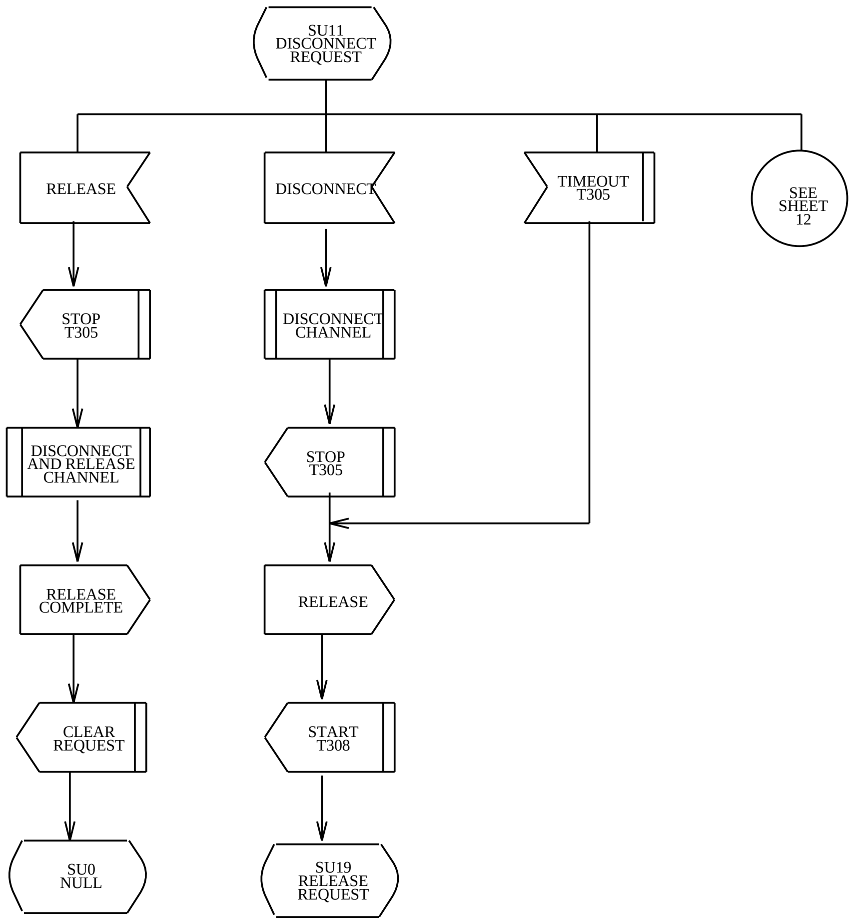


Figure 8-9 — Symmetrical User: SU11, Disconnect Request State

8.2.10 SU12, DISCONNECT INDICATION STATE AND MULTIPLE STATES

See Figure 8-10.

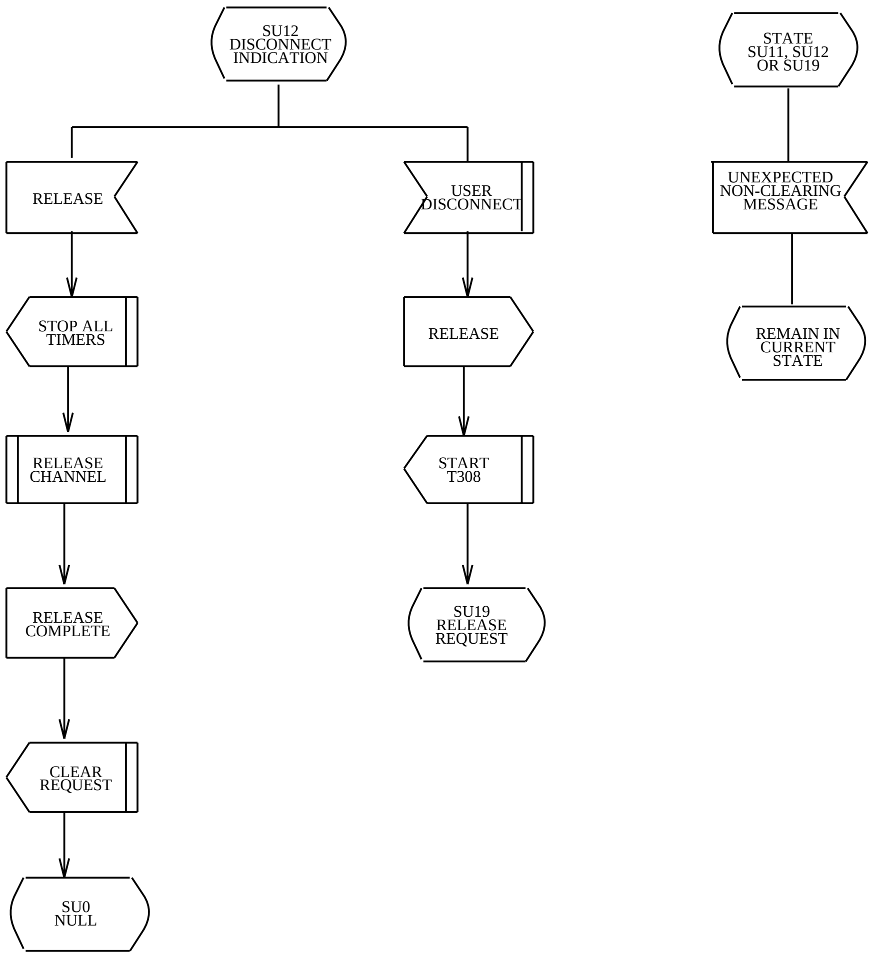


Figure 8-10 — Symmetrical User: SU12, Disconnect Indication State and Multiple States

8.2.11 SU19, RELEASE REQUEST STATE

See Figure 8-11.

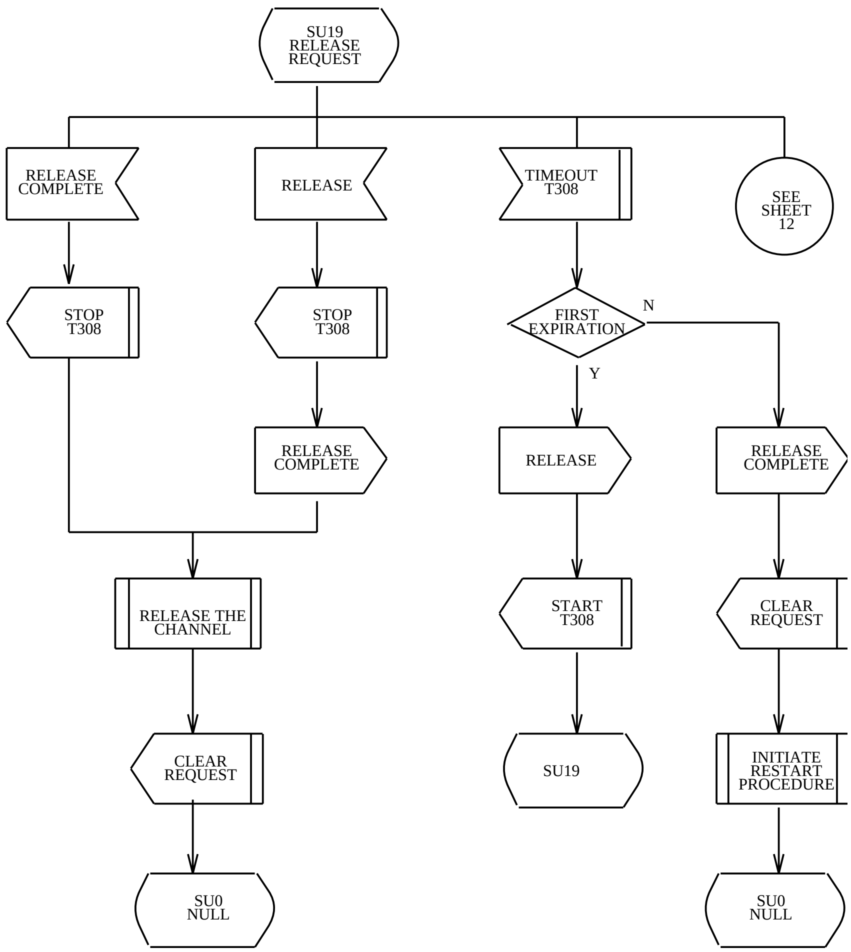


Figure 8-11 — Symmetrical User: SU19, Release Request State

8.2.12 MULTIPLE STATES

See Figure 8-12.

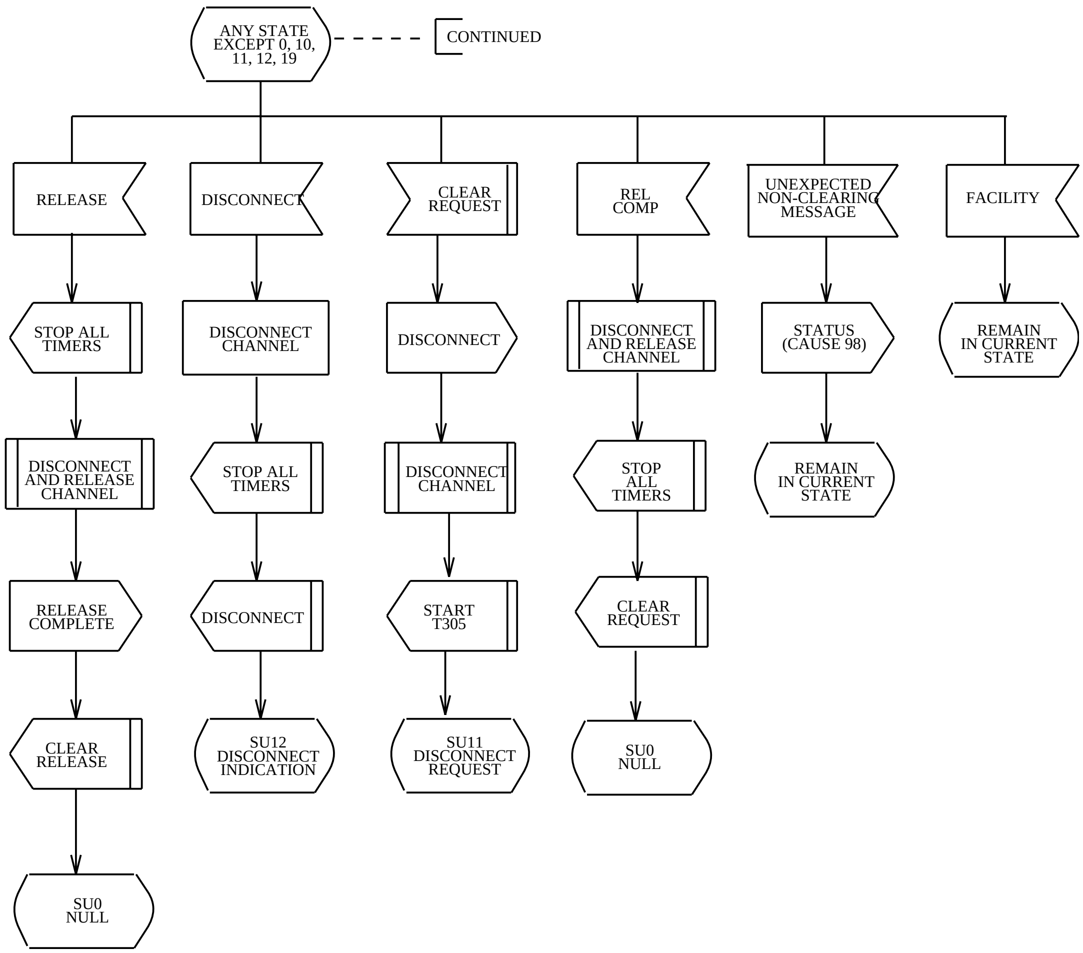


Figure 8-12 — Symmetrical User: All States Except SU0, SU10, SU11, SU12, and SU19

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9. MAINTENANCE CAPABILITIES AND PROCEDURES

This section documents the maintenance messages and procedures supported by the *5ESS*® switch for the Custom Primary Rate Interface (PRI) and the National ISDN PRI.

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9.1 GENERAL MAINTENANCE INFORMATION

9.1.1 CUSTOM PRI VERSUS NATIONAL ISDN PRI

The coding of the protocol discriminator, change status, and channel identification fields for maintenance messages is different for the Custom PRI compared to the National ISDN PRI. See "Maintenance Information Elements," Section 9.1.4, for further details.

Additionally, the maintenance procedures for the National ISDN PRI are different from the maintenance procedures for the Custom PRI. For the Custom PRI, the SERVICE and SERVICE ACKNOWLEDGE messages are used to control and monitor the B-channel state. For the National ISDN PRI, the RESTART and RESTART ACKNOWLEDGE messages are used to bring the B-channel into service. The SERVICE and SERVICE ACKNOWLEDGE messages are used to remove a B-channel from service and to audit a B-channel state if PRI B-channel Availability Signaling Procedures are provisioned. In addition, for the National ISDN PRI with the D-channel backup feature, the SERVICE and SERVICE ACKNOWLEDGE messages are used to control and monitor the D-channel state. For the Custom PRI and the National ISDN PRI without the D-channel backup feature, the SERVICE and SERVICE ACKNOWLEDGE messages are not used to control and monitor the D-channel state; rather, the D-channel is controlled and monitored by Layer 2 messages. See "Custom PRI Maintenance Procedures," Section 9.2, and "National ISDN PRI Maintenance Procedures," Section 9.3, for further details.

9.1.2 LAYER 2 OPERATION FOR MAINTENANCE

The D-channel uses service access point identifier (SAPI) 0 for signaling maintenance of the Custom PRI and the National ISDN PRI. Both the network and the user must use point-to-point operation for sending maintenance messages on SAPI 0.

9.1.3 LAYER 3 MAINTENANCE MESSAGES

The following sections present a brief summary of the maintenance messages supported by the *5ESS*® switch. The summary includes:

- A list, in order of appearance, of the information elements (IEs) allowed in the message
- An indication whether a particular IE is mandatory ("M") or optional ("O") in the message
- The associated length, in octets, of the IEs.

9.1.3.1 SERVICE

Table 9.1-1 shows the SERVICE Message.

Table 9.1-1 — SERVICE Message

INFORMATION ELEMENT	DIRECTION	TYPE	LENGTH
Protocol discriminator	both	M	1
Call Reference	both	M	2-3[a]
Message Type	both	M	1
Change Status	both	M	3
Channel Identification	both	M	3-8[b]

Note(s):
a. Custom PRI sends a 2-octet call reference; National ISDN PRI sends a 3-octet call reference.
b. The length of the channel identification IE must be 3 or 4 octets for the National ISDN PRI D-channel, 5 or 8 octets for the National ISDN PRI B-channel (depending on whether the coding is B-channel number or a slot map), and 5 or 6 octets for the Custom PRI.

Message type: SERVICE
Direction: both

9.1.3.2 SERVICE ACKNOWLEDGE

Table 9.1-2 shows the SERVICE ACKNOWLEDGE Message.

Table 9.1-2 — SERVICE ACKNOWLEDGE Message

INFORMATION ELEMENT	DIRECTION	TYPE	LENGTH
Protocol discriminator	both	M	1
Call Reference	both	M	2-3[a]
Message Type	both	M	1
Change Status	both	M	3
Channel Identification	both	M	3-8[b]

Note(s):
a. The length of the global call reference matches the length received in the SERVICE message.
b. The length of the channel identification IE must be 3 or 4 octets for the National ISDN PRI D-channel, 5 or 8 octets for the National ISDN PRI B-channel (depending on whether the coding is B-channel number or a slot map), and 5 or 6 octets for the Custom PRI.

Message type: SERVICE ACKNOWLEDGE
Direction: both

9.1.3.3 RESTART AND RESTART ACKNOWLEDGE

For the Custom PRI, RESTART and RESTART ACKNOWLEDGE messages are treated only as call processing messages and are used to clear calls on the far end. The RESTART and RESTART ACKNOWLEDGE messages are not considered maintenance messages and do not change the state of the B-channels. See “RESTART/RESTART ACKNOWLEDGE Procedures,” Section 5.2.2, for more information.

On the other hand, the National ISDN PRI uses the RESTART and RESTART ACKNOWLEDGE messages both as maintenance messages to bring the B-channel into service and as call processing messages used to clear calls on the far end (FE).

Note: For the RESTART and RESTART ACKNOWLEDGE messages, the protocol discriminator IE is coded as a user-network call control message, not as a maintenance message.

Additionally, the global call reference IE is used. Refer to “RESTART,” Section 4.2.11, and “RESTART ACKNOWLEDGE,” Section 4.2.12, for a summary of these messages.

9.1.4 MAINTENANCE INFORMATION ELEMENTS

9.1.4.1 Protocol Discriminator Information Element

The protocol discriminator distinguishes messages for user-network call control from other messages such as maintenance. The Custom PRI maintenance protocol discriminator is different from the National ISDN PRI maintenance protocol discriminator as shown in Table 9.1-3.

Table 9.1-3 — Custom and National ISDN PRI Protocol Discriminator Information Element

OCTET	FIELD	BITS	VALUE	MEANING
1	Protocol Discriminator	8-1	00000011	Custom maintenance protocol discriminator
			01000011	National maintenance protocol discriminator

9.1.4.2 Call Reference Information Element

For all Custom PRI and National ISDN PRI maintenance messages, the global call reference must be used (see Table 9.1-4). The global call reference is two or three octets long with the first octet coded with a length of one or two (“0000 0001” for a length or one, or “0000 0002” for a length of two) and the second octet coded “F000 0000,” where F is the call reference flag. The call reference flag is used to identify which end of the Layer 2 logical link originated a call reference. The call reference flag can take the values “0” or “1”. The origination side always sets the call reference flag to “0”. The destination side always sets the call reference flag to “1”. If a third octet is coded, it should have a value of “0000 0000.”

When the *5ESS* switch *sends* a RESTART or SERVICE message with a global call reference, the reference is coded to be three octets long in the National ISDN PRI, and two octets long in the Custom PRI, which includes the length. When the switch *responds to* a RESTART (or SERVICE) message by sending a RESTART ACKNOWLEDGE (or SERVICE ACKNOWLEDGE) message, the global call reference is of the same length as that of the RESTART (or SERVICE) message received—two octets or three.

Table 9.1-4 — Custom and National ISDN PRI Call Reference Information Element

OCTET	FIELD	BITS	VALUE	MEANING
1	Length of Call Reference	8-1	00000001	Length of the call reference value in octets
2	Call Reference Flag	8	0	Origination side
			1	Destination side
	Call Reference Value	7-1	0000000	Only allowed value
3	Call Reference Value continued	8-1	0000000	Only allowed value

9.1.4.3 Message Type Information Element

The message type, used to identify the function of the message sent, is coded the same for both the Custom PRI and the National ISDN PRI. See Table 9.1-5.

Table 9.1-5 — Custom and National ISDN PRI Message Type Information Element

OCTET	FIELD	BITS	VALUE	MEANING
1	Reserved	8	0	Possible future use as extension bit.
	Message Type	7-1	0001111	SERVICE
			0000111	SERVICE ACKNOWLEDGE

9.1.4.4 Change Status Information Element

The Custom PRI change status IE differs from the National ISDN PRI change status IE. For the Custom PRI, the change status IE is used in the SERVICE and SERVICE ACKNOWLEDGMENT messages to change the current status of either an interface or a B-channel to one of the following states: in service (IS), maintenance (MTCE), or out of service (OOS). See Table 9.1-6.

Note: The *5ESS* switch can *receive* a change status with preference equal to interface, but never *sends* a change status with preference equal to interface.

Table 9.1-6 — Custom PRI Change Status Information Element

OCTET	FIELD	BITS	VALUE	MEANING
1	Extension	8	0	Multiple octet element
	Information Element Identifier	7-1	0000001	Change status
2	Length	8-1	binary	Length of change status
3	Extension	8	1	Last octet of description
	Preference	7	0	Interface
			1	Single B-channel
	Spare	6-4	000	Spare
	Status	3-1	000	In service
			001	Maintenance
			010	Out of service

For the National ISDN PRI, the change status IE is used in D-channel SERVICE and SERVICE ACKNOWLEDGE messages to convey the D-channel status when D-channel backup is provisioned. (In the case of a simplex D-channel arrangement, a SERVICE message cannot be used to change the status of the D-channel.) For D-channel SERVICE and SERVICE ACKNOWLEDGE messages, only the IS status of the D-channel is conveyed. SERVICE messages that specify OOS or maintenance status are never sent for D-channels by the *5ESS* switch and will be ignored if received. See Table 9.1-7.

For the National ISDN PRI, the change status IE is used in B-channel SERVICE and SERVICE ACKNOWLEDGE messages if PRI B-channel Availability Signaling Procedures are provisioned. Also for National ISDN PRI, the B-channel SERVICE and SERVICE ACKNOWLEDGE messages are not used to bring the B-channels into service, except in the case of a status audit. Instead, the RESTART and RESTART ACKNOWLEDGE message are used. SERVICE and SERVICE ACKNOWLEDGE messages that specify OOS are used to remove a B-channel from service if PRI B-channel Availability Signaling Procedures are provisioned. See Table 9.1-7.

Table 9.1-7 — National ISDN PRI Change Status Information Element

OCTET	FIELD	BITS	VALUE	MEANING
1	Extension	8	0	Multiple octet element
	Information Element Identifier	7-1	0000001	Change status
2	Length	8-1	binary	Length of change status
3	Extension	8	1	Last octet of description
	Preference	7	1	Single channel
	Spare	6-4	000	Spare
	Status	3-1	000	In service
		3-1	010	Out of service[a]

Note(s):
a. Not used for D-channels.

9.1.4.5 Channel Identification Information Element

The channel identification IE specifies which PRI channel should receive the action initiated by the maintenance message. For the Custom and National PRI B-channel, the channel identification IE is coded as specified in “Channel Identification,” Section 4.3.3.9. For the National ISDN PRI, see Table 9.1-8 for coding of the channel identification IE used for the D-channel SERVICE and SERVICE ACKNOWLEDGE messages in the D-channel backup protocol.

Table 9.1-8 — National ISDN PRI D-channel Channel Identification Information Element

OCTET	FIELD	BITS	VALUE	MEANING
1	Bit 8	8	0	Set value
	Information Element Identifier	7-1	0011000	Channel identification
2	Length	8-1	binary	Length of channel identification contents
3	Extension	8	1	Last octet of description
	Interface Identifier Present	7[a]	0	Interface implicitly identified
			1	Interface explicitly identified in octet(s) beginning with Octet 3.1
	Interface Type	6	1	Other interface
	Spare	5	0	Spare
	Preferred/ Exclusive	4	1	Exclusive; only the indicated channel is acceptable.
	D-channel Indicator	3	1	The channel identified is the D-channel.
	Information Channel Selection	2-1	00	No channel
3.1	Extension	8	1	Last octet of the description
	Interface Identifier	7-1	binary	Number of DS1 facility (1-20).

Note(s):
a. Bit 7 of Octet 3 must be coded:
0 if the interface is implicitly identified (Octet 3.1 is excluded)
1 if the interface is explicitly identified in Octet 3.1.
If Bit 7 of Octet 3 is coded “1”, then Octet 3.1 is binary coded indicating the number of the DS1 facility (in the range of 1-20). Octets 3.2 and 3.3 are not included.

9.1.5 GENERAL CLASSES OF LAYER 3 MAINTENANCE ACTIVITIES

Three classes of maintenance activity on the user-network interface exist at Layer 3:

- SERVICE/SERVICE ACKNOWLEDGE messages used to convey the change in the status of any of the following:
  - — A Custom PRI B-channel
  - — A National ISDN PRI B-channel if PRI B-channel Availability Signaling Procedures are provisioned
  - — The interface for a Custom PRI
  - — A National ISDN PRI D-channel with D-channel backup (DCBU).

- RESTART/RESTART ACKNOWLEDGE messages used to bring a National ISDN PRI B-channel into service
- Test call generation used to identify and verify problems at the user-network interface.

9.1.5.1 SERVICE/RESTART Maintenance Activities on Custom and National PRI

SERVICE/RESTART maintenance activities on the user-network interface for the Custom PRI differ from those used for the National ISDN PRI as follows:

- For the Custom PRI, the SERVICE and SERVICE ACKNOWLEDGE messages are used to bring the B-channels IS, OOS, or into a maintenance state, and to audit the B-channel state.
- For the National ISDN PRI, SERVICE and SERVICE ACKNOWLEDGE messages are used as maintenance messages to bring B-channels OOS and to audit the B-channel state, if PRI B-channel Availability Signaling Procedures are provisioned.
- For the National ISDN PRI, RESTART and RESTART ACKNOWLEDGE messages are used as maintenance messages to bring the B-channels IS in addition to call control.
- For the National ISDN PRI with the D-channel backup feature, SERVICE and SERVICE ACKNOWLEDGE maintenance messages are used to control and monitor the D-channel state.

Refer to “Custom PRI Maintenance Procedures,” Section 9.2, and “National ISDN PRI Maintenance Procedures,” Section 9.3, for further information.

9.1.5.2 Test Calls

Test equipment, such as a trunk and line workstation, may be interfaced to the test ports for sending and receiving diagnostic information through test calls to prespecified test line directory numbers across the user-network interface. These test calls are never invoked automatically. Technicians request these calls in either a loop-back mode or an inverted loop-back mode, in which the bit stream is logically inverted by the receiver before it is sent back to the sender.

For the Custom PRI, test calls are placed by sending a SERVICE message, then a SETUP message. For the National ISDN PRI, test calls are placed by sending a SETUP message to a valid test directory number; no SERVICE message is necessary. Normal call processing procedures apply for the SETUP message (see “Layer 3: The PRI Network Interface Layer,” Section 4). These procedures include coding of a valid service in the network specific facilities (NSF) IE of the SETUP message whenever a call-by-call PRI is used. Test calls can be placed when normal outgoing traffic is barred.

Test lines may be provisioned and implemented as needed. Calls to any valid test line are considered test calls, and are identified using digit analysis. Collisions between SETUP messages for these calls follow normal glare procedures. When the *5ESS* switch receives a call to a test line not supported by the switch, the call is cleared (as for any invalid address) using a DISCONNECT message with a cause code value of 31 “normal, unspecified.”

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9.2 CUSTOM PRI MAINTENANCE PROCEDURES

This section presents the procedures for the Custom PRI to be used with the maintenance messages defined in “Layer 3 Maintenance Messages,” Section 9.1.3. Since the maintenance messages are symmetric, these procedures can be initiated by either side of the interface.

9.2.1 STATES FOR CUSTOM PRI MAINTENANCE PROCEDURES

The B-channel states, as implemented by the *5ESS*® switch for the Custom PRI maintenance procedures, are listed in the following table. Note that these states are conceptual and do not map one-to-one to a *5ESS* switch port state. For each state, the status (which is sent in the change status IE of the SERVICE message and SERVICE ACKNOWLEDGE message) is also listed.

STATUS	STATE	AVAILABILITY
In Service	In Service	Most Available
Maintenance	In Service Maintenance Near End	
	Maintenance Far End	
	Out of Service Maintenance Near End	
Out Of Service	Out of Service Far End	
	Out of Service Near End	Least Available

When a B-channel has been moved to the In Service (IS) state, normal call activity is supported.

When removed by manual or automatic action, the B-channel is placed in a conceptual Out of Service (OOS) state. The interface end that requests this state determines whether the state is:

- Out of Service Near End (OOS NE). This state is initially implemented for a newly provisioned B-channel on the *5ESS* switch, and implemented for a B-channel for which the local system (NE) has requested OOS. Although not available for any normal call originations or terminations, a B-channel in OOS NE is available for test calls originated from the local system. A 2-way PRI trunk B-channel in the OOS NE state can also receive test calls originated from the FE.
- Out of Service Far End (OOS FE). This state is implemented for a B-channel when the system on the other end of the interface (FE) has requested OOS. Although not available for any normal call originations or terminations, a B-channel in OOS FE is available for test calls originated from either the NE or the FE.

Only when sending or receiving a test call, the *5ESS* switch is in a conceptual Maintenance (MTCE) state. For a B-channel in the MTCE state, test call originations are the only call types allowed. The B-channel state when the test call is originated and the interface end that originates the test call determine whether the state is:

- In Service—Maintenance Near End (IS MTCE NE). This state is implemented if the near end B-channel is in an IS state when it originates a test call.
- Maintenance Far End (MTCE FE). This state is implemented if the near end B-channel is in an IS or the OOS FE state when the far end invokes a test call.

- Out of Service—Maintenance Near End (OOS MTCE NE). This state is implemented if the near end B-channel is in an OOS state when it originates a test call.

Note: A complete explanation of *5ESS* switch port states is provided in the Port Status Appendix (APP:PORT-STATUS) of document 235-600-750, **5ESS** *Switch Output Messages*.

9.2.2 B-CHANNEL MAINTENANCE PROCEDURES FOR CUSTOM PRI

The valid transitions among the various B-channel states are shown in the following figures:

- Figure 9.2-2
- Figure 9.2-3
- Figure 9.2-4
- Figure 9.2-5
- Figure 9.2-6
- Figure 9.2-7.

Transitions from a more available state to a less available state occur without negotiation. Notification of these transitions are made by the use of the SERVICE message. Transitions from a less available state to a more available state require both sides of the interface to agree on the transition. Notification of these transitions are made by the use of the SERVICE message and the SERVICE ACKNOWLEDGE message.

As a standard procedure, if one side of the interface detects a failure condition, the *5ESS* switch will always move the B-channels to the OOS state. If the failure condition clears, an attempt should be made to return the channel to the IS state. A B-channel or interface that is in the OOS state may be moved to the IS state only if both sides of the interface agree to do so by exchanging a SERVICE message and a SERVICE ACKNOWLEDGE message with a change status IE indicating the IS status. A B-channel or interface that is in the OOS state may be moved to the maintenance state only if both sides of the interface agree to do so in one of the following ways:

- By exchanging a SERVICE message and a SERVICE ACKNOWLEDGE message with a change status IE indicating the maintenance status
- By exchanging a SERVICE message with a change status IE indicating the IS status and a SERVICE ACKNOWLEDGE message with a change status IE indicating the maintenance status.

The *5ESS* switch may perform audits periodically on a routine basis. If a call is on the channel, a maintenance action is in progress, or a B-channel is waiting for a SERVICE ACKNOWLEDGE message, the channel is considered in use and the audit procedure is ignored. Otherwise, the Custom PRI responds to audits as specified in Figure 9.2-7.

9.2.2.1 SERVICE Messages Sent by *5ESS* Switch

The *5ESS* switch will never generate a SERVICE message to change the entire interface. A SERVICE message is sent for each individual B-channel indicating the channel and its new status. When the *5ESS* switch sends a SERVICE message, Timer T317 is started. If no SERVICE ACKNOWLEDGE message is received within 120 seconds after the *5ESS* switch has sent a SERVICE message (Timer T317 expires), the *5ESS* switch responds based on the current state of the B-channel.

- If the state equals IS, the *5ESS* switch sends a second SERVICE message and starts a Timer T317. If this second attempt times out, the switch terminates all call processing on the B-channel and the B-channel enters an OOS FE state.
- If the state equals IS maintenance NE, the *5ESS* switch enters an IS state.
- If the state equals OOS maintenance NE, the *5ESS* switch enters an OOS NE state.
- If the state equals maintenance FE, the *5ESS* switch enters an OOS FE state.
- If the state equals OOS FE, the *5ESS* switch sends a second SERVICE message and starts a Timer T317. If this second attempt times out, the B-channel remains in the OOS FE state.

Note: When the B-channel enters the OOS NE state, a SERVICE message is sent but Timer T317 is not started; the B-channel remains in the OOS NE state.

If a SERVICE message is received by the *5ESS* switch before Timer T317 expires and before the corresponding SERVICE ACKNOWLEDGE is received, then Timer T317 is stopped and the appropriate SERVICE ACKNOWLEDGE is sent. This situation is considered message collision. See Figures 9.2-2, 9.2-4, and 9.2-6 for further information.

9.2.2.2 SERVICE Messages Received by *5ESS* Switch

The *5ESS* switch can receive a SERVICE message that changes the state for either a single B-channel or the entire interface. If the switch receives a SERVICE message coded for a single B-channel, the switch returns a SERVICE ACKNOWLEDGE message with the channel status of equal or lesser availability. For example, if the switch receives a SERVICE message of IS, the switch returns a SERVICE ACKNOWLEDGE message of IS, maintenance or OOS, depending on the current status in effect. If the switch receives a SERVICE message of maintenance, the switch returns a SERVICE ACKNOWLEDGE message of maintenance or OOS, depending on the current status in effect. If the switch receives a SERVICE message of OOS, the switch returns a SERVICE ACKNOWLEDGE message of OOS, regardless of the current status in effect.

If the switch receives a SERVICE message coded for the entire interface, the switch returns a SERVICE ACKNOWLEDGE message that specifies the interface. In cases where not all channels in the interface can be placed in the service status specified in the SERVICE message, however, the switch also sends, for each channel, individual SERVICE messages that specify service status availability. In this case, individual SERVICE ACKNOWLEDGE messages are required for each channel.

9.2.2.3 Test Calls on Custom PRI

For the Custom PRI, when a technician's input message invokes a test call, the *5ESS* switch sends a SERVICE message, then a SETUP message for which normal call processing procedures apply. See “Layer 3: The PRI Network Interface Layer,” Section 4, and “Call Control Procedures,” Section 5. These procedures include coding of a valid service in the network specific facilities IE of the SETUP message whenever a call-by-call PRI is used.

Test calls may be placed when normal outgoing traffic is barred, and are identified by digit analysis. Collisions between SETUP messages for test calls follow normal glare procedures. When the *5ESS* switch receives a SERVICE message followed by a SETUP message, it responds with a CALL PROCEEDING message followed by a CONNECT message. The following examples of test call procedures are based on the SDL diagrams in the following figures:

- Figure 9.2-2
- Figure 9.2-3
- Figure 9.2-4
- Figure 9.2-5
- Figure 9.2-6
- Figure 9.2-7.

A test call originated from the far end when the near end is in the IS state proceeds as follows. When a SERVICE (Maintenance) message is received by the *5ESS* switch for a B-channel in the IS state, as shown in Figure 9.2-2, new normal calls are blocked on that channel, but test calls are allowed. A SERV ACK (Maintenance) message is returned to the sender, and the state transitions to the MTCE FE state. In this state, a SETUP message may be received from the far end to initiate a test call.

A test call originated by a technician's request proceeds as follows. As shown in Figure 9.2-2, the technician's request is received in the In Service state, and new normal calls are barred. A SERV (Maintenance) message is sent to the far end, Timer T317 is started, and the state transitions to the IS MTCE (Waiting for ACK) state. When a SERV ACK (Maintenance) message is received from the far end, the test call is originated by sending a SETUP message to the far end.

A test call originated from the far end when the B-channel is in the OOS FE state proceeds as follows. When a SERVICE (Maintenance) message is received on a OOS FE state as shown in Figure 9.2-6, test call call processing is activated, a SERV ACK (Maintenance) message is returned, and the state transitions to the MTCE FE state, in which the test call is allowed.

When a B-channel in an OOS NE state receives a Move to In Service request from the near end as shown in Figure 9.2-5, a SERVICE (In Service) message is sent to the far end, Timer T317 is started, and the state transitions to the OOS (Waiting for ACK) FE state. If the far end wishes to initiate a test call, it responds with a SERVICE (Maintenance) message. When the near end receives it, the near end cancels Timer T317, activates call processing for the test call, sends a SERV ACK (Maintenance) message to the far end, and transitions to the MTCE FE state, in which the test call can be processed.

9.2.2.4 Relationship of Service Status to Call Processing State

The exchange of SERVICE and SERVICE ACKNOWLEDGE messages do not of themselves change the call processing state of either a stable call or an in-progress call. Change in service status, however, can have implications for call processing that may trigger the exchange of call processing messages.

Conversely, the exchange of call processing messages does not change the service status category. However, call processing messages that are inconsistent with the current status category may trigger service status procedures that result in the exchange of SERVICE messages that change the service status category.

9.2.2.5 Cause Codes Invoked by Custom PRI Maintenance Procedures

The following cause codes may be produced during execution of the Custom PRI maintenance procedures.

- Cause code value 34 “no circuit or channel available”

  If a SETUP message is received for a channel in the MTCE FE state, the OOS MTCE NE state, the OOS FE state, or the OOS NE state, the *5ESS* switch returns a RELEASE COMPLETE message with a cause code value of 34.

- Cause code value 44 “requested circuit or channel unavailable”

  If a SETUP message is received for a channel in the IS MTCE NE state, the *5ESS* switch returns a RELEASE COMPLETE message with a cause code value of 44.

  If a non-test call origination is sent when the B-channel is in a MTCE status, the *5ESS* switch returns a RELEASE COMPLETE message with a cause code value of 44.

- Cause code value 81 “invalid CRV”

  If a SERVICE or SERVICE ACKNOWLEDGE message with a non-global call reference value is received, the *5ESS* switch returns a STATUS message with a cause code value of 81.

- Cause code value 82 “identified channel does not exist”

  If the channel ID received in a SERVICE message is recognized as referring to an unprovisioned B-channel, the *5ESS* switch returns a STATUS message with a cause code value of 82.

  SERVICE messages are never generated by the *5ESS* switch to change the service status of Custom PRI D-channels. SERVICE messages for D-channels that are sent to the *5ESS* switch will invoke a response of a STATUS message with a cause code value of 82.

- Cause code value 96 “mandatory information element missing”

  If a SERVICE or SERVICE ACKNOWLEDGE message is received with a missing change status IE or missing channel identification IE, the *5ESS* switch returns a STATUS message with a cause code value of 96.

- Cause code value 100 “invalid information element contents”

  If a SERVICE message is received with an invalid change status or channel identification IE, the *5ESS* switch returns a STATUS message with a cause code value of 100. Invalid change status means that the change status is not one of the two recognized values (IS or OOS).

  If a solicited or unsolicited SERVICE ACKNOWLEDGE message is received with an invalid channel identification IE, the *5ESS* switch returns a STATUS message with a cause code value of 100. A SERVICE ACKNOWLEDGE message coded for the entire interface is considered an invalid channel identification IE. Changing the status of all B-channels is not valid for the SERVICE ACKNOWLEDGE message.

If a solicited SERVICE ACKNOWLEDGE message is received with a missing change status IE, the *5ESS* switch returns a STATUS message with a cause code value of 100. If a solicited SERVICE ACKNOWLEDGE message with an invalid change status IE is received, the *5ESS* switch will treat it as though the status was set to MTCE.

Note: The *5ESS* switch ignores all unsolicited SERVICE ACKNOWLEDGE messages when it is in a stable state (not waiting for ACK).

9.2.2.6 SDL Diagrams For Custom PRI B-channel Maintenance Procedures

Figure 9.2-1 is a legend for the SDL diagrams shown in this section. The following SDL diagrams describe the maintenance procedures for Custom PRI B-channels:

- Figure 9.2-2
- Figure 9.2-3
- Figure 9.2-4
- Figure 9.2-5
- Figure 9.2-6
- Figure 9.2-7.

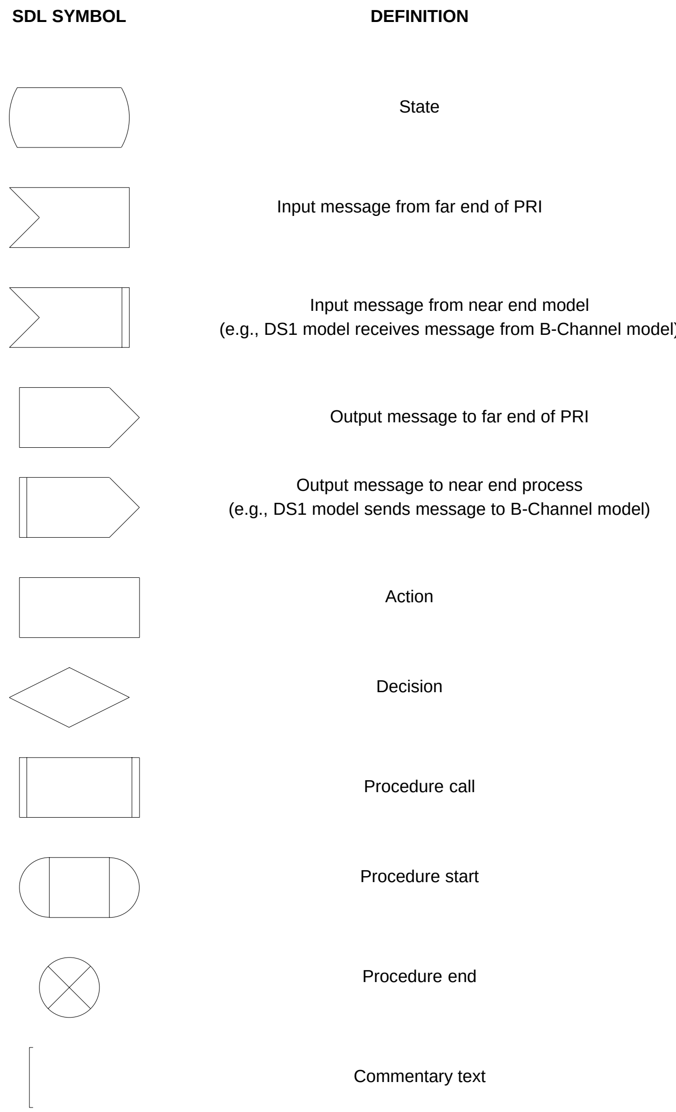


Figure 9.2-1 — Legend for SDL Diagrams: Custom ISDN PRI

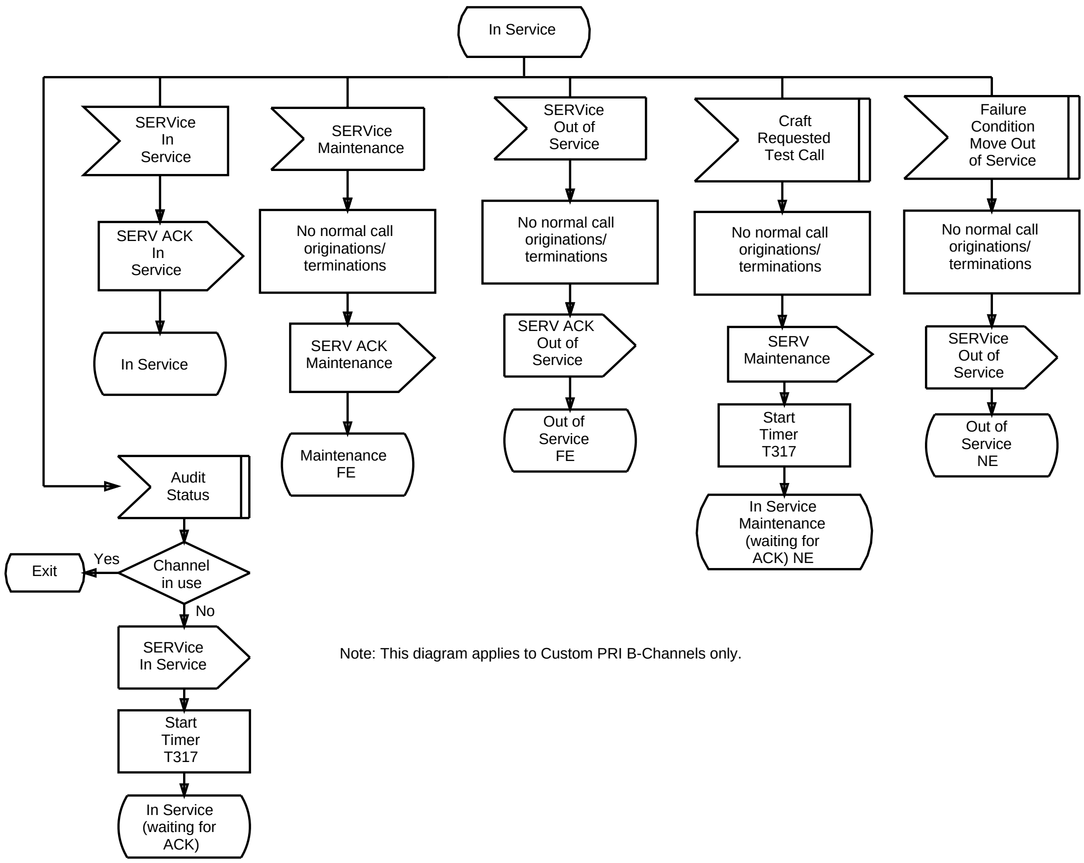
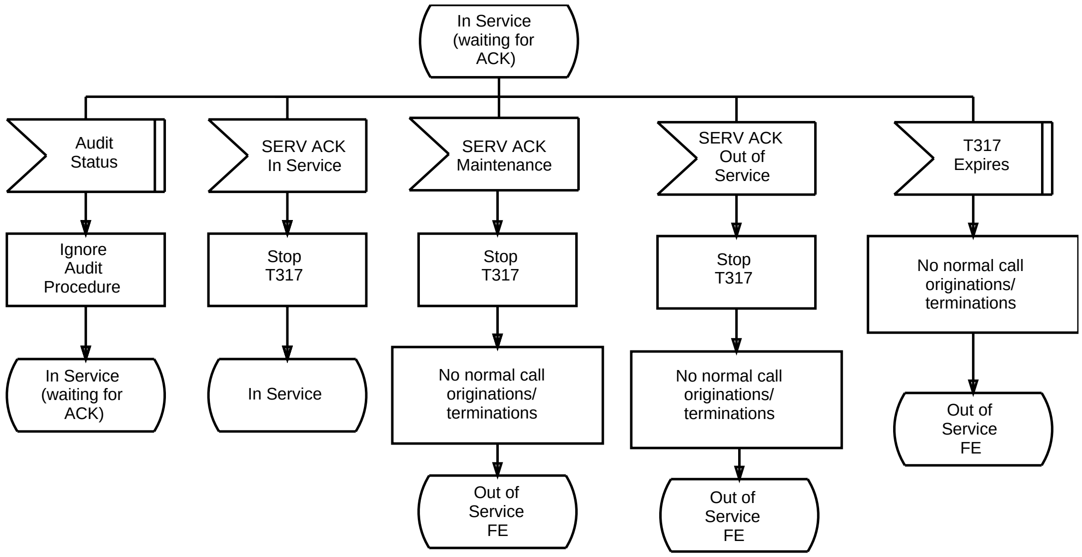
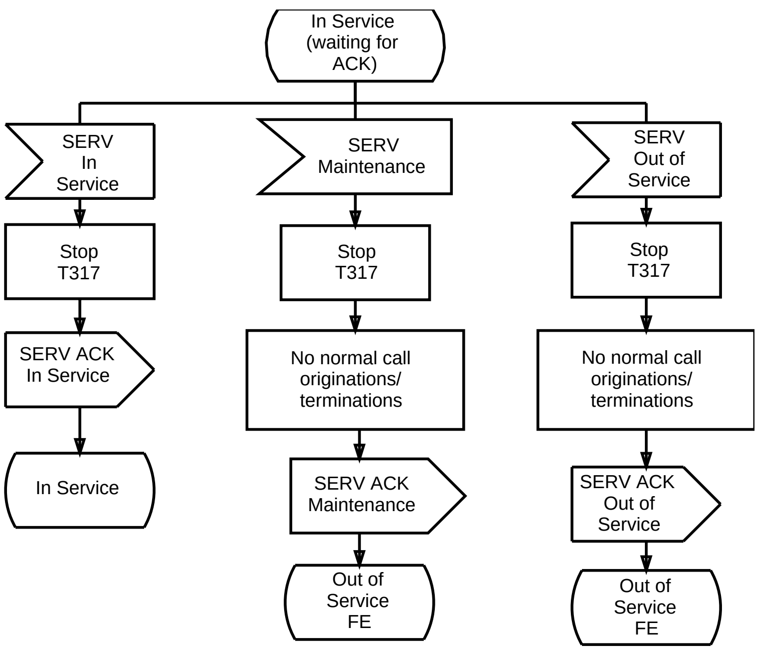


Figure 9.2-2 — Custom ISDN PRI: In Service State



Note: This diagram applies to Custom PRI B-Channels only.

Figure 9.2-3 — Custom ISDN PRI: In Service State, Waiting for ACK (1 of 2)



Note: This diagram applies to Custom PRI B-Channels only.

Figure 9.2-3 — Custom ISDN PRI: In Service State, Waiting for ACK (2 of 2)

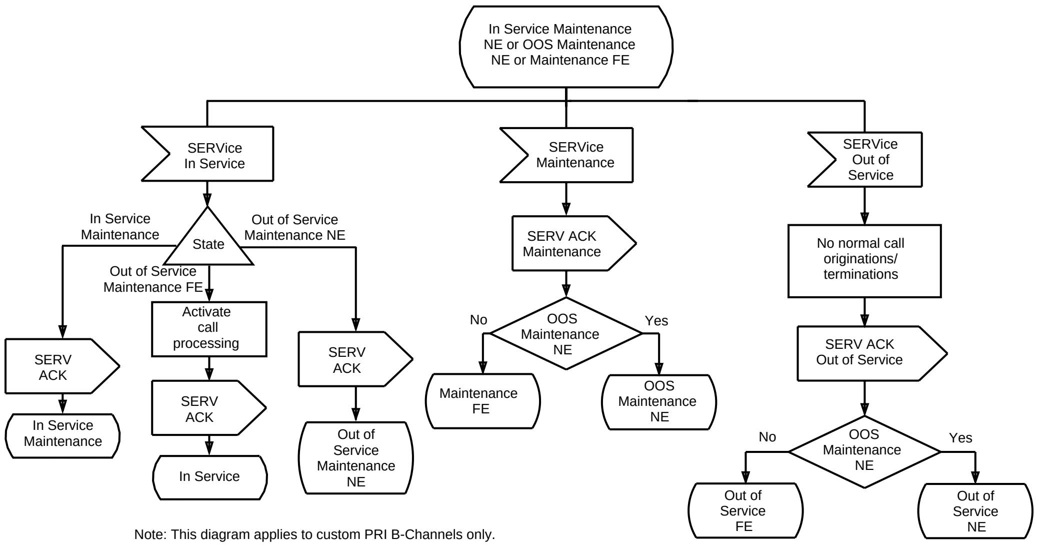


Figure 9.2-4 — Custom ISDN PRI: In Service Maintenance State (1 of 4)

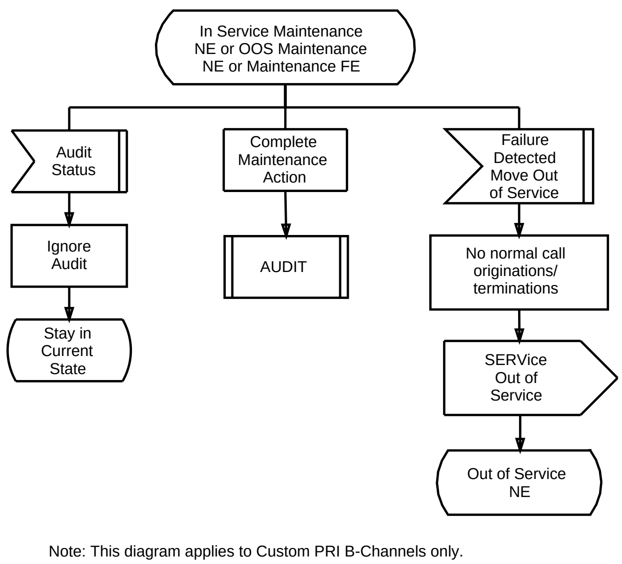
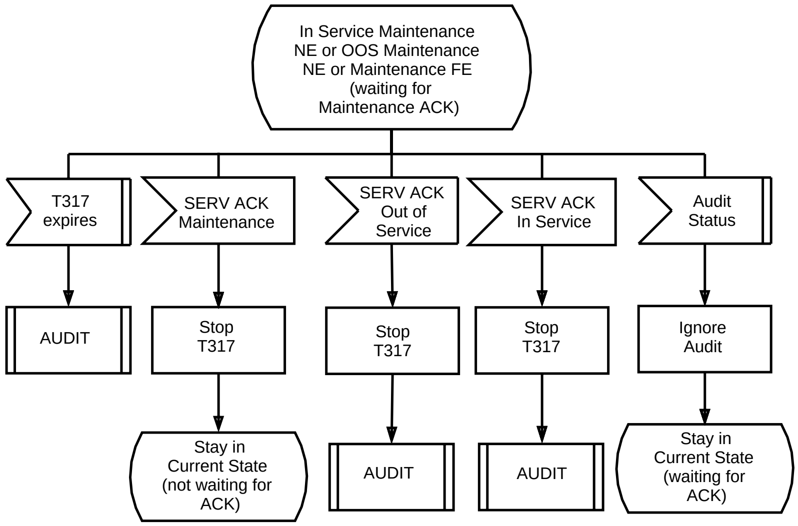
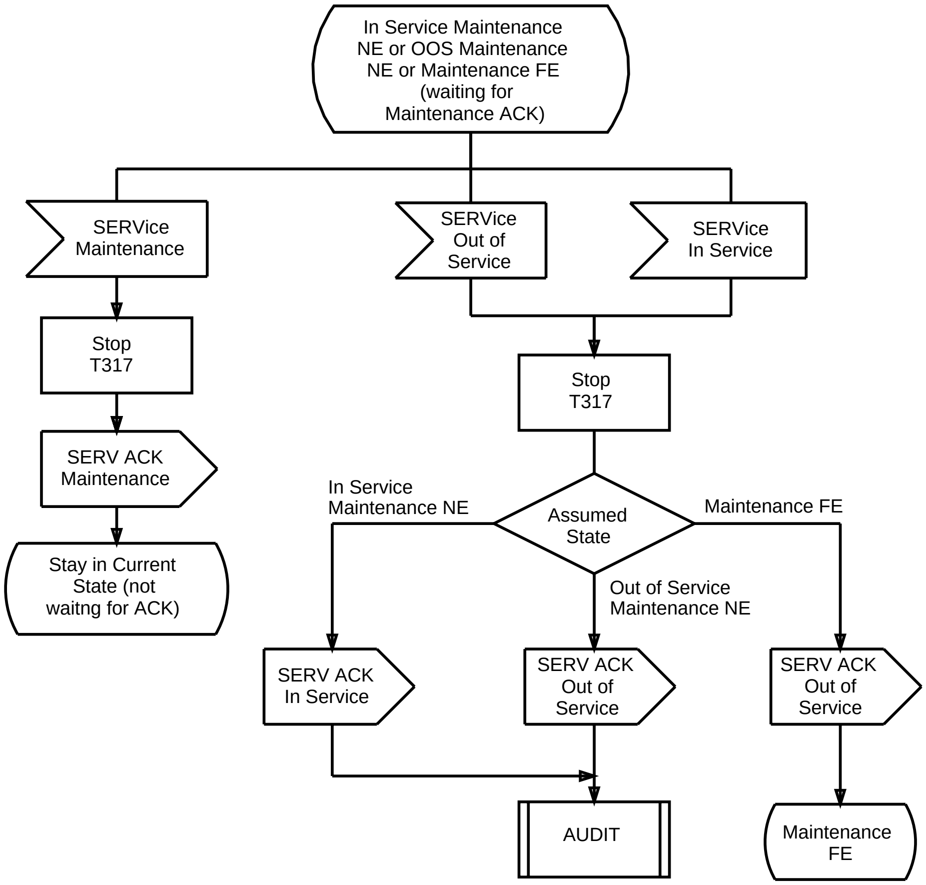


Figure 9.2-4 — Custom ISDN PRI: In Service Maintenance State (2 of 4)



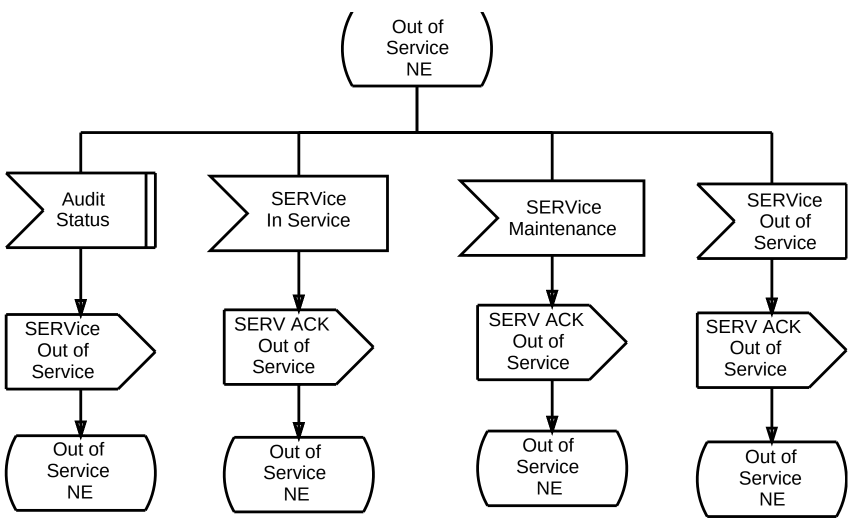
Note: This diagram applies to Custom PRI B-channels only.

Figure 9.2-4 — Custom ISDN PRI: In Service Maintenance State (3 of 4)



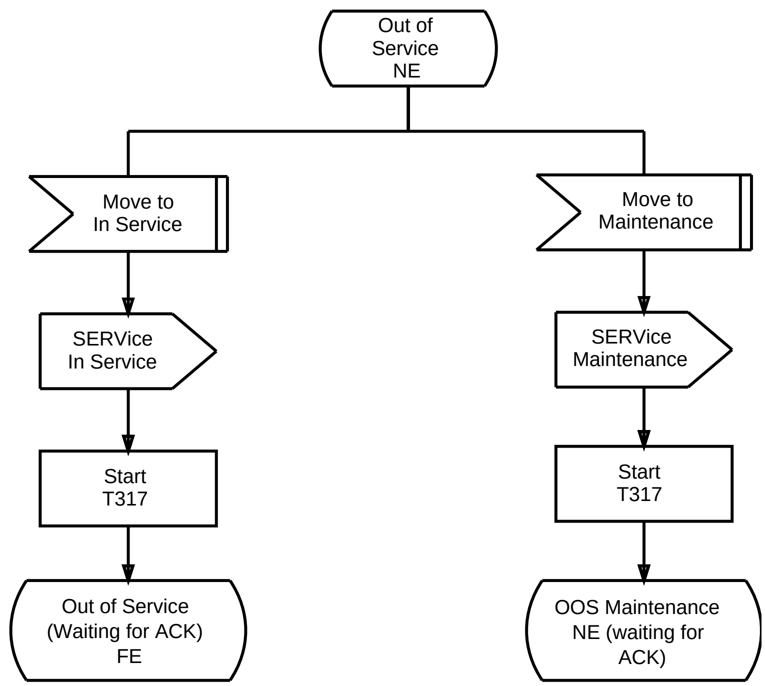
Note: This diagram applies to Custom PRI B-channels only.

Figure 9.2-4 — Custom ISDN PRI: In Service Maintenance State (4 of 4)



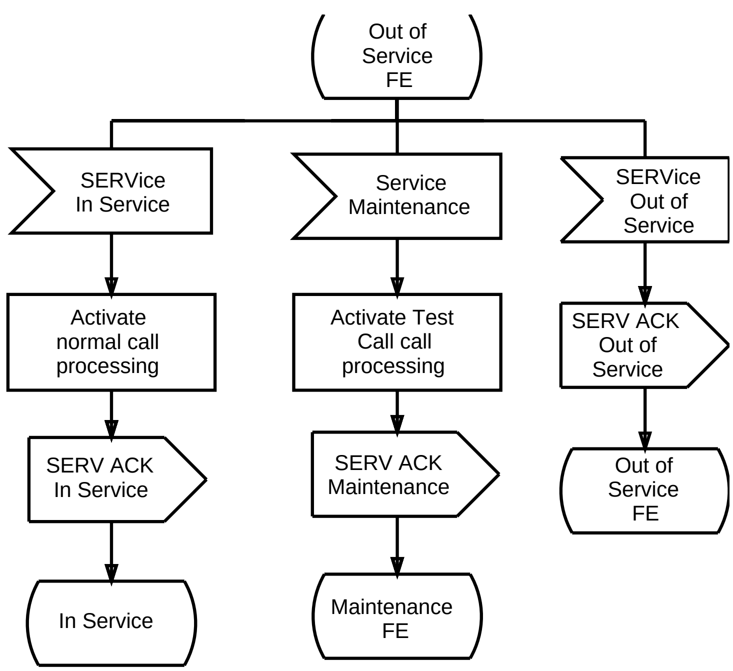
Note: This diagram applies Custom PRI to B-Channels only.

Figure 9.2-5 — Custom ISDN PRI: Out of Service State NE (1 of 2)



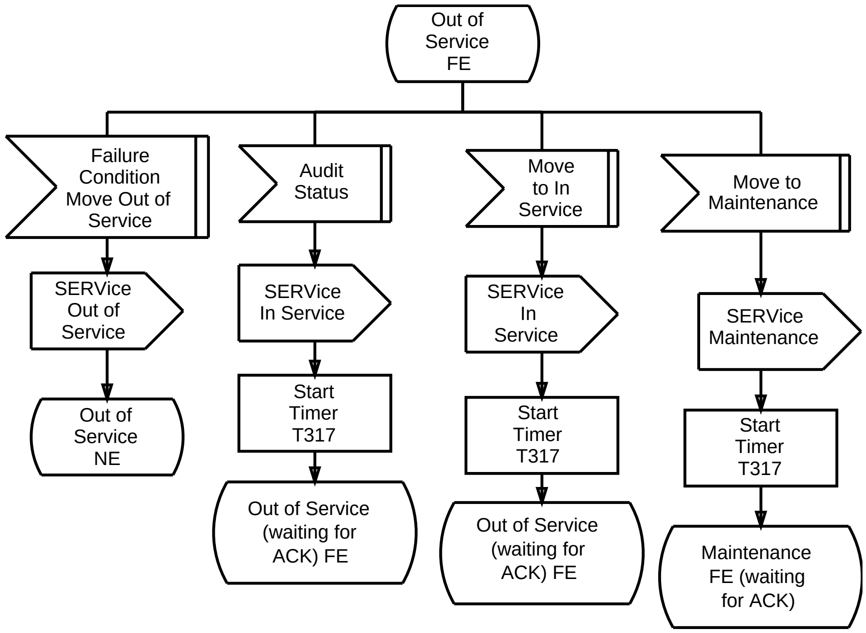
Note: This diagram applies custom PRI to B-Channels only.

Figure 9.2-5 — Custom ISDN PRI: Out of Service State NE (2 of 2)



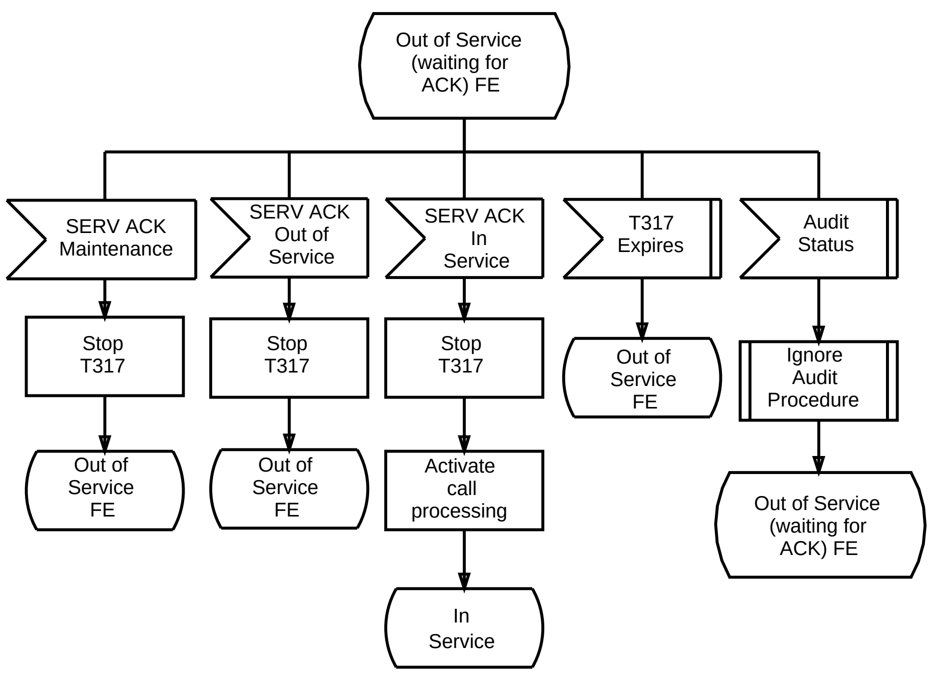
Note: This diagram applies to Custom PRI B-Channels only.

Figure 9.2-6 — Custom ISDN PRI: Out of Service State FE (1 of 4)



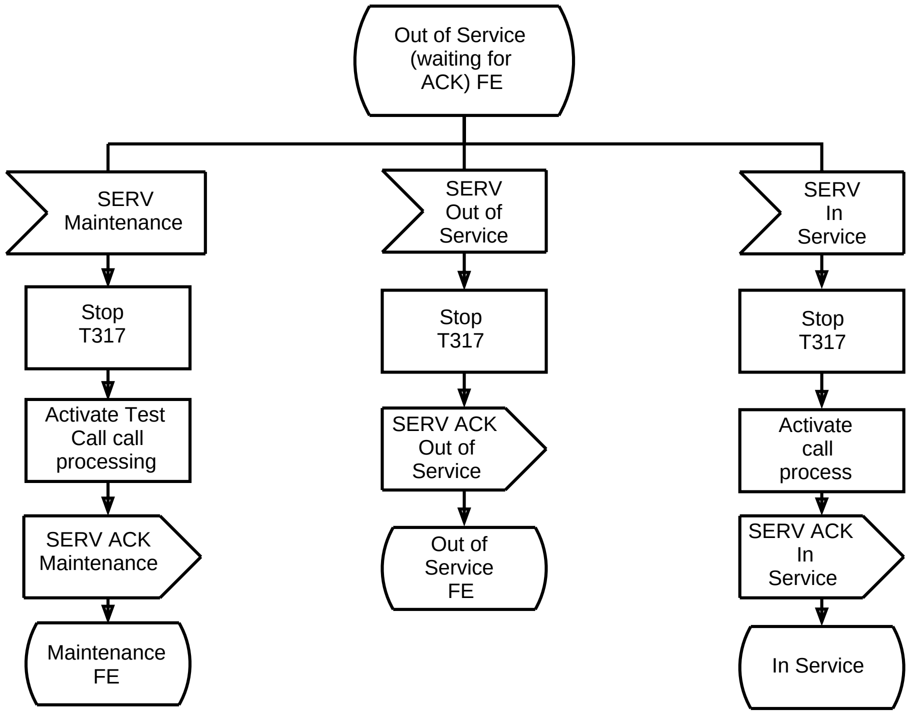
Note: This diagram applies to custom PRI B-Channels only.

Figure 9.2-6 — Custom ISDN PRI: Out of Service State FE (2 of 4)



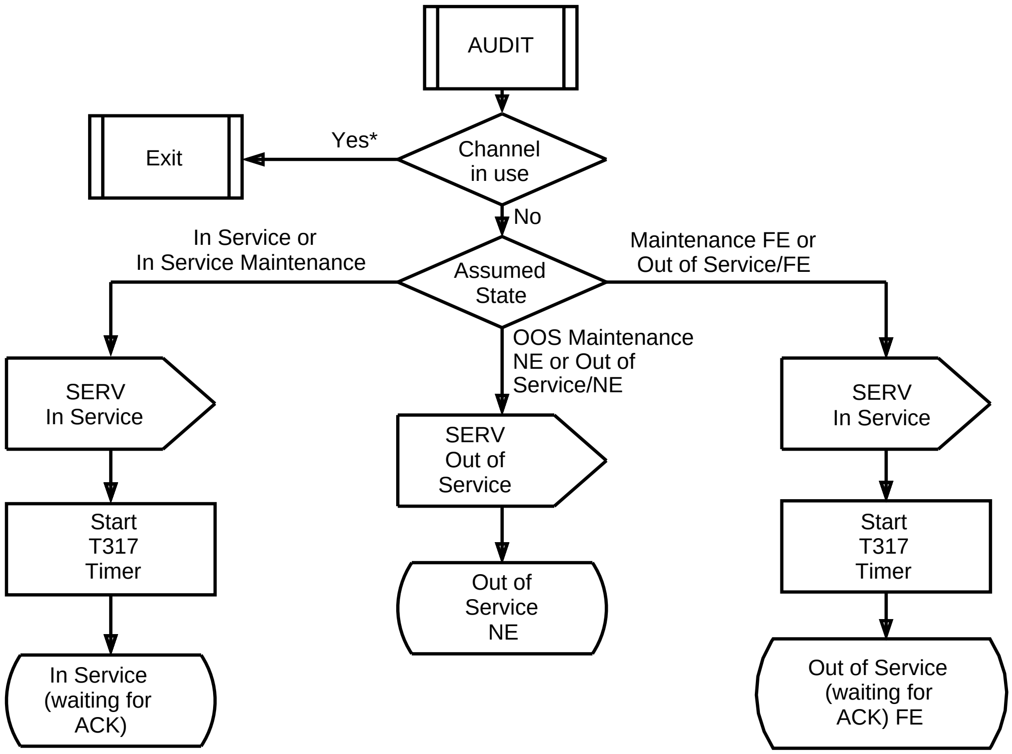
Note: This diagram applies to Custom PRI B-Channels only.

Figure 9.2-6 — Custom ISDN PRI: Out of Service State FE (3 of 4)



Note: This diagram applies to custom PRI B-Channels only.

Figure 9.2-6 — Custom ISDN PRI: Out of Service State FE (4 of 4)



* A channel is in use when:

1. A call is upon the channel.
2. Maintenance action is in progress.
3. A B-channel is waiting for a SERV ACK.

Note: This diagram applies to Custom PRI B-Channels only.

Figure 9.2-7 — Custom ISDN PRI: Audit Procedure

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9.3 NATIONAL ISDN PRI MAINTENANCE PROCEDURES

This section presents the procedures for the National ISDN PRI to be used with the maintenance messages defined in “Layer 3 Maintenance Messages,” Section 9.1.3. Since the maintenance messages are symmetric, these procedures can be initiated by either side of the interface.

9.3.1 STATES FOR NATIONAL ISDN PRI MAINTENANCE PROCEDURES

The B-channel states, as implemented by the *5ESS*® switch for the National ISDN PRI maintenance procedures are as follows:

- In Service (IS)
- In Service, Waiting for SERV ACK

  Note: In Service, Waiting for SERV ACK is implemented only during an audit and is, therefore, invisible to the Far End.

- Out of Service (OOS) Near End
- Out of Service Far End—RESTART
- Out of Service Far End—RESTART IN PROGRESS (IP)

  Note: The Out of Service Far End—RESTART IP state is represented in Figure 9.3-24 as “Out of Service—Waiting for B-Chan REST ACK FE.”

As an aid to implementation, the OOS category is divided into NE and FE subcategories that signify whether the state was requested by the local system (NE) or the system on the other end of the interface (FE). The OOS NE state is entered by either a technician’s command to the *5ESS* switch to remove the B-channel port or a hardware/software fault involving the B-channel. Newly provisioned B-channels on the *5ESS* switch are initially placed in the OOS NE state.

In addition, if PRI B-channel Availability Signaling Procedures are not provisioned, the OOS FE subcategory consists of the following states:

- OOS FE—RESTART, entered when the *5ESS* switch fails to receive a RESTART ACKNOWLEDGE message after sending two or more RESTART messages.
- OOS FE—RESTART IP, when the B-channel is OOS and waiting for a RESTART ACKNOWLEDGE.
- OOS FE, when the B-channel is OOS due to a request from the FE.

The *5ESS* switch allows the following call types on B-channels:

- Normal and test call originations and terminations on B-channels in the IS state.
- Test call originations and terminations on B-channels in the OOS NE state, entered using technician action. (These are the only call types allowed on B-channels in the OOS NE state.)
- Test call originations on B-channels in the OOS-FE state.

The *5ESS* switch does not allow any call originations or terminations on a B-channel in any of the following states:

- OOS NE state, entered using hardware/software fault.
- OOS FE—RESTART state, if PRI B-channel Availability Signaling Procedures are not provisioned.

- OOS FE—RESTART IP state.

The National ISDN PRI D-channel without D-channel backup is controlled by Layer 2 messages or by technician action. The D-channel states defined by Bellcore for the D-channel without backup are IS, OOS, and manual out of service (MOOS). Additional D-channel states defined by Bellcore for the PRI with D-channel backup are maintenance busy (MB), standby (STBY), and WAIT. In addition, the discussion of D-channel backup in this specification uses a set of states implemented by the *5ESS* switch grouped under the name automatic out of service (AOOS) for convenience. See "D-channel States," Section 10.2, for further information.

9.3.2 B-CHANNEL MAINTENANCE PROCEDURES FOR NATIONAL ISDN PRI

The valid transitions among the various B-channel states, if PRI B-channel Availability Signaling Procedures are not provisioned, are shown in Figures 9.3-2, 9.3-3, 9.3-4, 9.3-5. The valid transitions among the various B-channel states, if PRI B-channel Availability Signaling Procedures are provisioned, are shown in the following figures:

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If PRI B-channel Availability Signaling Procedures are not provisioned, the concept of transitioning from a more available state to a less available state does not apply to the National ISDN PRI B-channel, because SERVICE and SERVICE ACKNOWLEDGE messages are not used; the RESTART message is used to bring the National ISDN PRI B-channel IS. The RESTART ACKNOWLEDGE message is used to notify the FE that the local system has received a RESTART message. RESTART and RESTART ACKNOWLEDGE messages are not used to take the B-channels OOS.

If PRI B-channel Availability Signaling Procedures are not provisioned, the switch will not notify the FE when a National ISDN B-channel is removed from service. If PRI B-channel Availability Signaling Procedures are provisioned, SERVICE and SERVICE ACKNOWLEDGE messages accomplish this status change; otherwise, no message is sent. In either case, the FE will continue to keep the B-channel IS, potentially routing calls that fail on the *5ESS* switch due to an OOS state.

If PRI B-channel Availability Signaling Procedures are not provisioned, the following procedures apply to the B-channel, depending on its state:

- If the B-channel is in OOS FE—RESTART IP when it receives a RESTART message, it sends a RESTART ACKNOWLEDGE and continues waiting for a RESTART ACKNOWLEDGE before going IS.
- If the B-channel is in OOS FE—RESTART when it receives a RESTART message, it must go through RESTART procedures initiated by the NE in order to be placed IS.

See Figure 9.3-3 for more information.

9.3.2.1 RESTART Message Sent by *5ESS* Switch

The *5ESS* switch sends a RESTART message to clear a call on the FE, or to inform the FE that the B-channel is IS. It also sends a DS1 RESTART during PRI initialization if PRI B-channel Availability Signaling (BCAS) Procedures are provisioned. See Figures 9.3-8, 9.3-9, 9.3-10, 9.3-14 and 9.3-15 for further information. The *5ESS* switch never generates a RESTART message that applies to the entire PRI group, and never sends a RESTART for a DS1 if PRI B-channel Availability Signaling Procedures are not provisioned.

When the switch sends a RESTART message, Timer T316 is started. Timer T316 is *5ESS* switch-provisionable, ranging from 10 seconds to 120 seconds in 10-second increments, and its default value is 30 seconds. For a DS1 RESTART (sent to initialize the DS1 during PRI initialization), if no RESTART ACKNOWLEDGE message is received before Timer T316 expires, the switch will instead initialize each individual B-channel on the DS1. For a B-channel RESTART, if no RESTART ACKNOWLEDGE message is received before Timer T316 expires, then the switch retransmits the RESTART message. If Timer T316 expires for a second time, B-channel transitioning depends on whether PRI B-channel Availability Signaling Procedures are provisioned:

- If PRI B-channel Availability Signaling Procedures are not provisioned, the B-channel transitions to the OOS FE—RESTART state. Here, a RESTART message will be sent periodically to determine when the FE is able to communicate. See Figures 9.3-3 and 9.3-3 for further information.
- If PRI B-channel Availability Signaling Procedures are provisioned, the B-channel remains OOS FE, and periodic service audits attempt to bring the channel back into service. See Figures 9.3-17 and 9.3-24 for further information.

In either case, once the NE receives a RESTART ACKNOWLEDGE message, Timer T316 is stopped and the B-channel transitions to the IS state.

9.3.2.2 RESTART Message Received by *5ESS* Switch

The *5ESS* switch can receive a RESTART message that applies to a single B-channel, the entire DS1 facility, or the entire PRI group. If the switch receives a RESTART message coded for a single B-channel that is IS, the switch clears any call on that channel and sends a RESTART ACKNOWLEDGE message. If PRI B-channel Availability Signaling Procedures are not provisioned, refer to Figures 9.3-2 and 9.3-3 for further information. If PRI B-channel Availability Signaling Procedures are provisioned, refer to Figures 9.3-20, 9.3-21, 9.3-22, 9.3-23, and 9.3-24.

If the *5ESS* switch receives a RESTART message coded for the entire DS1 facility, the RESTART message acts as a call control message, clearing all calls on the facility that belong to the PRI group and sending one RESTART ACKNOWLEDGE message for the entire DS1 facility, if PRI B-channel Availability Signaling Procedures are not provisioned. See Figure 9.3-4. If PRI B-channel Availability Signaling Procedures are provisioned, all calls on the facility that belong to the PRI group are cleared, a SERV(OOS) message is sent for each B-channel that cannot be brought into service, and one RESTART ACKNOWLEDGE message for the entire DS1 facility is sent. See Figures 9.3-11 and 9.3-12.

If the *5ESS* switch receives a RESTART message coded for the entire PRI group, the RESTART message acts as a call control message, clearing all calls on the PRI group and sending one RESTART ACKNOWLEDGE message for the entire PRI group, if PRI B-channel Availability Signaling Procedures are not provisioned here, no B-channel states throughout the entire facility/group will change. This is shown in Figure 9.3-4. If PRI B-channel Availability Signaling Procedures are provisioned, all calls that belong to the PRI group are cleared, a SERV(OOS) message is sent for each B-channel that cannot be brought into service, and one RESTART ACKNOWLEDGE message for the entire PRI group is sent. For further information, refer to Figures 9.3-7, 9.3-11, 9.3-12 and 9.3-22.

9.3.2.3 Test Calls on the National ISDN PRI with or without BCAS

Test calls are diagnostic calls placed to prespecified numbers across the user-network interface. For the National ISDN PRI, test calls are originated by sending a SETUP message to a valid test directory number; no SERVICE message is used. Normal call processing procedures apply for the SETUP message (see Section 4). These procedures include coding of a valid service in the network specific facilities IE in the SETUP message whenever a call-by-call PRI is used.

Test calls may be placed when normal outgoing traffic is barred, and are identified by Call Type, using digit analysis. Collisions between SETUP messages for test calls follow normal glare procedures.

Test calls for the National ISDN PRI can be originated and terminated on a B-channel that is in the In Service state. See Figure 9.3-20.

Test calls can be made as follows on a B-channel that is in an Out of Service state. The switch can initiate a test call by sending a SETUP message under any one of the following conditions:

- The B-channel was manually removed by the technician.
- The B-channel is in a Circuit Administration (CADN) state.
- The B-channel is in a Locked Out (LKDO) state.

The switch can accept a SETUP message for a test call on an OOS B-channel that has been manually removed to a LKDO state. The switch will not accept a SETUP message in any other OOS state. See Figures 9.3-21, 9.3-22, 9.3-23, and 9.3-24.

9.3.2.4 RESTART Procedures for NxDS0 Calls

If a PRI group (or DS1 facility) with NxDS0 calls receives a RESTART message from the FE for the PRI group (or DS1 facility), a RESTART ACKNOWLEDGE message is sent with the same PRI group (or DS1 facility) to the FE. All calls are cleared, but the B-channel states are not changed, as shown in Figure 9.3-5.

The *5ESS* switch sends a RESTART message to clear an NxDS0 call at the FE when call clearing fails. See “RESTART/RESTART ACKNOWLEDGE Procedures,” Section 5.2.2, for call control procedures. If the RESTART procedure for a channel fails, that channel will be removed to an OOS FE state.

The first RESTART message contains the channel number of lowest NxDS0 channel. The lowest NxDS0 channel transitions to the OOS FE (waiting for ACK) state. All other channels are marked OOS FE (restart). Timer T316 is started, as shown in Figure 9.3-5. If a RESTART ACK is received for the lowest NxDS0 channel, before the expiry of T316, all of the NxDS0 channels are placed IS (idle). RESTART ACK messages received for a nonlowest NxDS0 channel are discarded. When T316 expires the first time, the channels remain in their current state, a RESTART is resent on the lowest NxDS0 channel, and T316 is restarted. If T316 expires the second time, the lowest NxDS0 channel transitions to the OOS FE RESTART state; all others are marked OOS FE (waiting for ACK) and RESTART messages are sent for the remaining channels on the call. Timer T316 is restarted and this procedure is repeated. If Timer T316 expires twice for any of the remaining NxDS0 channels, the channels are marked OOS FE RESTART.

9.3.2.5 SERVICE and SERVICE ACKNOWLEDGE Messages with PRI B-channel Availability Signaling Procedures Provisioned

Either end of the interface may attempt to change the agreed-upon status of the B-channel by sending a SERVICE message that contains a Change Status Information Element (IE) indicating the desired status, either In Service (IS) or Out of Service (OOS).

Note: The *5ESS* switch moves a B-channel to IS using only a DS1 or B-channel RESTART and RESTART ACKNOWLEDGE message exchange, except for a service audit.

Each end keeps track internally of whether an OOS status is due to a near end condition (OOS/NE) or a far end condition (OOS/FE). When a SERVICE message is received, the receiving end returns a SERVICE ACKNOWLEDGE message that contains a change status IE. Only if both the SERVICE and SERVICE ACKNOWLEDGE messages indicate the status is IS, the B-channel is moved to IS; if either end indicates the status is OOS, the B-channel remains OOS.

An active call is not affected by a status change; only future calls are affected.

Timer T323 is used to time for SERVICE ACKNOWLEDGE messages for National ISDN B-channels. Timer T323 is started when a SERVICE message is sent with a change status IE coded with In Service, and can be retired by receipt of a SERVICE or SERVICE ACKNOWLEDGE message, or by an internal message from the near end, such as a technician request or failure condition.

Note: When the B-channel enters the OOS NE state, a SERVICE message with a change status IE coded with Out of Service is sent, but Timer T323 is not started; the B-channel remains in the OOS NE state.

For additional information about SERVICE and SERVICE ACKNOWLEDGE messages and procedures, refer to the following sections:

- "SERVICE Messages Sent by *5ESS* Switch," Section 9.2.2.1
- "SERVICE Messages Received by *5ESS* Switch," Section 9.2.2.2
- "Relationship of Service Status to Call Processing State," Section 9.2.2.4.

9.3.2.6 Cause Codes Invoked by National ISDN PRI B-channel Maintenance Procedures

The following cause codes may be produced during execution of the National ISDN PRI B-channel restart procedures.

- Cause code value 34 "no circuit or channel available"

  If a SETUP message is received for a B-channel in the OOS FE state, then the *5ESS* switch returns a RELEASE COMPLETE message coded with a cause code value of 34.

- Cause code value 44 "requested circuit or channel unavailable"

  If a SETUP message is received for a IS B-channel that has a test call present or if the B-channel is in the OOS NE state, then the switch returns a RELEASE COMPLETE message coded with a cause code value of 44.

- Cause code value 81 "invalid call reference value"

  If a RESTART or RESTART ACKNOWLEDGE message that does not contain a global call reference value is received, then the switch returns a STATUS message coded with a cause code value of 81.

- Cause code value 82 "identified channel does not exist"

  If a RESTART or RESTART ACKNOWLEDGE message is received containing a restart indicator of single channel and a channel identification IE that does not contain a valid channel number coding, then the switch returns a STATUS message coded with a cause code value of 82.

  If a RESTART or RESTART ACKNOWLEDGE message is received containing a restart indicator of single channel and a channel identification IE that indicates an unprovisioned channel, then the switch returns a STATUS message coded with a cause code value of 82.

  If a RESTART or RESTART ACKNOWLEDGE message is received containing a restart indicator of single channel and a channel identification IE that indicates a channel that is not a PRI B-channel, then the switch returns a STATUS message coded coded with a cause code value of 82.

- Cause code value of 96 "mandatory information is missing"

  If a RESTART message is received containing a restart indicator of single channel or single interface and a channel identification IE that is not populated, then the switch returns a STATUS message coded with a cause code value of 96.

If a RESTART ACKNOWLEDGE message is received containing a restart indicator of single channel and a channel identification IE that is not populated, then the switch returns a STATUS message coded with a cause code value of 96.

If a RESTART or RESTART ACKNOWLEDGE message is received with the restart indicator IE not populated, then the switch returns a STATUS message coded with a cause code value of 96.

If a RESTART or RESTART ACKNOWLEDGE message is received without the restart indicator IE populated, or with a mandatory IE missing, then the switch returns a STATUS message coded with a cause code value of 96.

- Cause code value 100 “invalid information element contents”

  If a RESTART or RESTART ACKNOWLEDGE message that contains an invalid restart indicator is received, then the switch returns a STATUS message coded with a cause code value of 100.

  The following cause codes may be produced during execution of the National ISDN PRI B-channel Availability Signaling Procedures.

  — Cause code value 81 “invalid call reference value”

    If a SERVICE or SERVICE ACKNOWLEDGE message that contains a non-global call reference value is received (the value is associated with a call), then the switch returns a STATUS message coded with both the call reference value received and a cause code value of 81.

  — Cause code value 82 “identified channel does not exist”

    If the channel identification IE received in a SERVICE message is recognized as referring to an unprovisioned, unadministered B-channel, then the switch returns a STATUS message coded with both a global call reference value and a cause code value of 82.

  — Cause code value of 96 “mandatory information is missing”

    If a SERVICE or SERVICE ACKNOWLEDGE message that contains no change status IE or contains no channel identification IE is received, then the switch returns a STATUS message coded with both a global call reference value and a cause code value of 96.

  — Cause code value 100 “invalid information element contents”

    If a SERVICE or SERVICE ACKNOWLEDGE message is received, in which either the change status IE or the channel identification IE contains invalid contents, then the switch returns a STATUS message coded with both a global call reference value and a cause code value of 100.

9.3.2.7 SDL Diagrams for National ISDN PRI B-channel Maintenance Procedures

SDL diagrams in Figures 9.3-2, 9.3-3, 9.3-3, 9.3-4, 9.3-5, and 9.3-5 describe the maintenance procedures for National ISDN PRI B-channels if PRI B-channel Availability Signaling Procedures are not provisioned. These diagrams are interpreted by the legend provided in Figure 9.3-1.

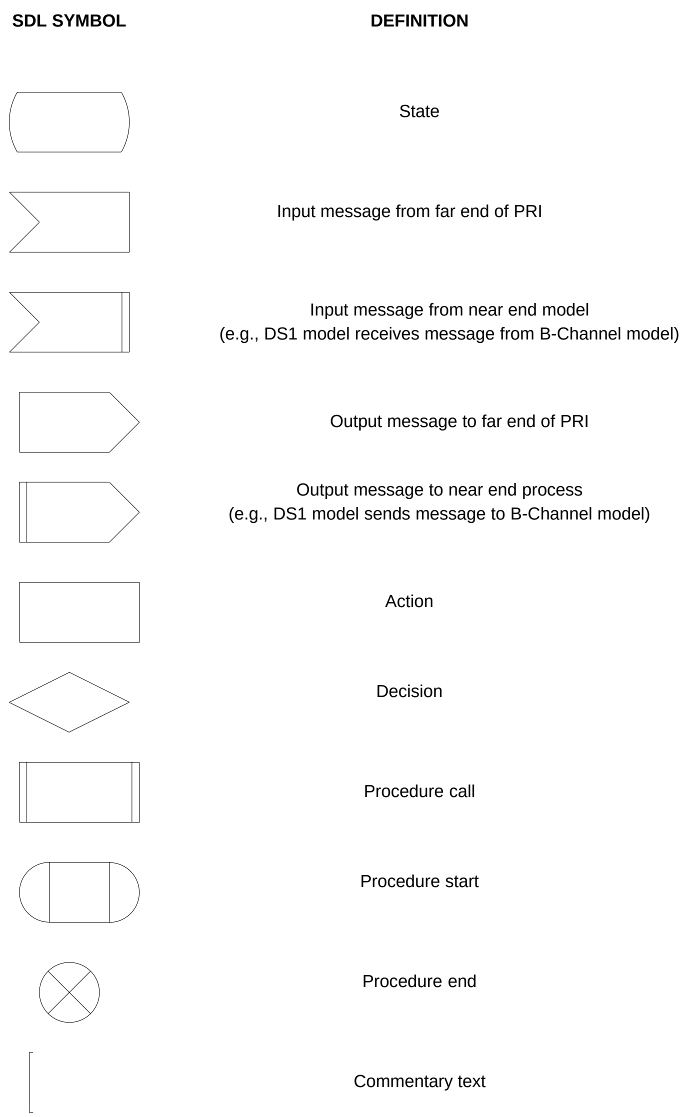
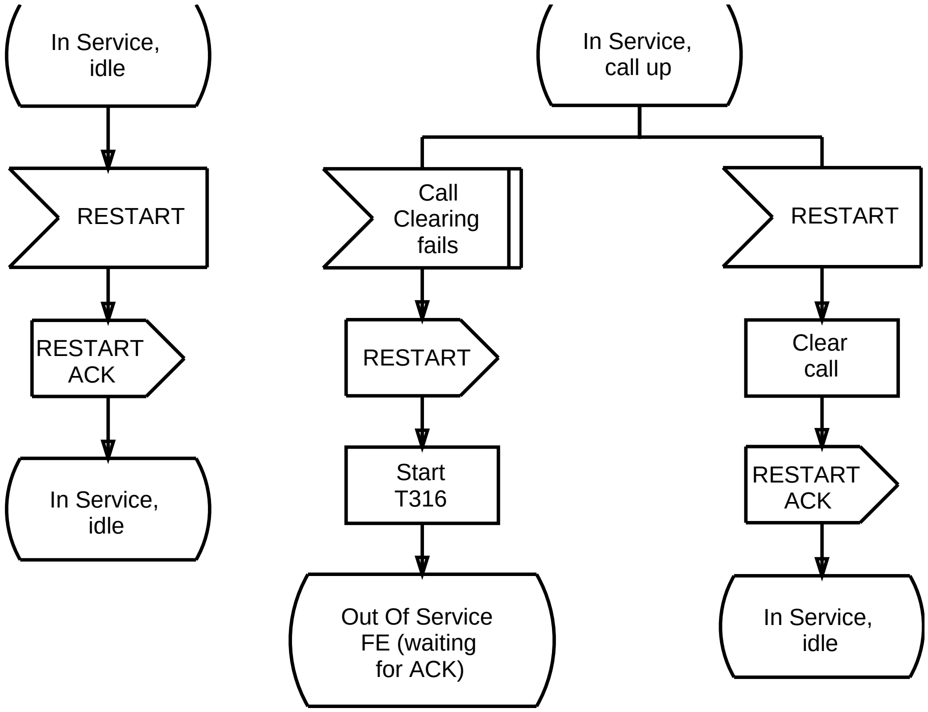
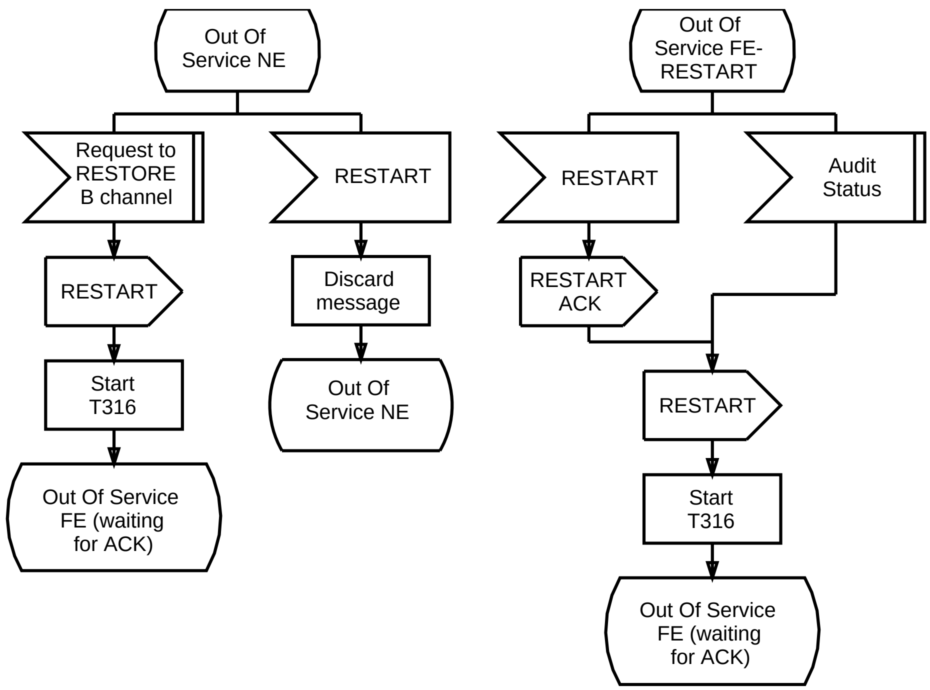


Figure 9.3-1 — Legend for SDL Diagrams: National ISDN PRI without BCAS



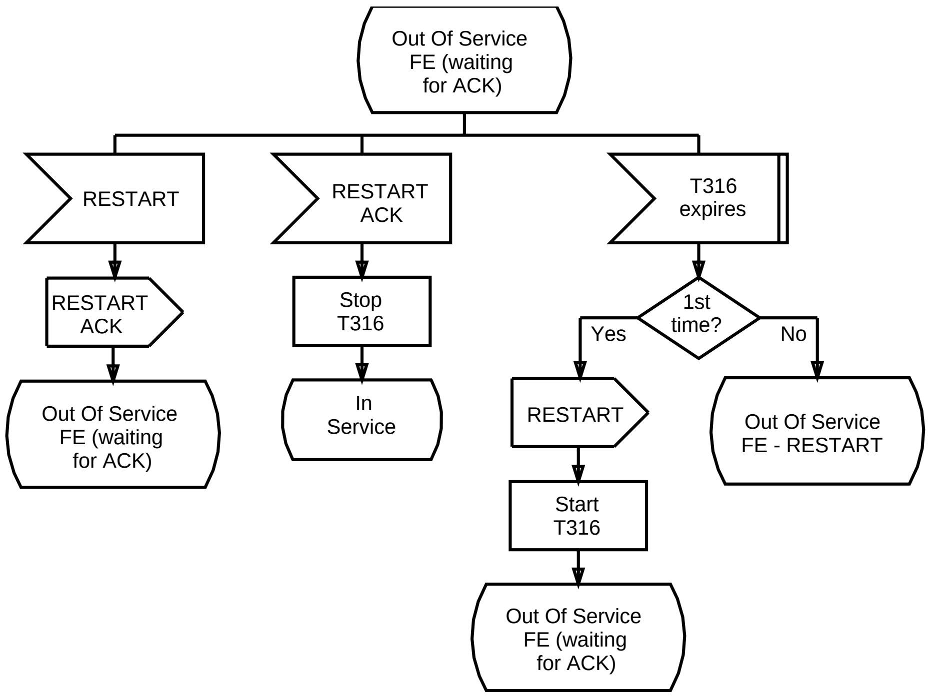
Note: This diagram applies to National ISDN PRI B-Channels only.

Figure 9.3-2 — National ISDN PRI without BCAS: In Service State



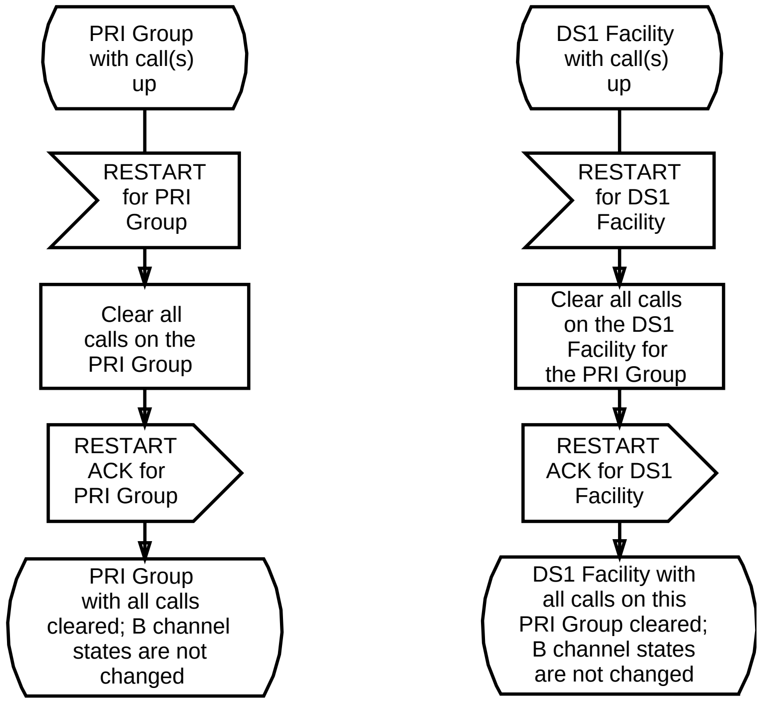
Note: This diagram applies to National ISDN PRI B-Channels only.

Figure 9.3-3 — National ISDN PRI without BCAS: Out of Service State (1 of 2)



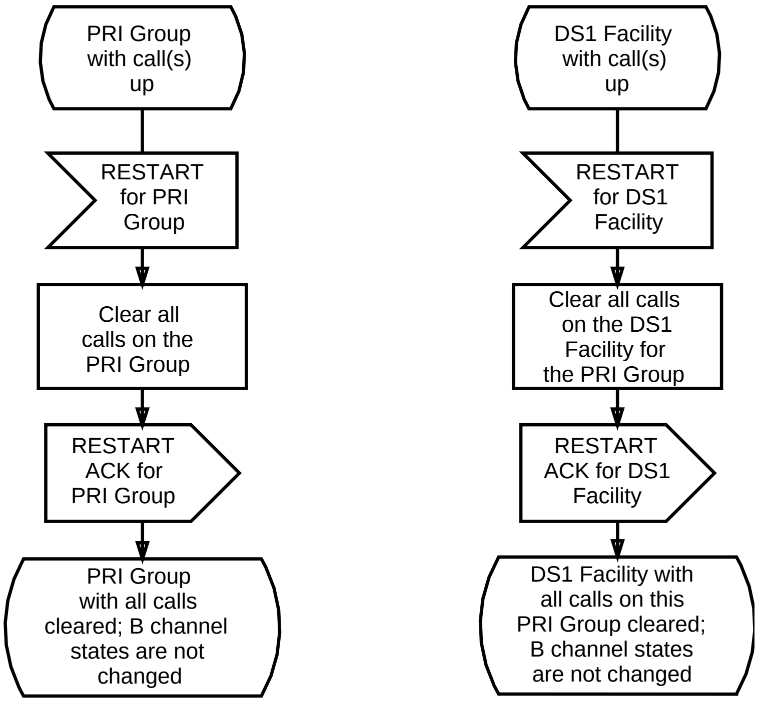
Note: This diagram applies to National ISDN PRI B-Channels only.

Figure 9.3-3 — National ISDN PRI without BCAS: Out of Service State (2 of 2)



Note: This diagram applies to National ISDN PRI B-Channels only.

Figure 9.3-4 — National ISDN PRI without BCAS: PRI Group and DS1 Facility, with Call Up



Note: This diagram applies to National ISDN PRI B-Channels only.

Figure 9.3-5 — National ISDN PRI without BCAS: NxDS0 Calls, RESTART (1 of 2)

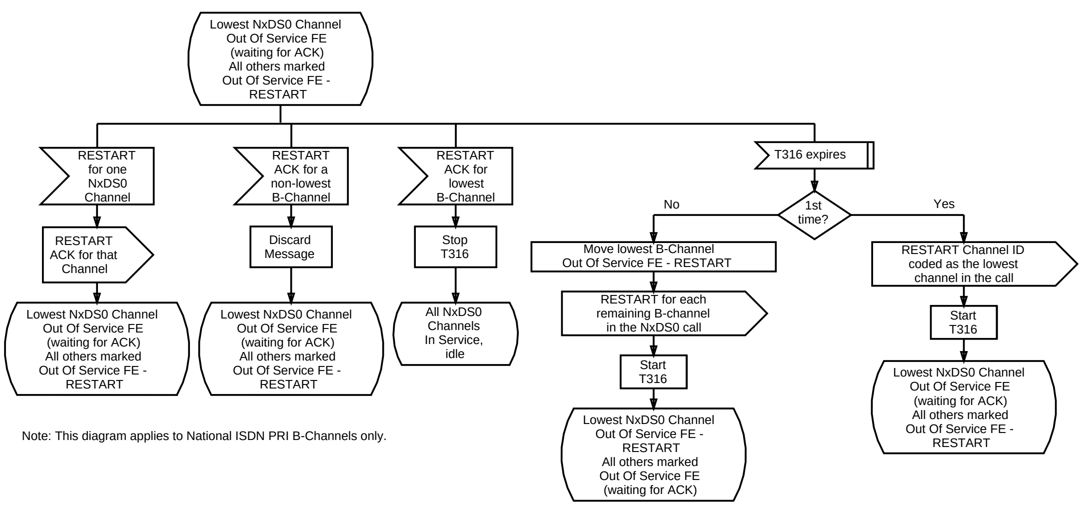


Figure 9.3-5 — National ISDN PRI without BCAS: NxDS0 Calls, RESTART (2 of 2)

The following figures, interpreted by the legend provided in Figure 9.3-6, describe the maintenance procedures for National ISDN PRI B-channels where PRI B-channel Availability Signaling Procedures are provisioned:

- Figure 9.3-7

- Figure 9.3-8
- Figure 9.3-9
- Figure 9.3-10
- Figure 9.3-11
- Figure 9.3-12
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- Figure 9.3-24

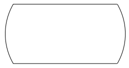
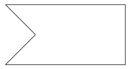
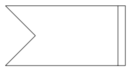
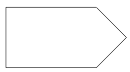
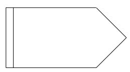
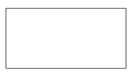
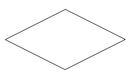
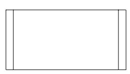
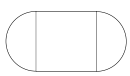
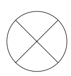
SDL SYMBOL	DEFINITION
	State
	Input message from far end of PRI
	Input message from near end model (e.g., DS1 model receives message from B-Channel model)
	Output message to far end of PRI
	Output message to near end process (e.g., DS1 model sends message to B-Channel model)
	Action
	Decision
	Procedure call
	Procedure start
	Procedure end
	Commentary text

Figure 9.3-6 — Legend for SDL Diagrams: National ISDN PRI with BCAS

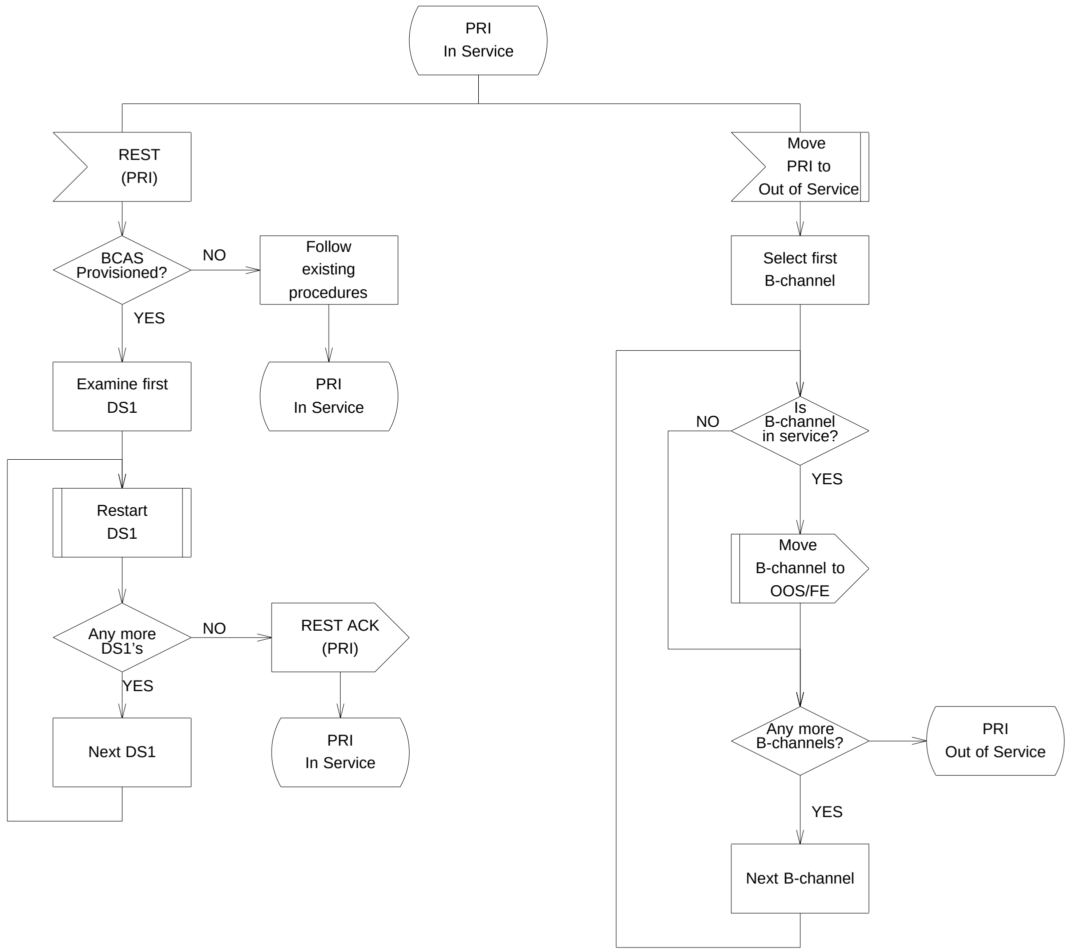


Figure 9.3-7 — National ISDN PRI with BCAS: In Service State

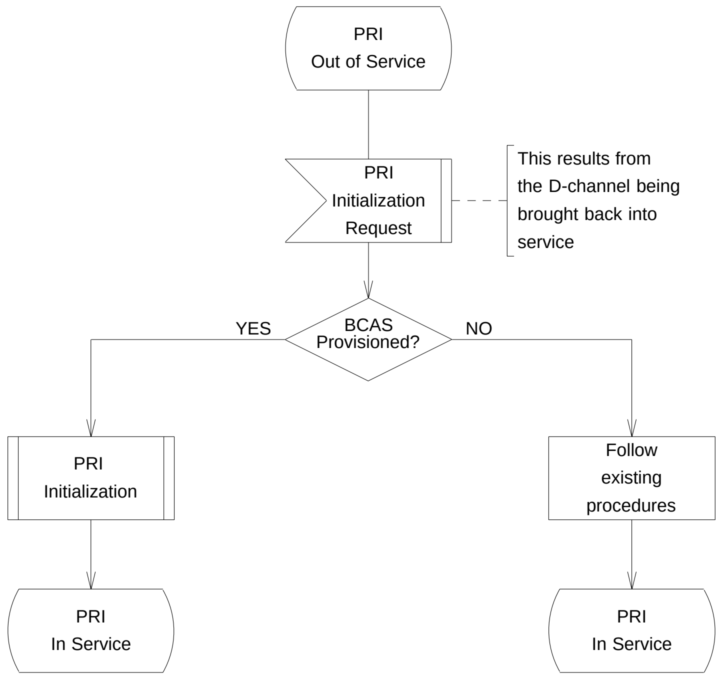


Figure 9.3-8 — National ISDN PRI with BCAS: Out of Service State

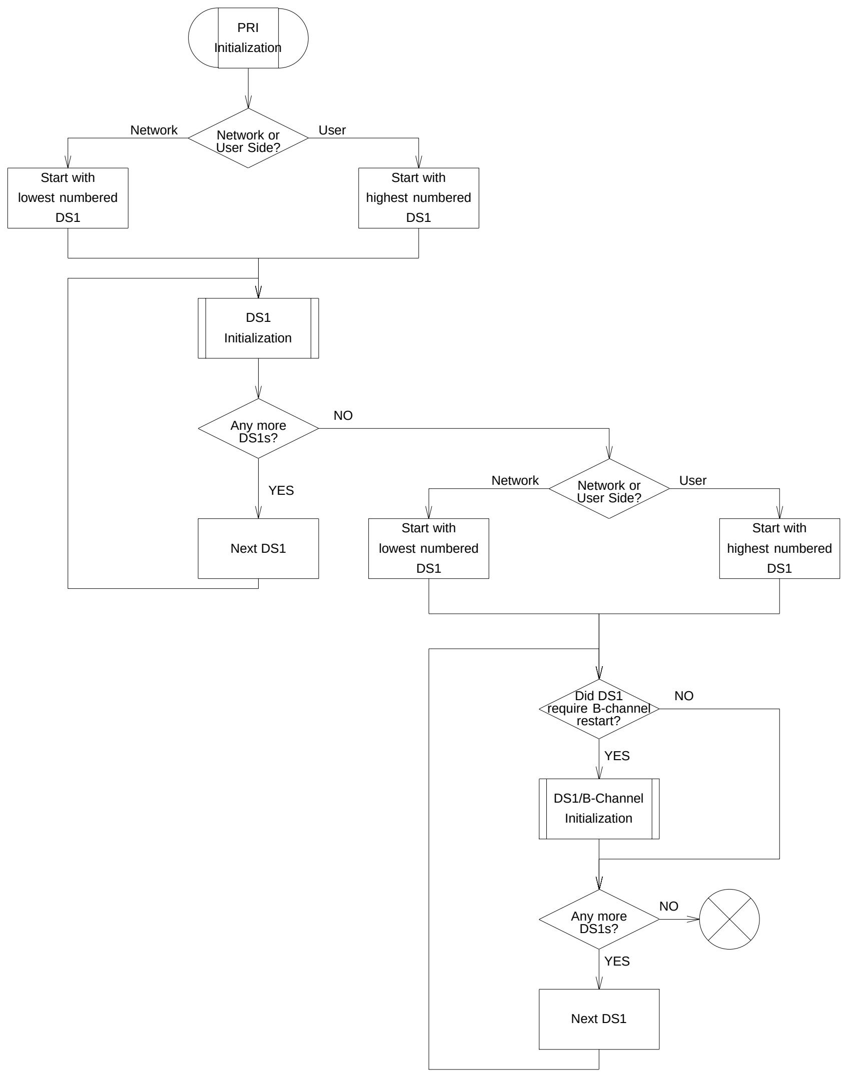
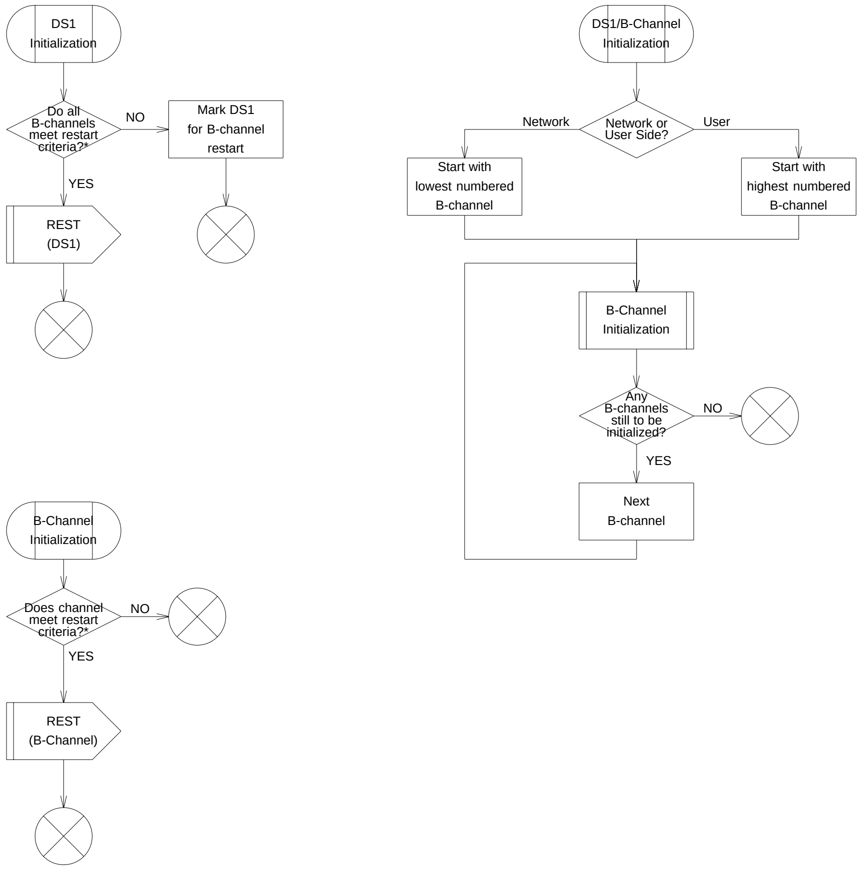


Figure 9.3-9 — National ISDN PRI with BCAS: Initialization Procedure



A B-channel meets restart criteria if any of the following are true:
a) the B-channel is in service without a call
b) the B-channel is OOS due to the far end
c) the B-channel is OOS undergoing restart procedures
d) the B-channel is OOS because previous restart procedures failed
e) the B-channel is OOS because the D-channel was OOS

Figure 9.3-10 — National ISDN PRI with BCAS: DS1, DS1/B-channel, and B-channel Initialization Procedures

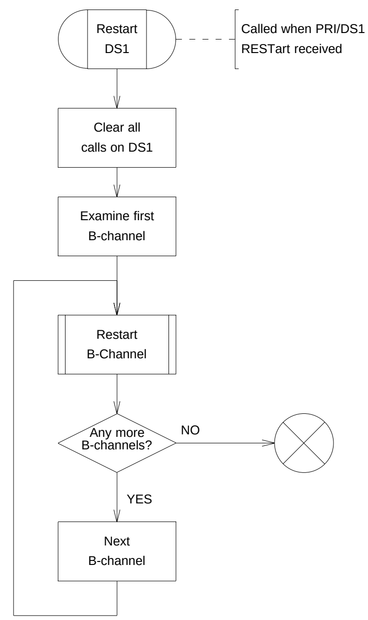


Figure 9.3-11 — National ISDN PRI with BCAS: Restart DS1 Procedure

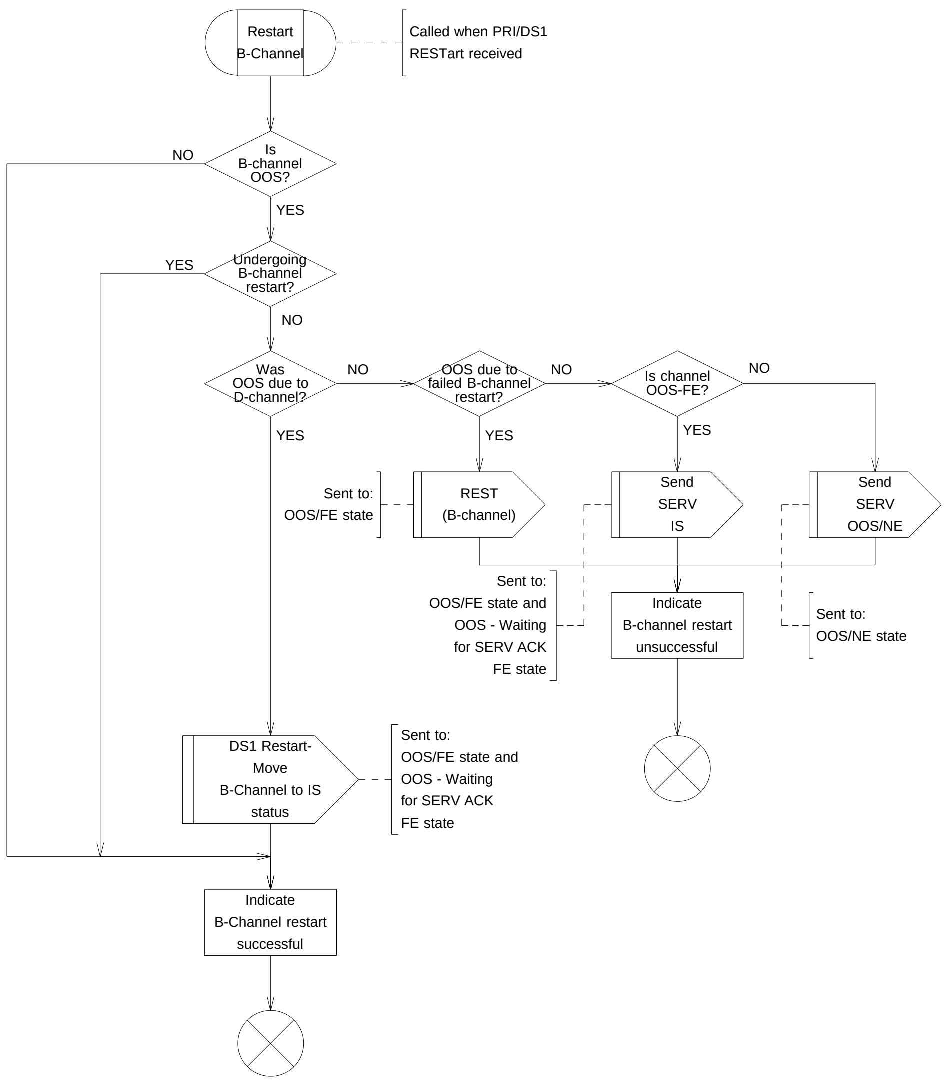


Figure 9.3-12 — National ISDN PRI with BCAS: Restart B-channel Procedure

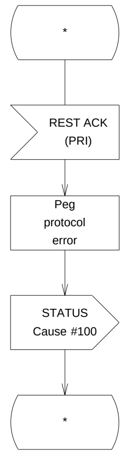


Figure 9.3-13 — National ISDN PRI with BCAS: Any State

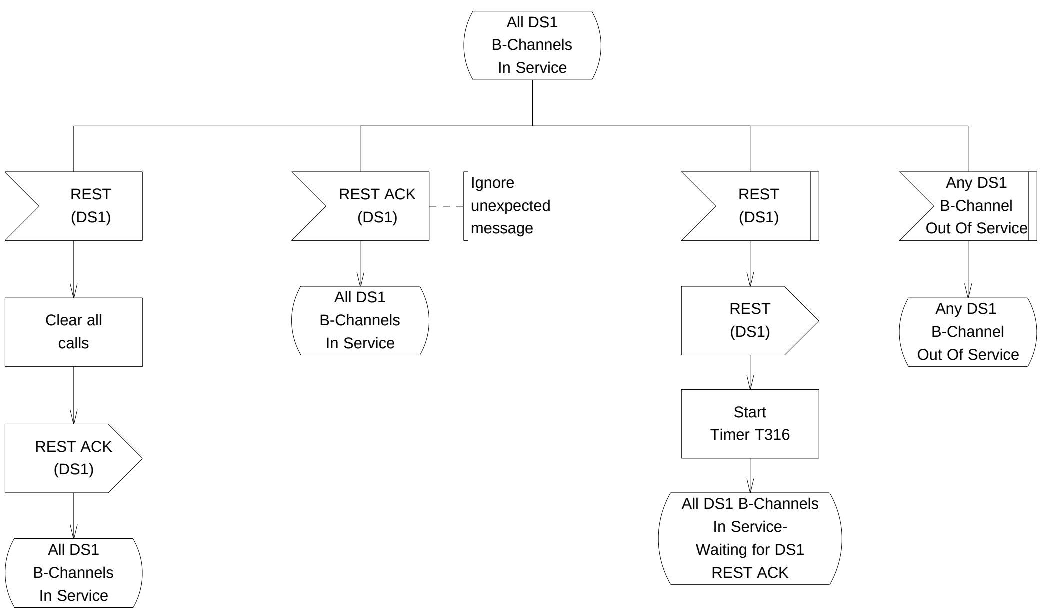


Figure 9.3-14 — National ISDN PRI with BCAS: DS1, All B-channels In Service State (1 of 2)

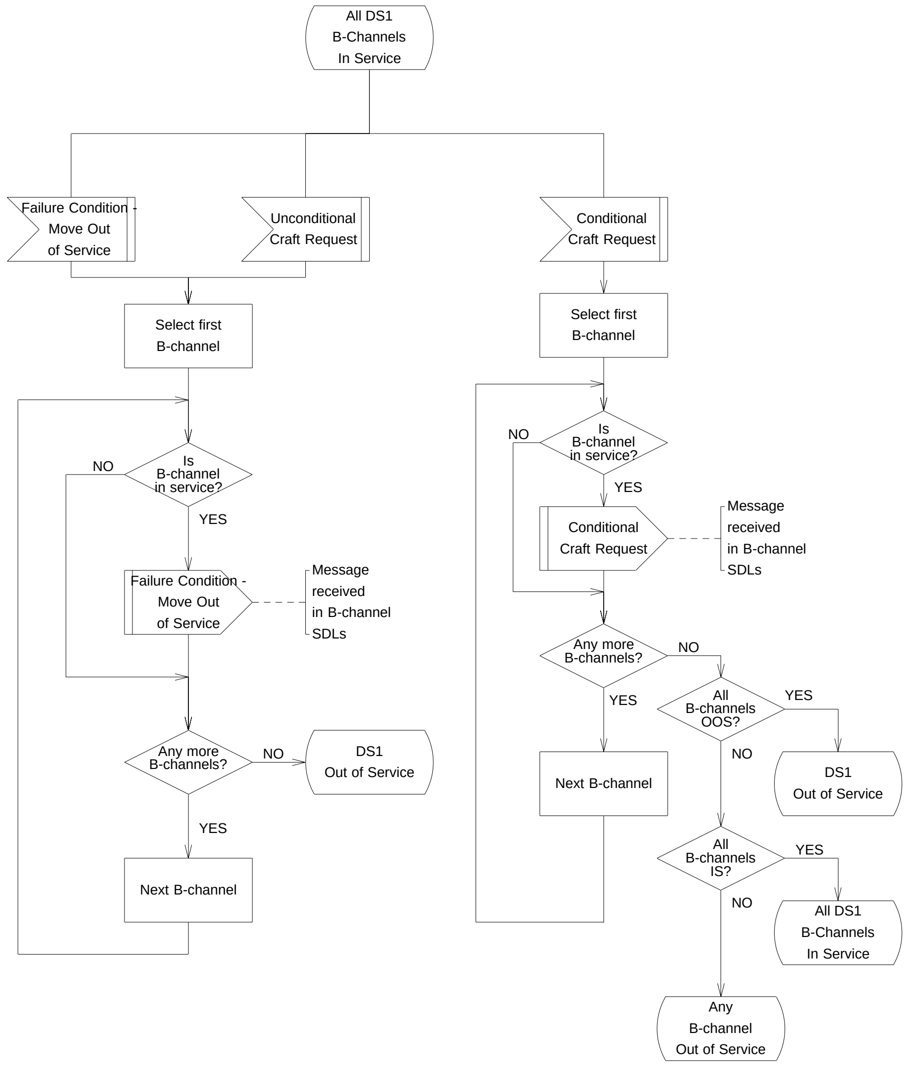


Figure 9.3-14 — National ISDN PRI with BCAS: DS1, All B-channels In Service State (2 of 2)

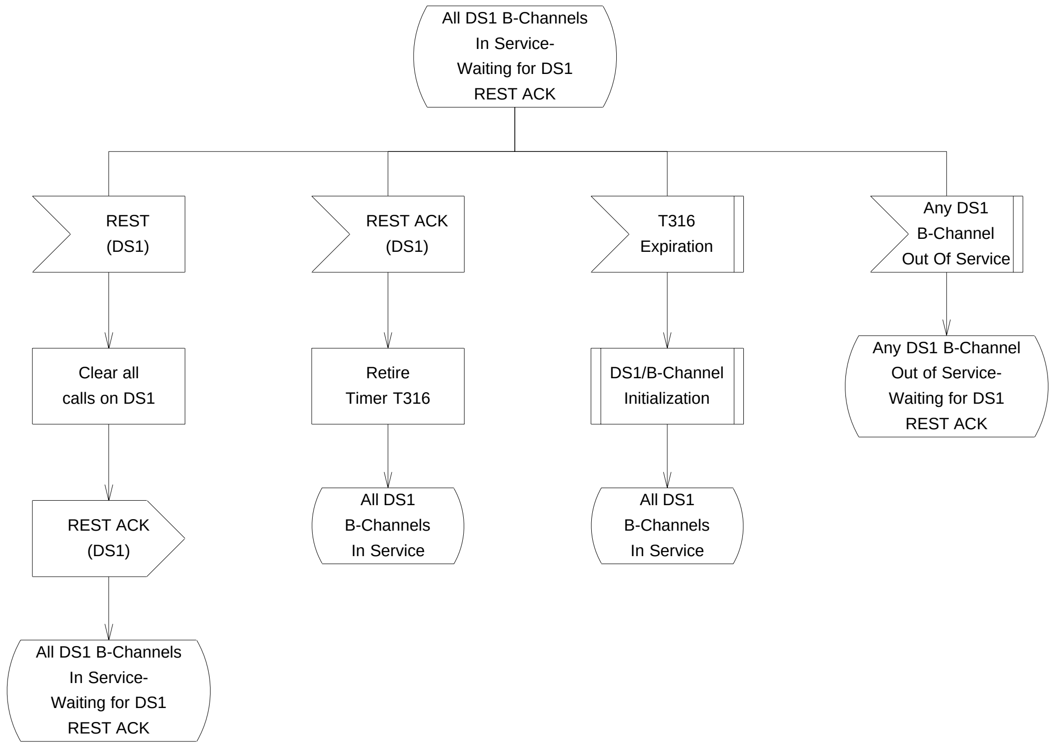


Figure 9.3-15 — National ISDN PRI with BCAS: DS1, All B-channels In Service State, Waiting for DS1 REST ACK

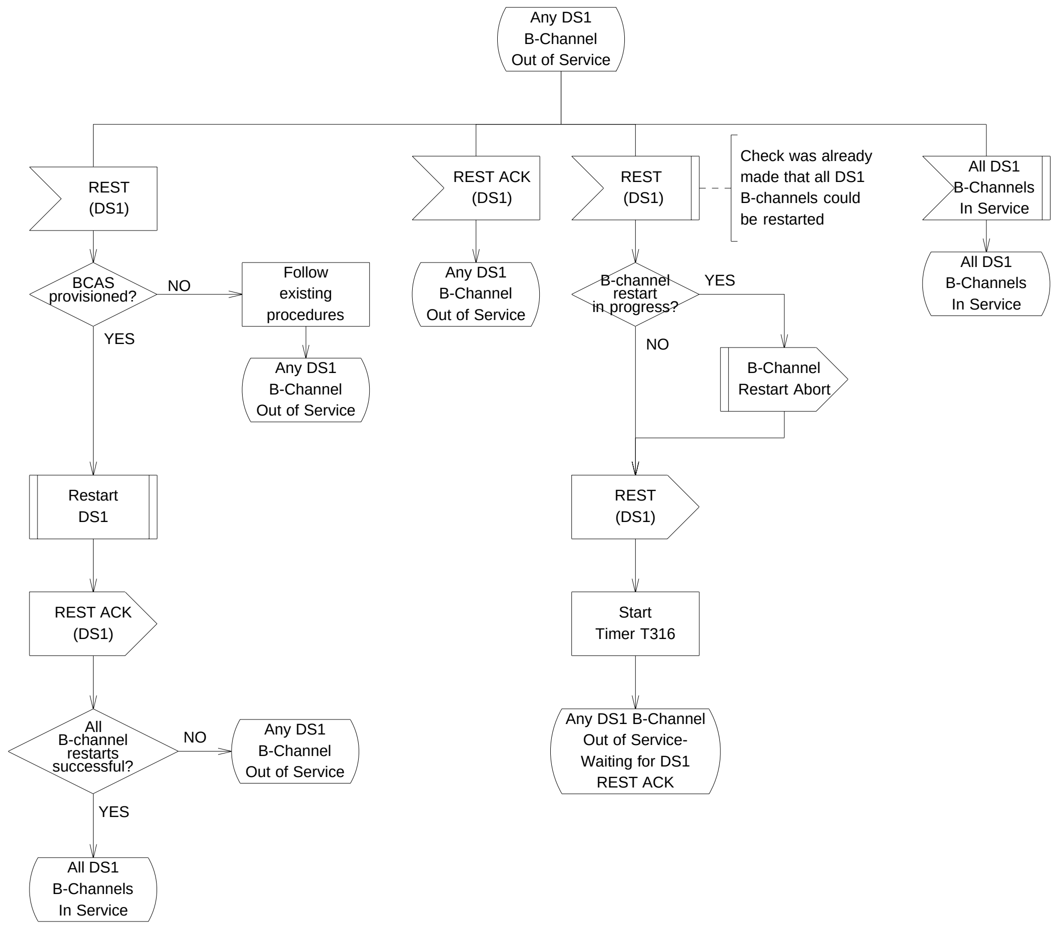


Figure 9.3-16 — National ISDN PRI with BCAS: DS1, Any B-channel Out of Service State (1 of 2)

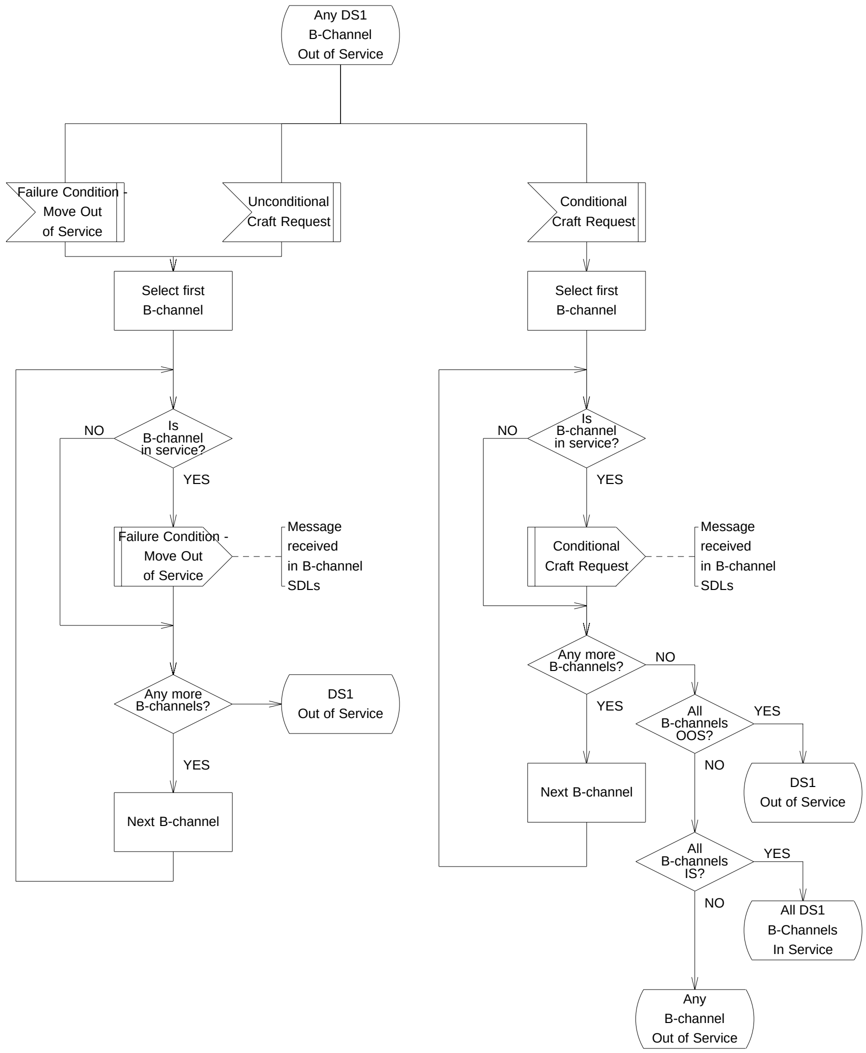


Figure 9.3-16 — National ISDN PRI with BCAS: DS1, Any B-channel Out of Service State (2 of 2)

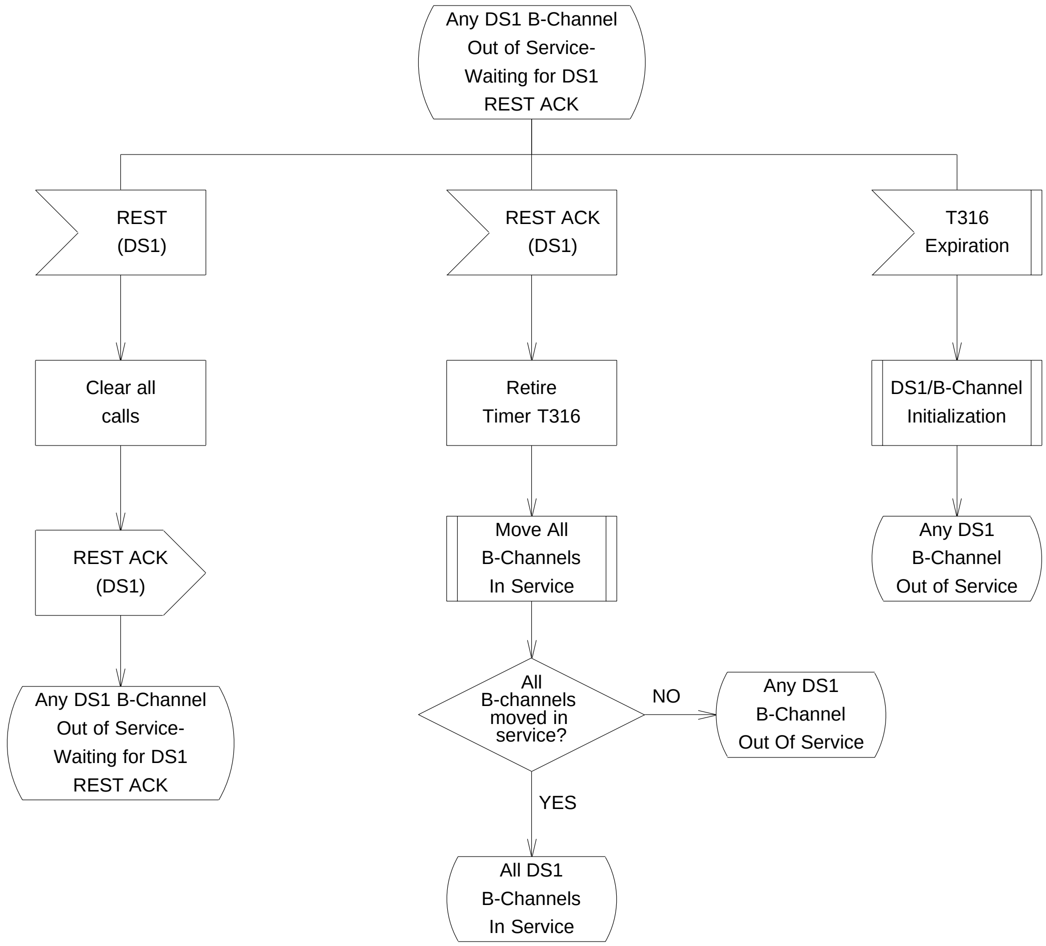


Figure 9.3-17 — National ISDN PRI with BCAS: DS1, Any B-channel Out of Service State, Waiting for DS1 REST ACK

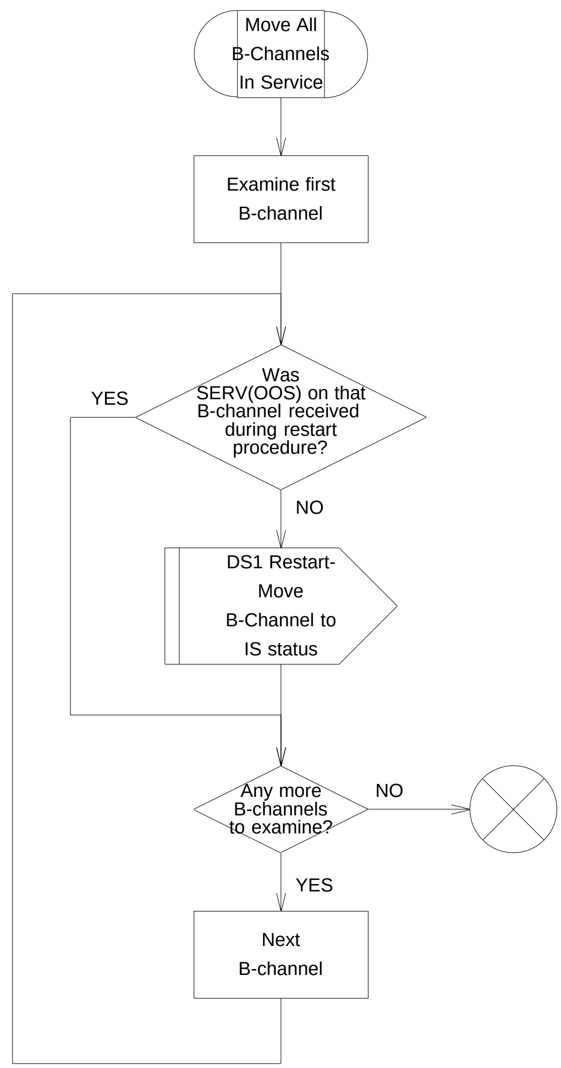


Figure 9.3-18 — National ISDN PRI with BCAS: DS1, Move All B-channels In Service

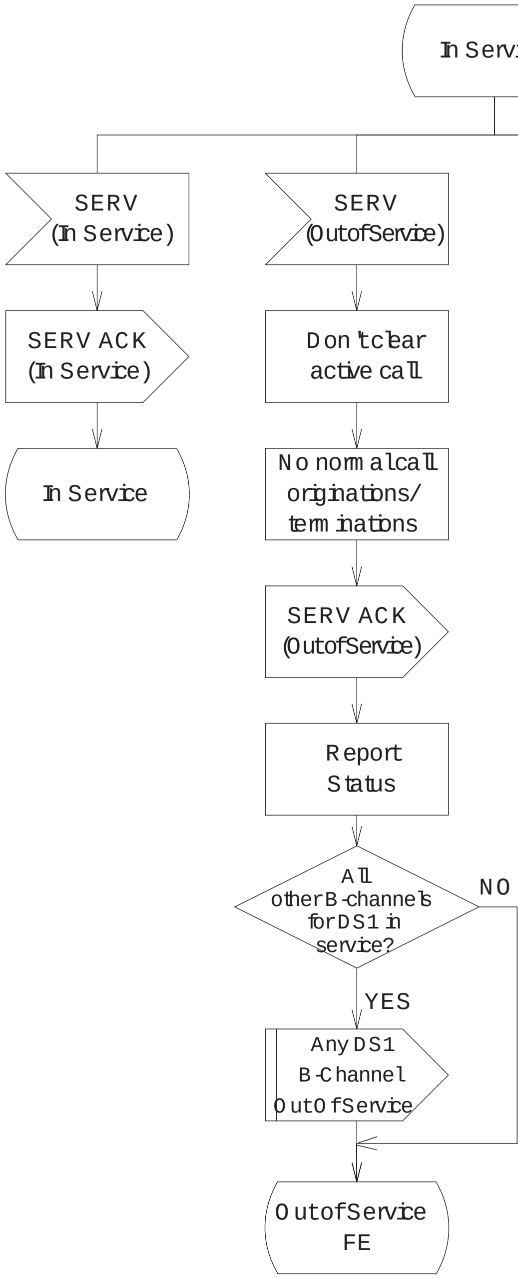


Figure 9.3-19 — National ISDN PRI with BCAS: B-channels, In Service (1 of 3)

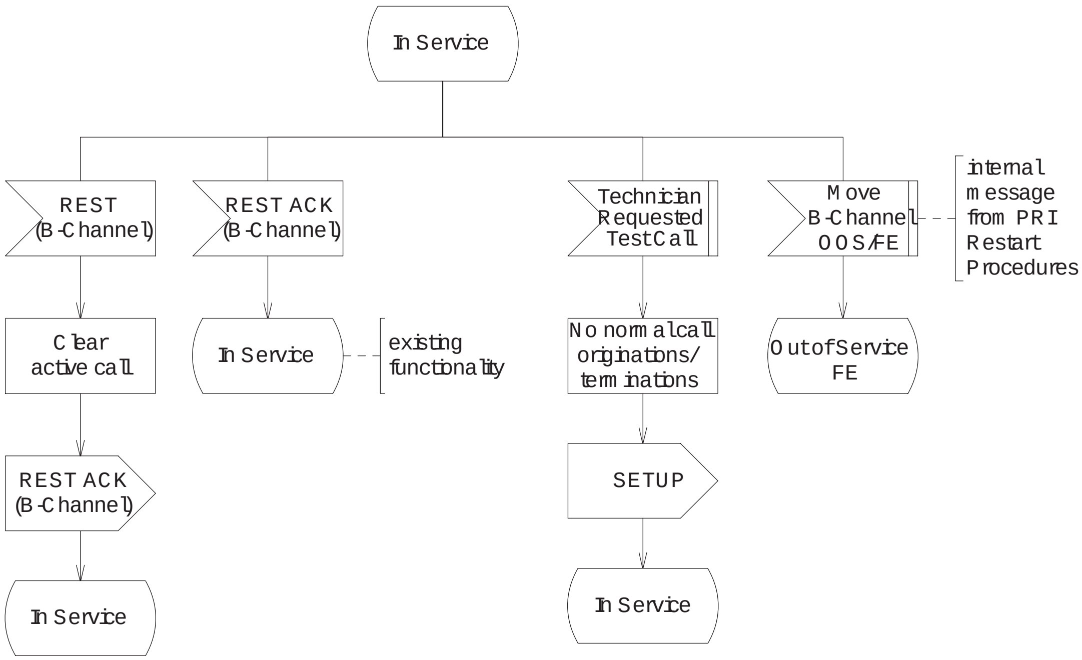


Figure 9.3-19 — National ISDN PRI with BCAS: B-channels, In Service (2 of 3)

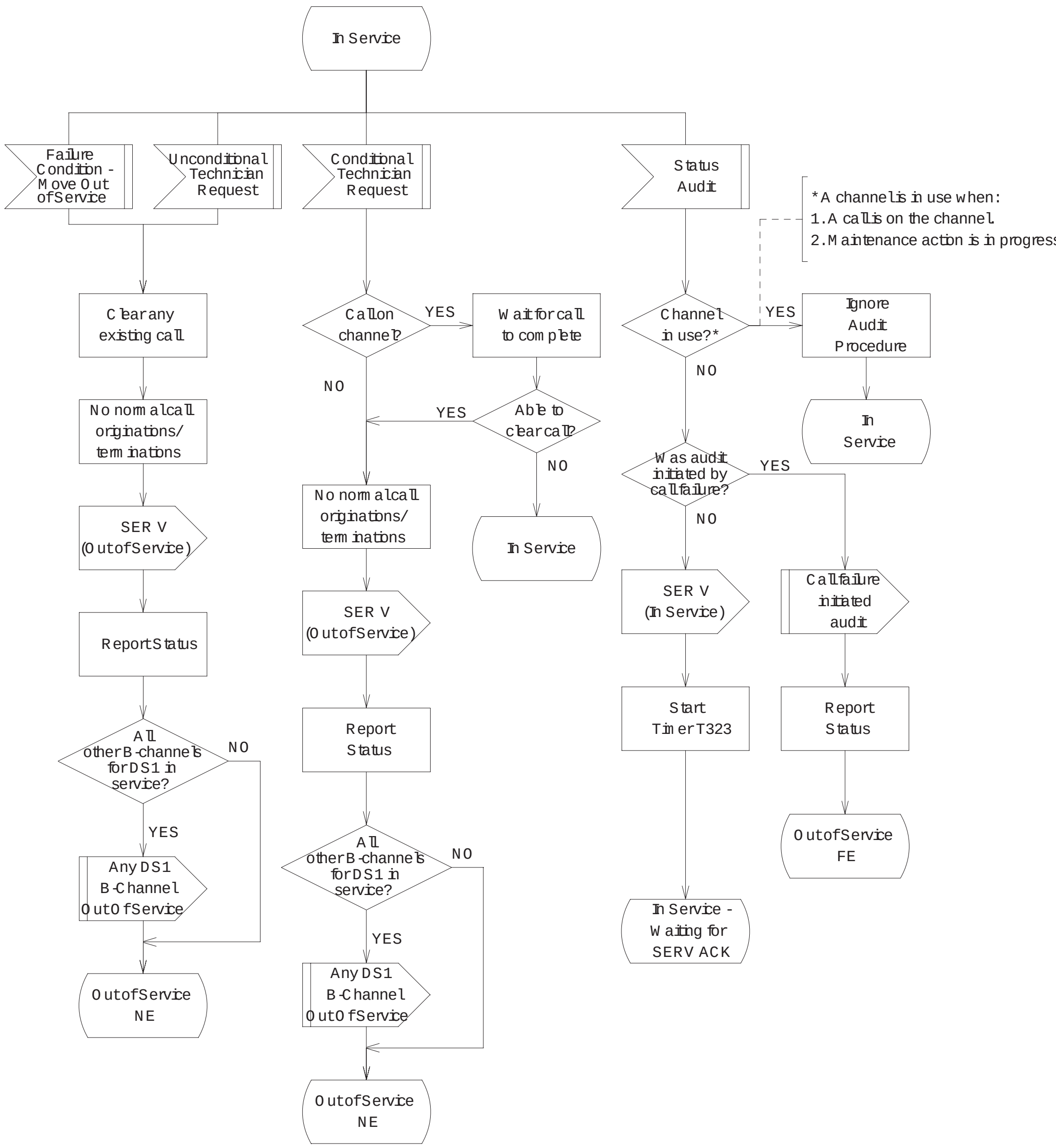


Figure 9.3-19 — National ISDN PRI with BCAS: B-channels, In Service (3 of 3)

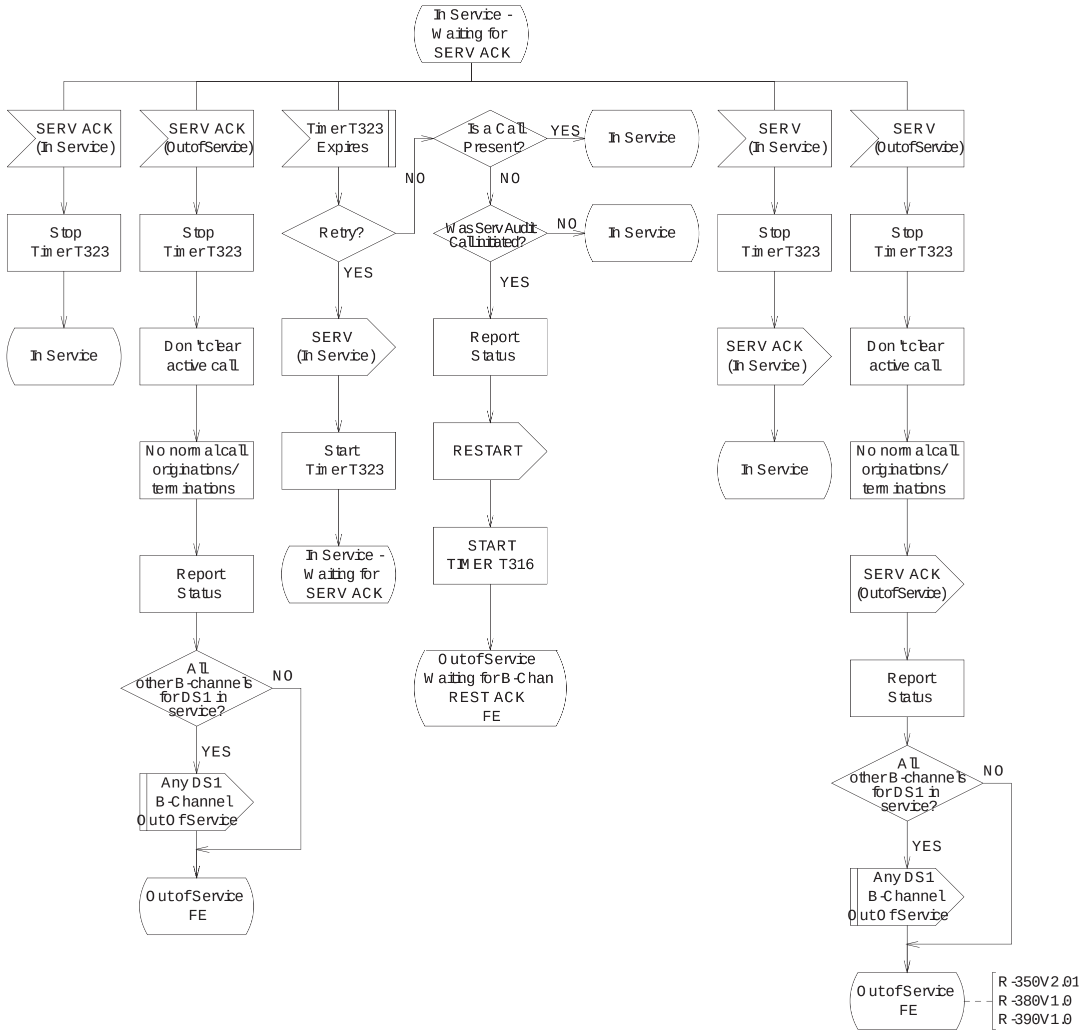


Figure 9.3-20 — National ISDN PRI with BCAS: B-channels, In Service, Waiting for SERV ACK (1 of 3)

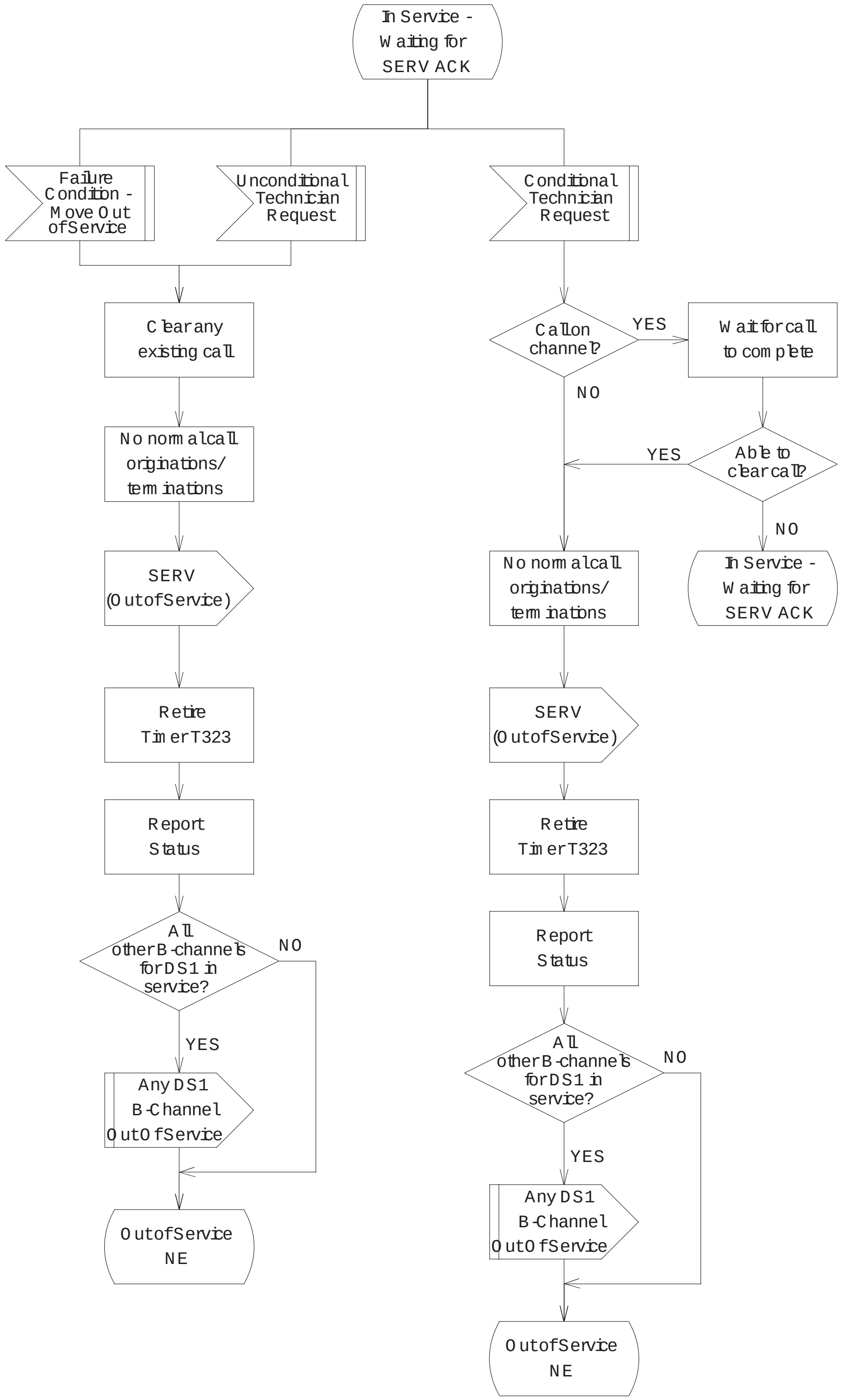


Figure 9.3-20 — National ISDN PRI with BCAS: B-channels, In Service, Waiting for SERV ACK (2 of 3)

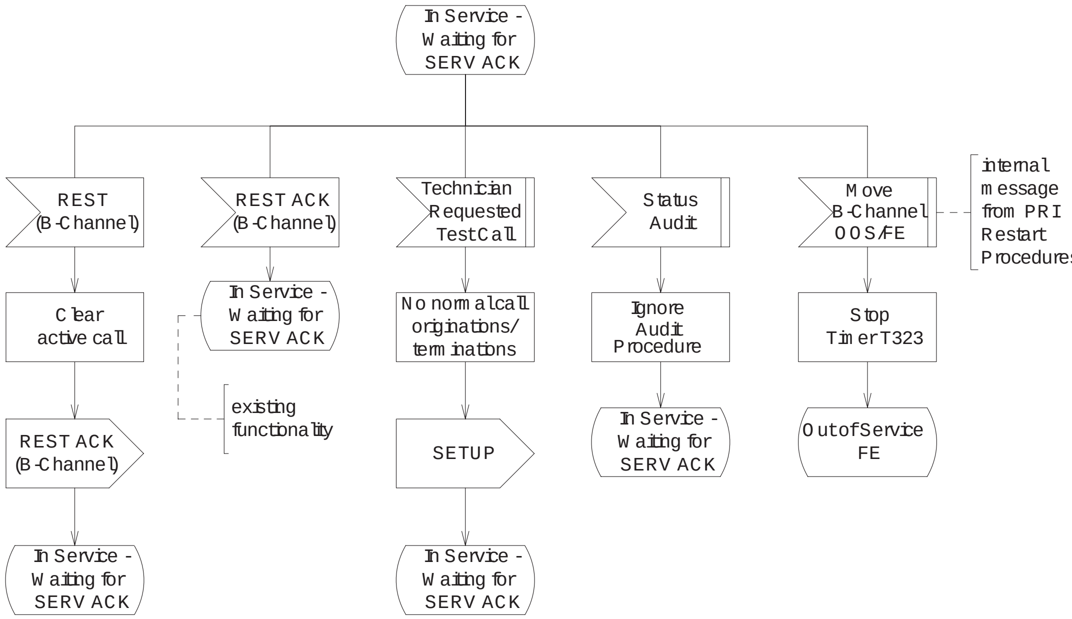


Figure 9.3-20 — National ISDN PRI with BCAS: B-channels, In Service, Waiting for SERV ACK (3 of 3)

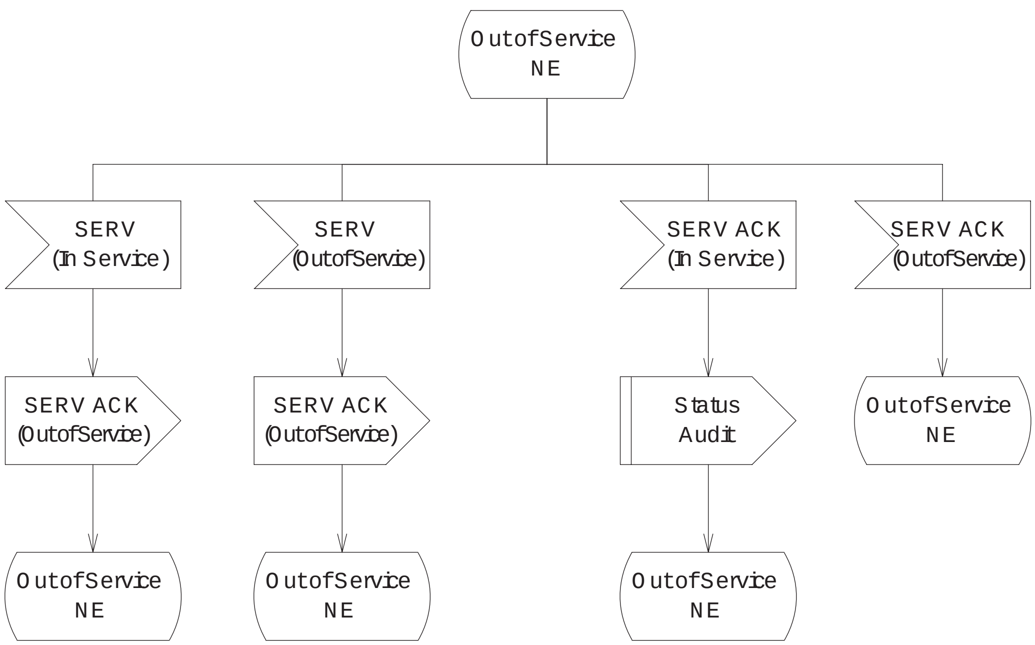


Figure 9.3-21 — National ISDN PRI with BCAS: B-channels, Out of Service NE (1 of 3)

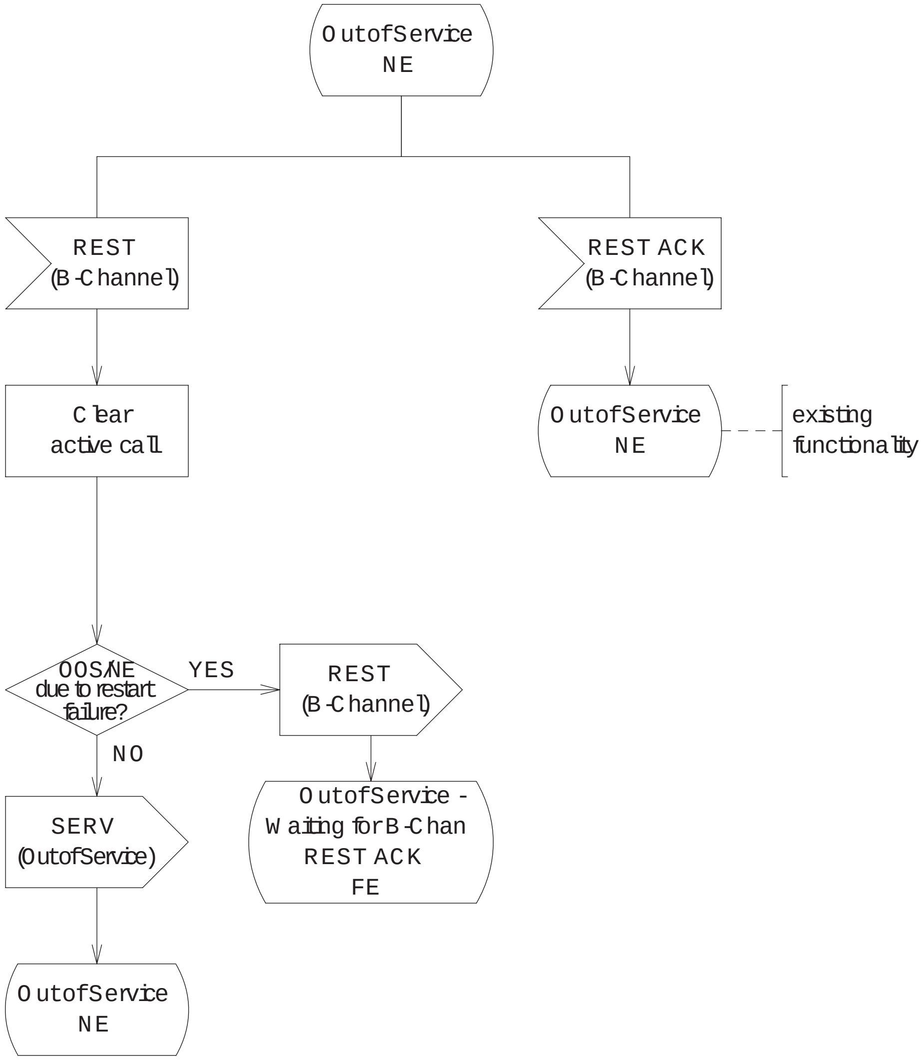


Figure 9.3-21 — National ISDN PRI with BCAS: B-channels, Out of Service NE (2 of 3)

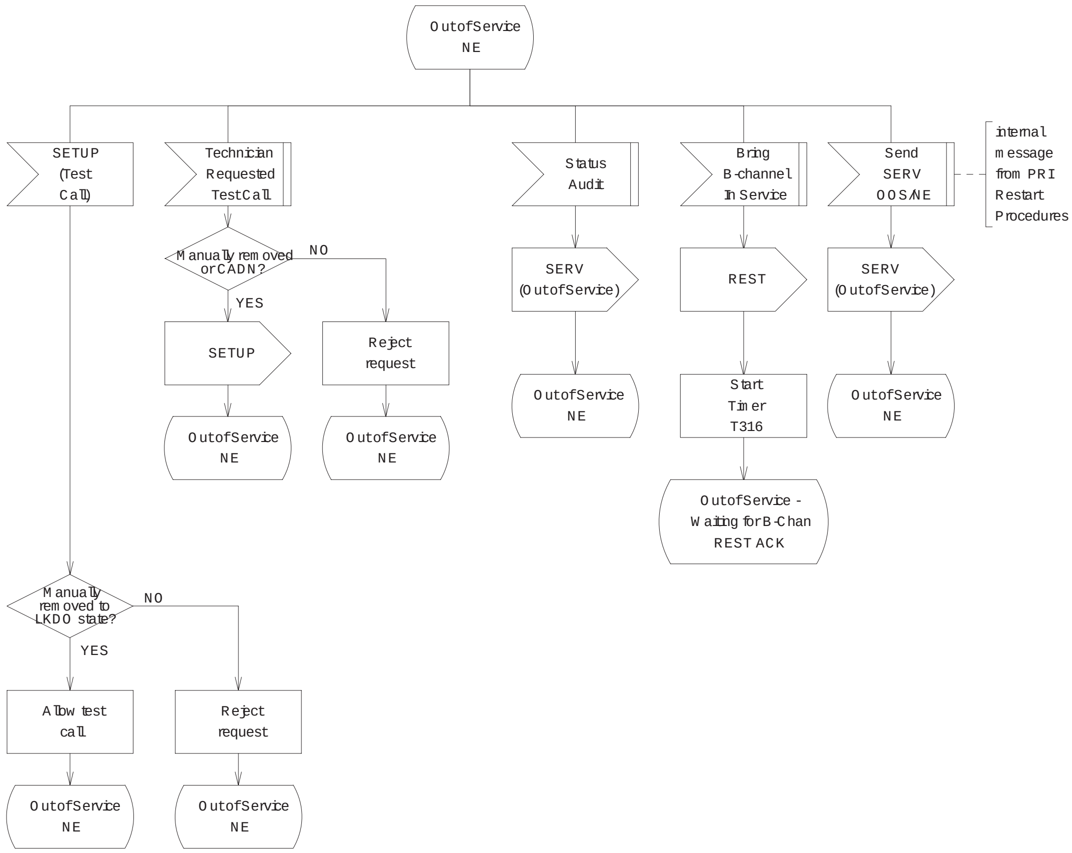


Figure 9.3-21 — National ISDN PRI with BCAS: B-channels, Out of Service NE (3 of 3)

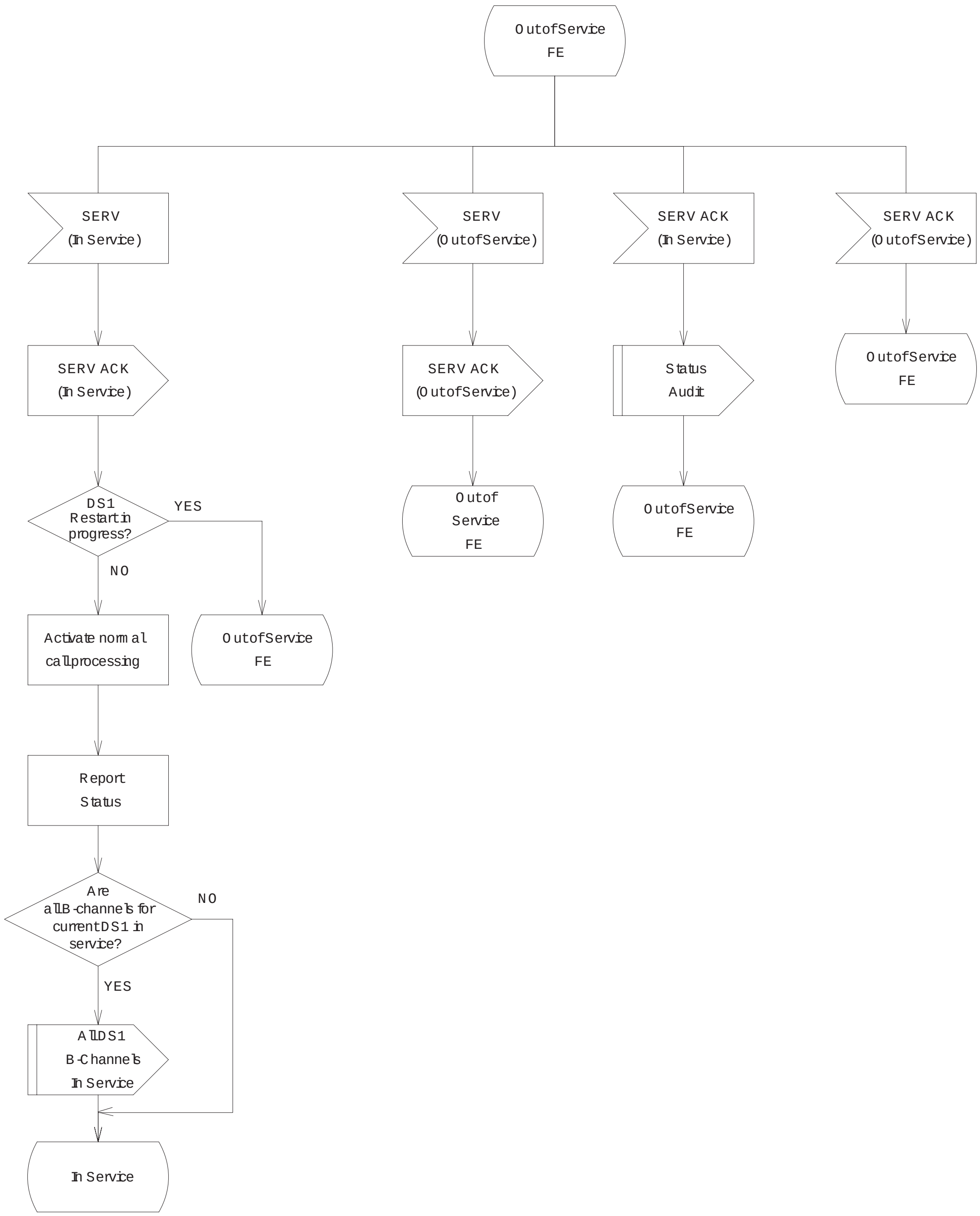


Figure 9.3-22 — National ISDN PRI with BCAS: B-channels, Out of Service FE (1 of 4)

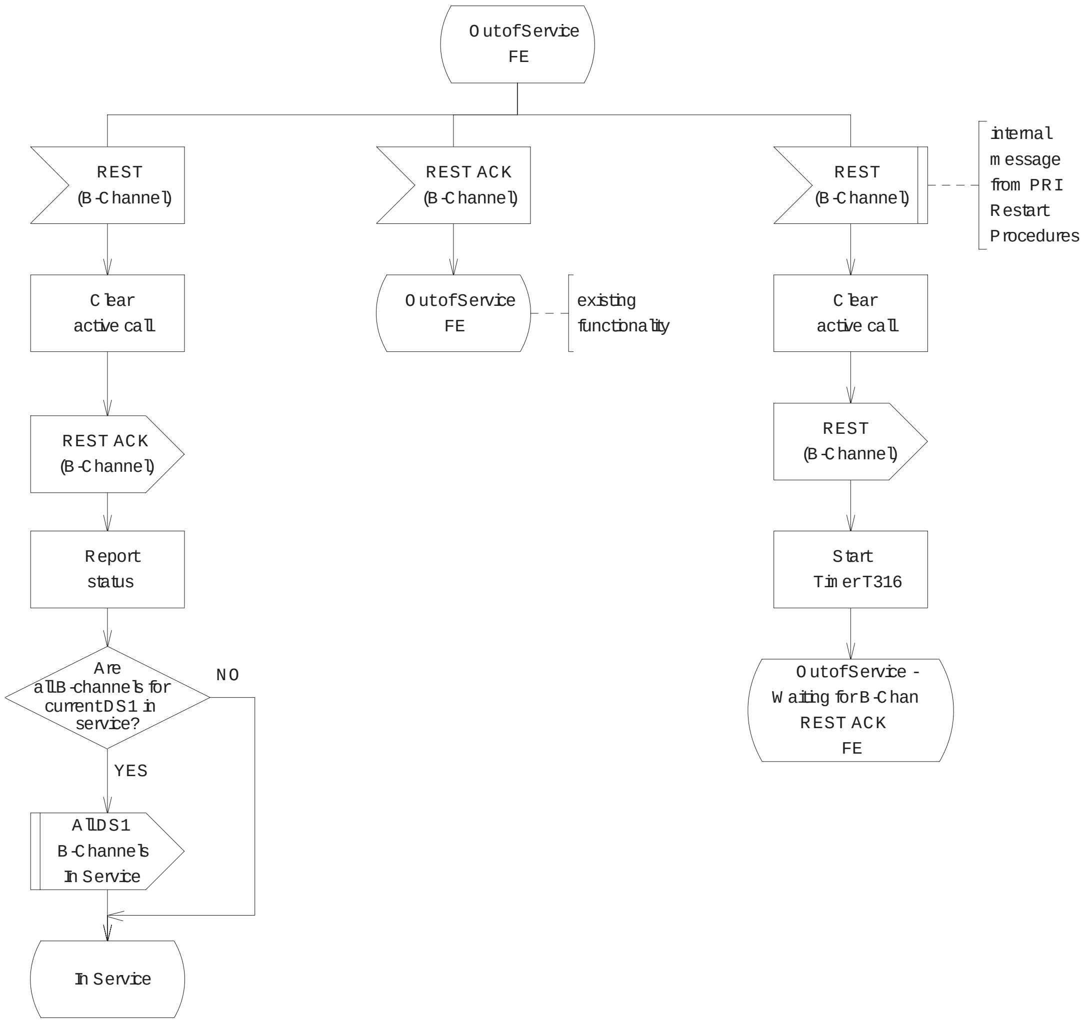


Figure 9.3-22 — National ISDN PRI with BCAS: B-channels, Out of Service FE (2 of 4)

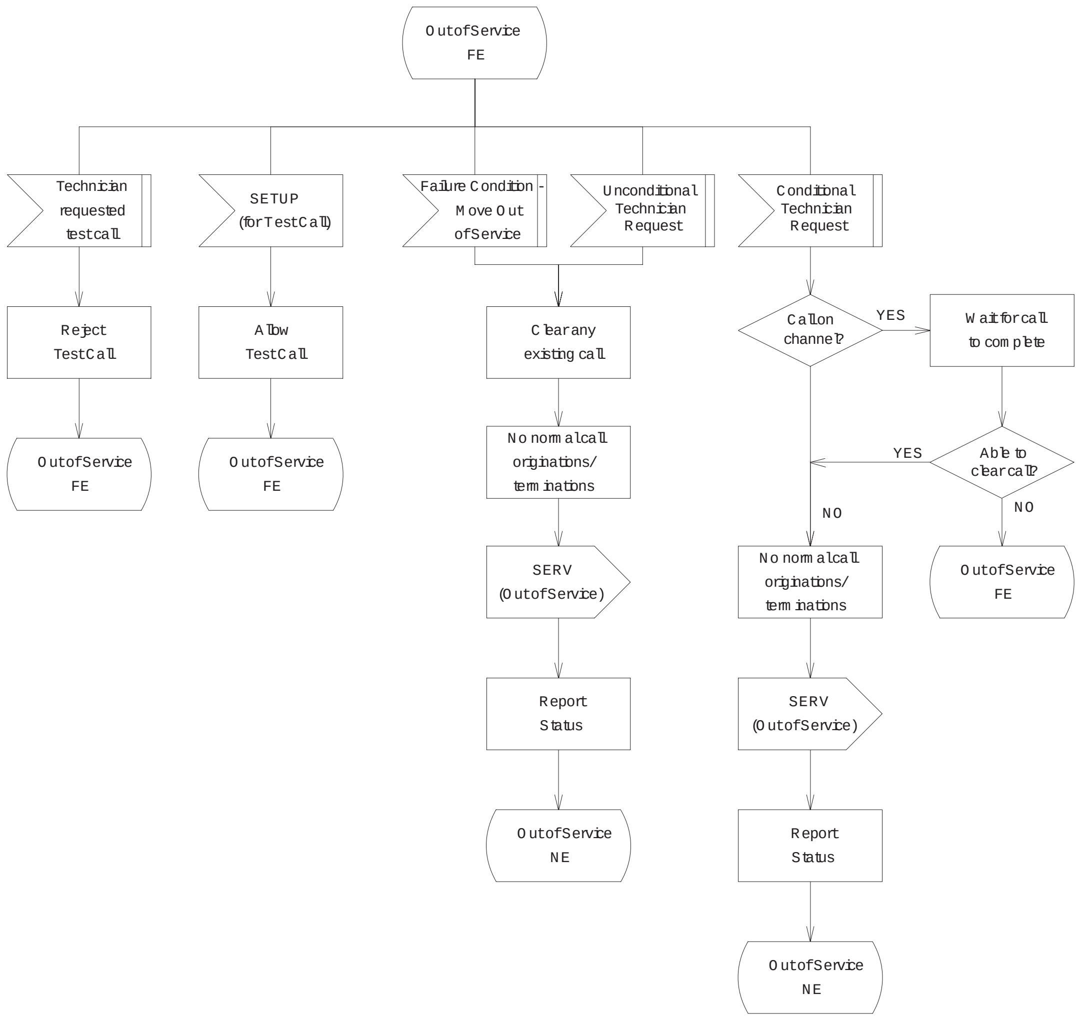


Figure 9.3-22 — National ISDN PRI with BCAS: B-channels, Out of Service FE (3 of 4)

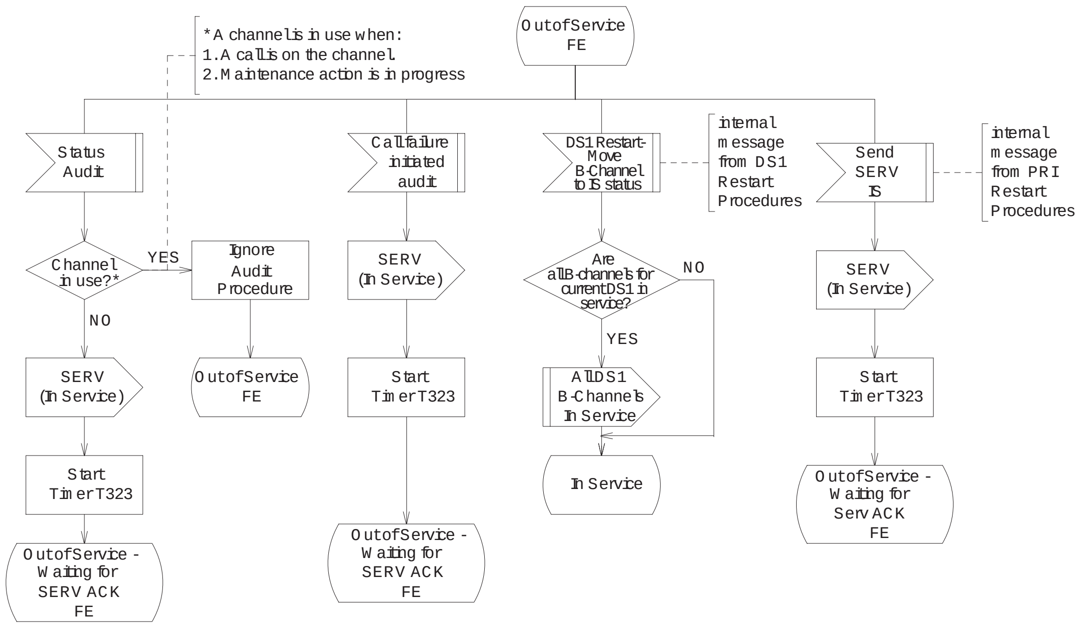


Figure 9.3-22 — National ISDN PRI with BCAS: B-channels, Out of Service FE (4 of 4)

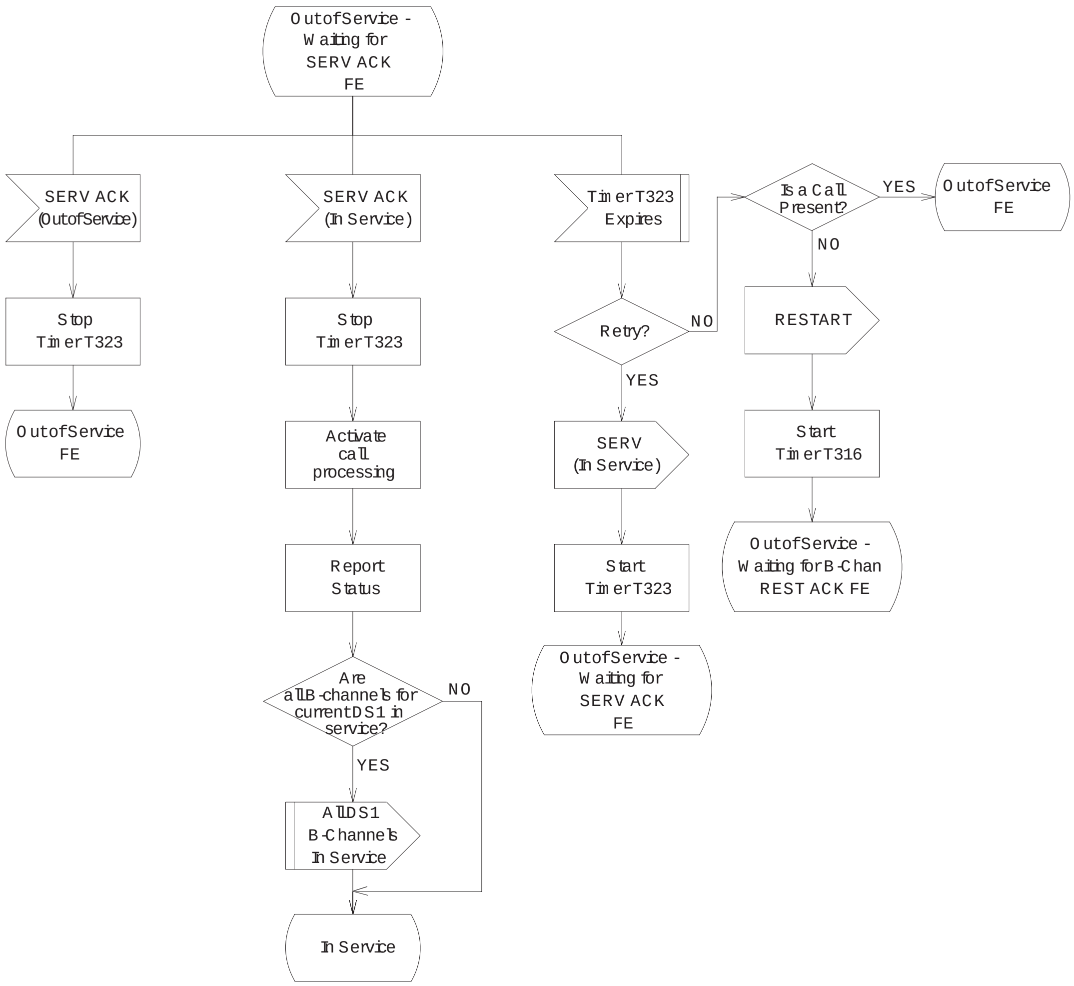


Figure 9.3-23 — National ISDN PRI with BCAS: B-channels, Out of Service FE, Waiting for SERV ACK (1 of 4)

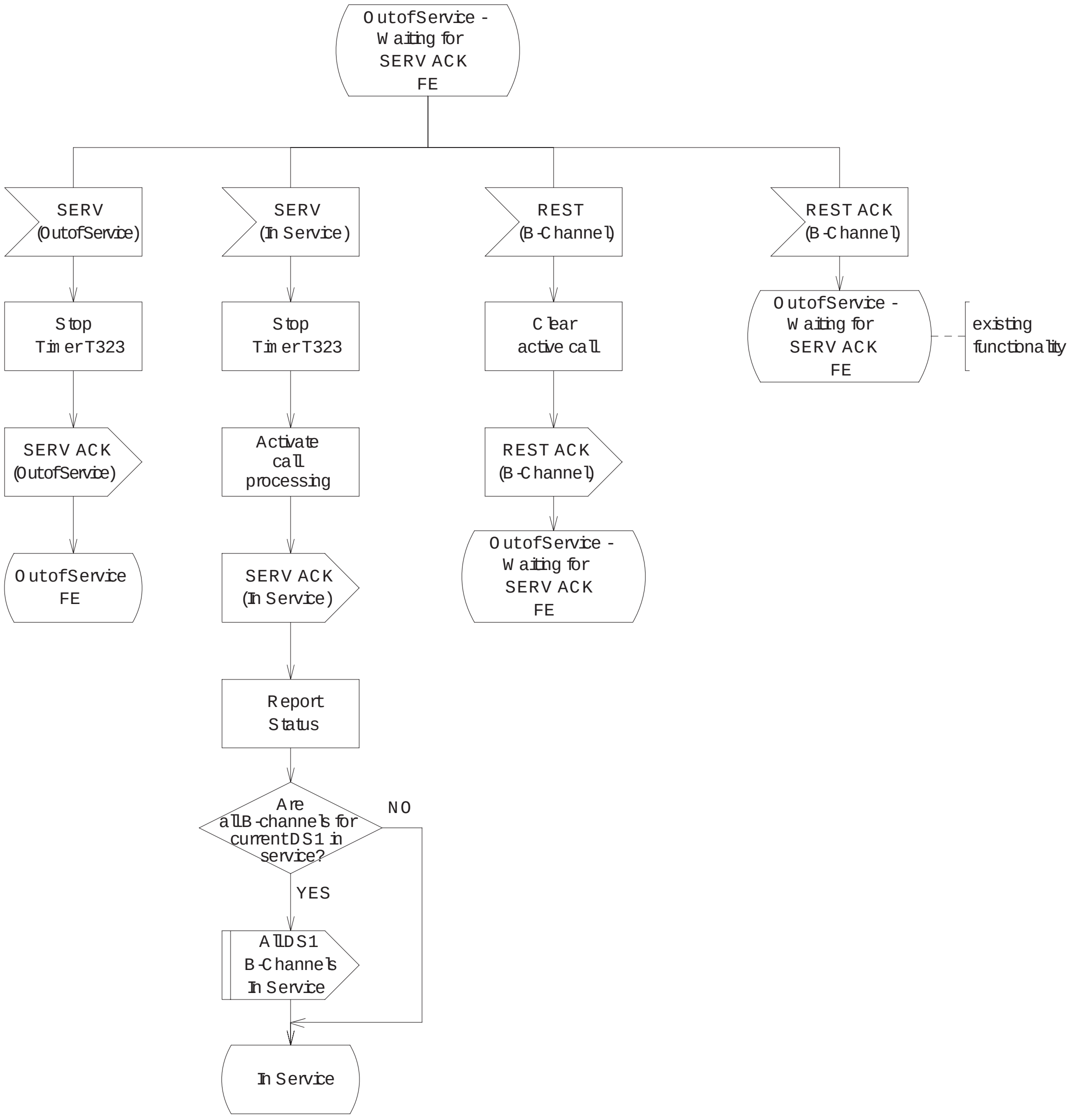


Figure 9.3-23 — National ISDN PRI with BCAS: B-channels, Out of Service FE, Waiting for SERV ACK (2 of 4)

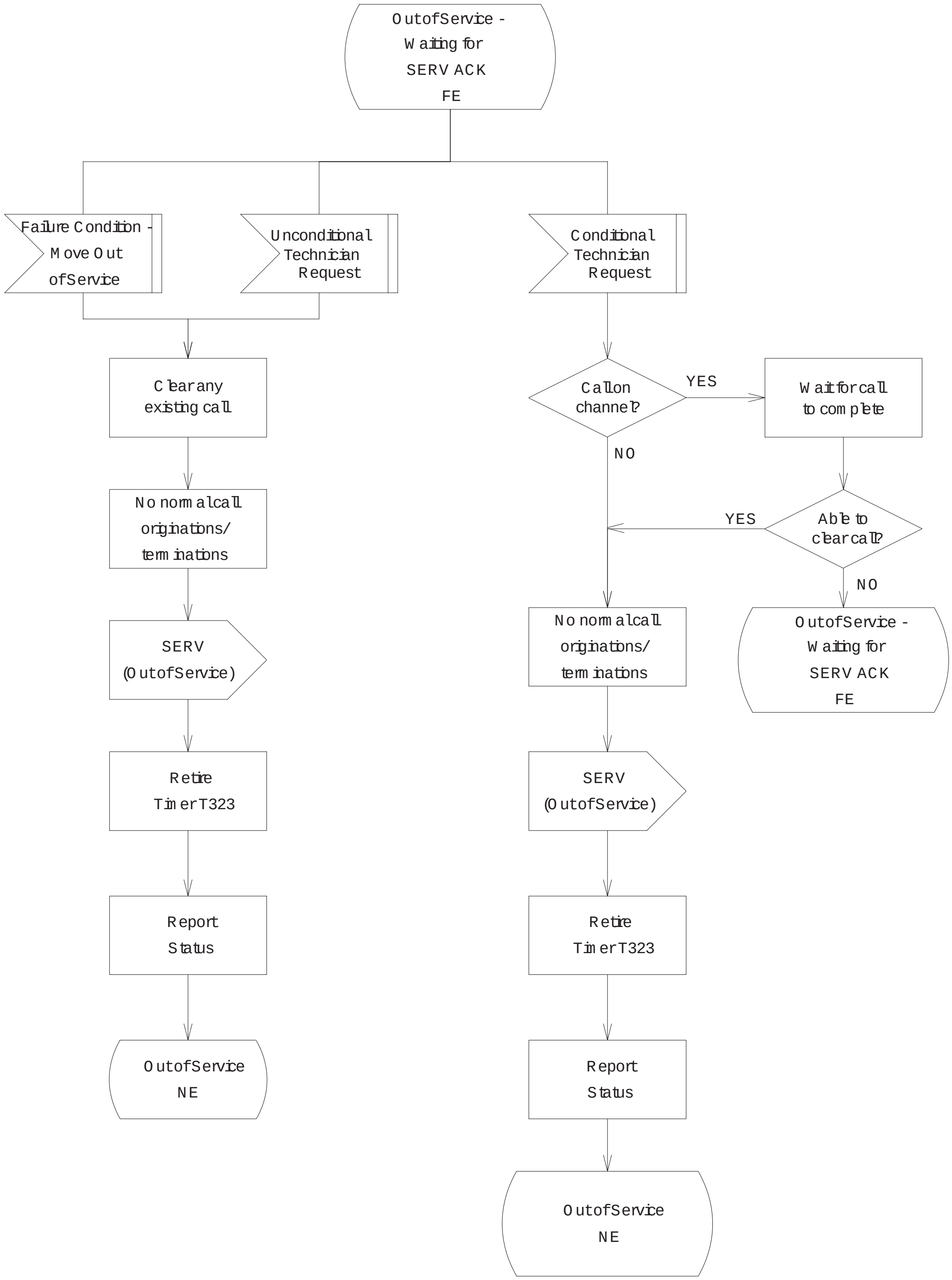


Figure 9.3-23 — National ISDN PRI with BCAS: B-channels, Out of Service FE, Waiting for SERV ACK (3 of 4)

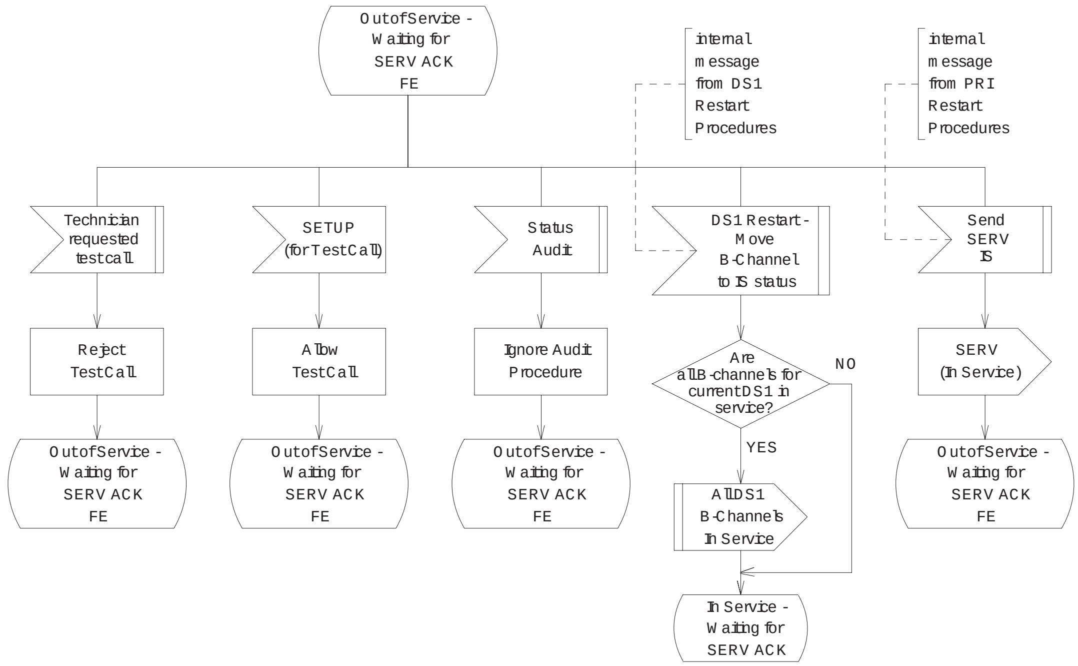


Figure 9.3-23 — National ISDN PRI with BCAS: B-channels, Out of Service FE, Waiting for SERV ACK (4 of 4)

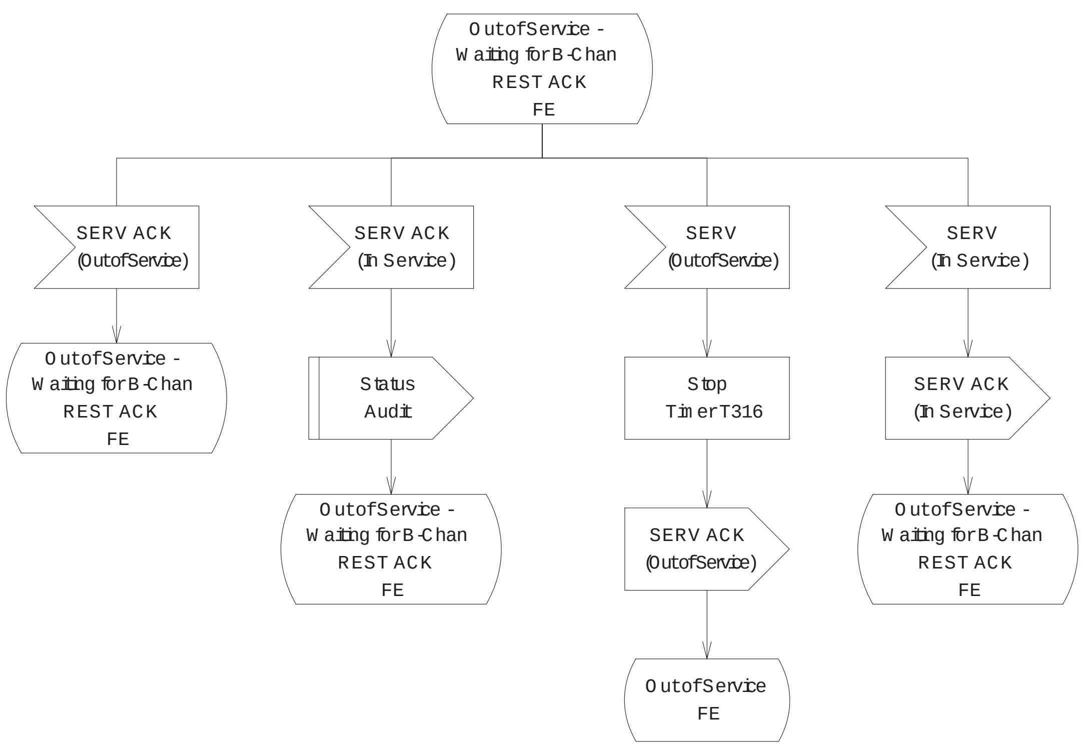


Figure 9.3-24 — National ISDN PRI with BCAS: B-channels, Out of Service FE, Waiting for B-channel REST ACK (1 of 4)

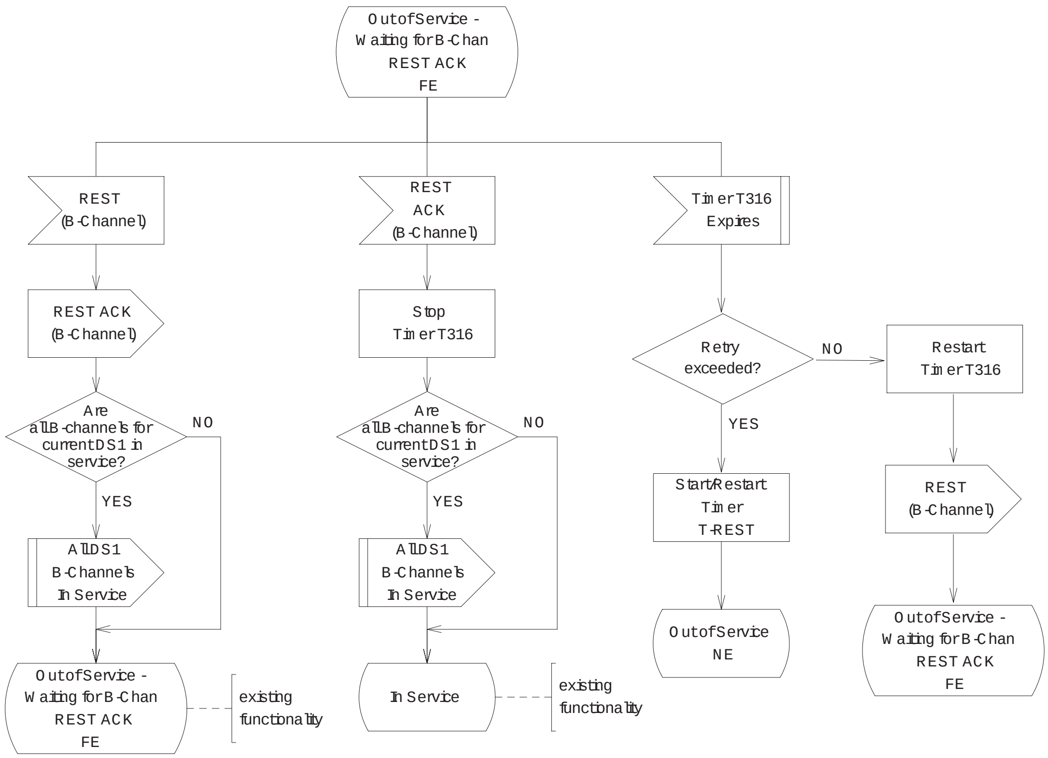


Figure 9.3-24 — National ISDN PRI with BCAS: B-channels, Out of Service FE, Waiting for B-channel REST ACK (2 of 4)

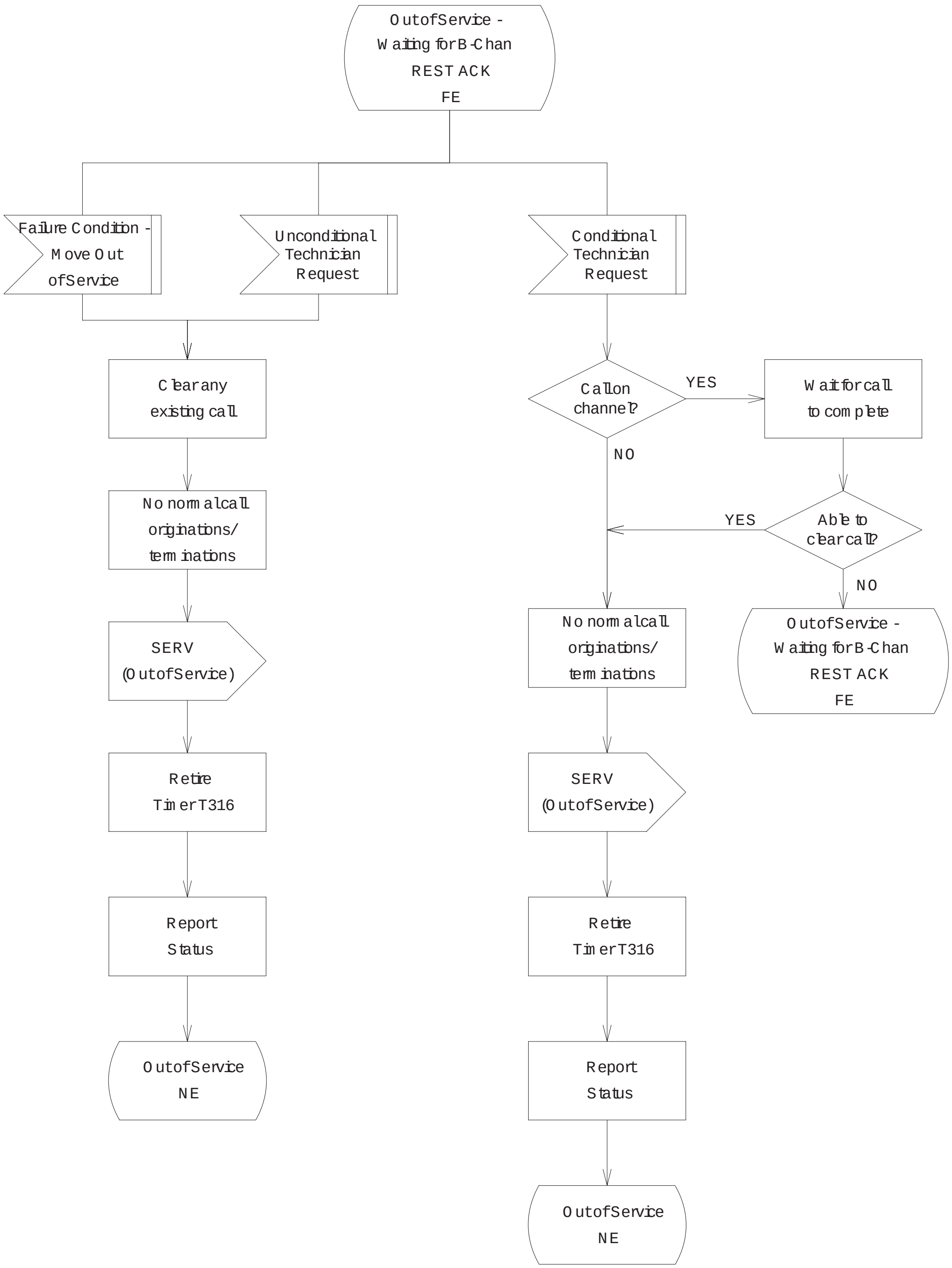


Figure 9.3-24 — National ISDN PRI with BCAS: B-channels, Out of Service FE, Waiting for B-channel REST ACK (3 of 4)

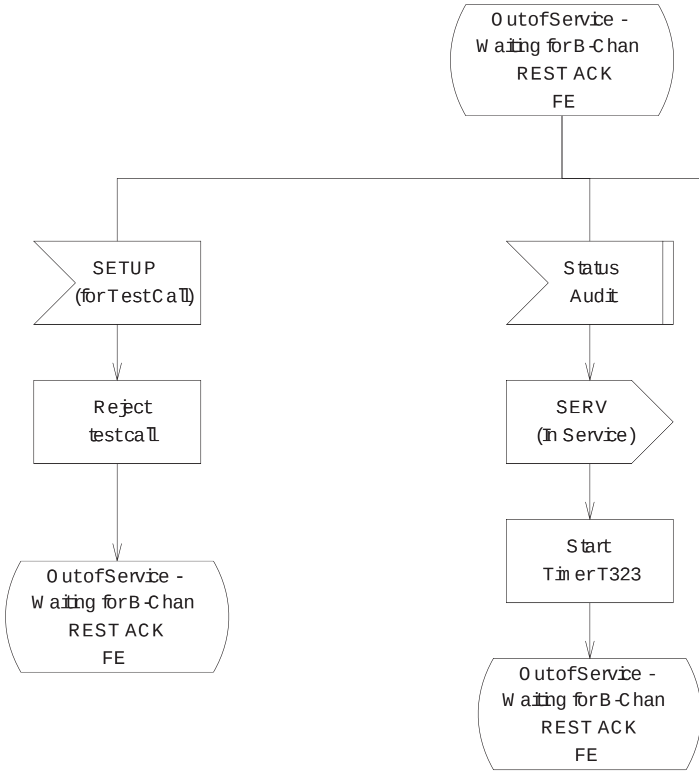


Figure 9.3-24 — National ISDN PRI with BCAS: B-channels, Out of Service FE, Waiting for B-channel REST ACK (4 of 4)

9.3.3 D-CHANNEL PROCEDURES FOR THE NATIONAL ISDN PRI

The National ISDN PRI D-channel without D-channel backup is controlled by Layer 2 messages. Therefore, the following procedures apply to the National ISDN PRI with D-channel backup only. The valid transitions among the various D-channel states are shown in the following figures:

- Figure 9.3-26
- Figure 9.3-27
- Figure 9.3-28
- Figure 9.3-29
- Figure 9.3-30
- Figure 9.3-31
- Figure 9.3-32
- Figure 9.3-33.

The concept of transitioning from a more available state to a less available state does not apply to the National ISDN PRI D-channel because the SERVICE and SERVICE ACKNOWLEDGE messages use only the IS status category for both Layer 3 switch-over and audit procedures. SERVICE and SERVICE ACKNOWLEDGE messages specifying maintenance or OOS status for D-channels are never generated by the *5ESS* switch. When the *5ESS* switch receives a SERVICE or SERVICE

ACKNOWLEDGE message specifying maintenance or OOS, the *5ESS* switch responds by ignoring the message and logging a unique protocol error.

In the D-channel backup feature, the SERVICE and SERVICE ACKNOWLEDGE messages are used to bring the standby D-channel into an IS state, and to perform audits on an IS D-channel to ensure it is operating properly and to avoid any possible deadlock conditions. When the *5ESS* switch sends a SERVICE message during switch-over, initialization, automatic recovery, or manual intervention, Timer T321 is started. During switch-over Timer T309 is also started. Timer T321, which equals 50 seconds, is the maximum time allowed to complete the transition to the backup D-channel, guarding against the D-channel remaining in WAIT for an indeterminate period of time. Timer T309, which equals 90 seconds, times the wait interval before tearing down stable calls. For the National ISDN PRI, D-channel stable calls remain active while transient calls in the network direction are disconnected. If Timer T309 for a PRI group expires and neither D1 nor D2 is IS, the *5ESS* switch clears all calls on the PRI group with a cause code value of 41. The B-channels in this same PRI group will be placed in OOS. If Timer T309 or Timer T321 for a PRI group expires and either D1 or D2 is IS, the *5ESS* switch considers the expiration as an abnormal event and an assert is generated.

Timer Tserve is used when auditing the IS D-channel. This 5-minute timer is started after sending a SERVICE message on an IS D-channel while waiting for a SERVICE ACKNOWLEDGE. A SERVICE message is sent every minute. Timer Tserve is stopped with the receipt of a SERVICE ACKNOWLEDGE message. If Timer Tserve expires, the IS D-channel is taken OOS, and switch-over procedures are started, if possible.

At the time of initialization or after an outage of both the primary D-channel and the backup D-channel (OOS,OOS), both sides will attempt to bring up one D-channel as the active D-channel. During this process, the primary D-channel will have higher priority than the backup D-channel in being chosen as the active D-channel. See Figure 9.3-33 and “Non-Facility Associated Signaling and D-channel Backup,” Section 10, for more details.

9.3.3.1 Cause Codes Invoked by National ISDN PRI D-channel Maintenance Procedures

The following cause code values are common for all SERVICE messages:

- Cause code value 81 “invalid CRV”

  If a SERVICE or SERVICE ACKNOWLEDGE message with a non-global call reference value is received, the *5ESS* switch returns a STATUS message with a cause code value of 81.

- Cause code value 96 “mandatory information element missing”

  If a SERVICE or SERVICE ACKNOWLEDGE message is received with a missing change status IE or missing channel identification IE, the *5ESS* switch returns a STATUS message with a cause code value of 96.

- Cause code value 100 “invalid information element contents”

  If a SERVICE or SERVICE ACKNOWLEDGE message is received with an invalid change status or channel identification IE, the *5ESS* switch returns a STATUS message with a cause code value of 100.

9.3.3.2 SDL Diagrams for National ISDN PRI D-channel Procedures with D-channel Backup

SDL diagrams in the following figures describe both the maintenance and call control procedures for National ISDN PRI D-channels with the D-channel backup feature:

- Figure 9.3-26
- Figure 9.3-27
- Figure 9.3-28
- Figure 9.3-29
- Figure 9.3-30
- Figure 9.3-31
- Figure 9.3-32
- Figure 9.3-33.

The *5ESS* switch implements the OOS state, the MOOS state and the AOOS state. The relationship of these states are described in “D-channel States,” Section 10.2. For simplicity, the following SDL diagrams show the procedures for the OOS state only. The following nomenclature is used.

- The states of D1 and D2 are represented as (D1 state, D2 state). For example, while D1 is active (IS) and D2 is standby (STBY), the notation used is (IS, STBY).
- The primitives sent to Layer 3 from Layer 2 or received from Layer 2 from Layer 3 are represented as D-channel:primitive. For example, the event D1:Layer 2 release indication means that the Layer 2 release indication primitive is received on D-channel D1.
- D-channel SERVICE messages sent or received by Layer 3 are represented by the notation D-channel: SERV(D-channel=state). For example, D1: SERV(D1=IS) means a Layer 3 D-channel IS message is sent on D1.
- An optional SABME/UA exchange procedure is provided for during transfer to the STBY link. The actions and states that are used with this optional procedure are marked with an "*".
- Layer 2 disconnect causes Layer 2 to be torn down.

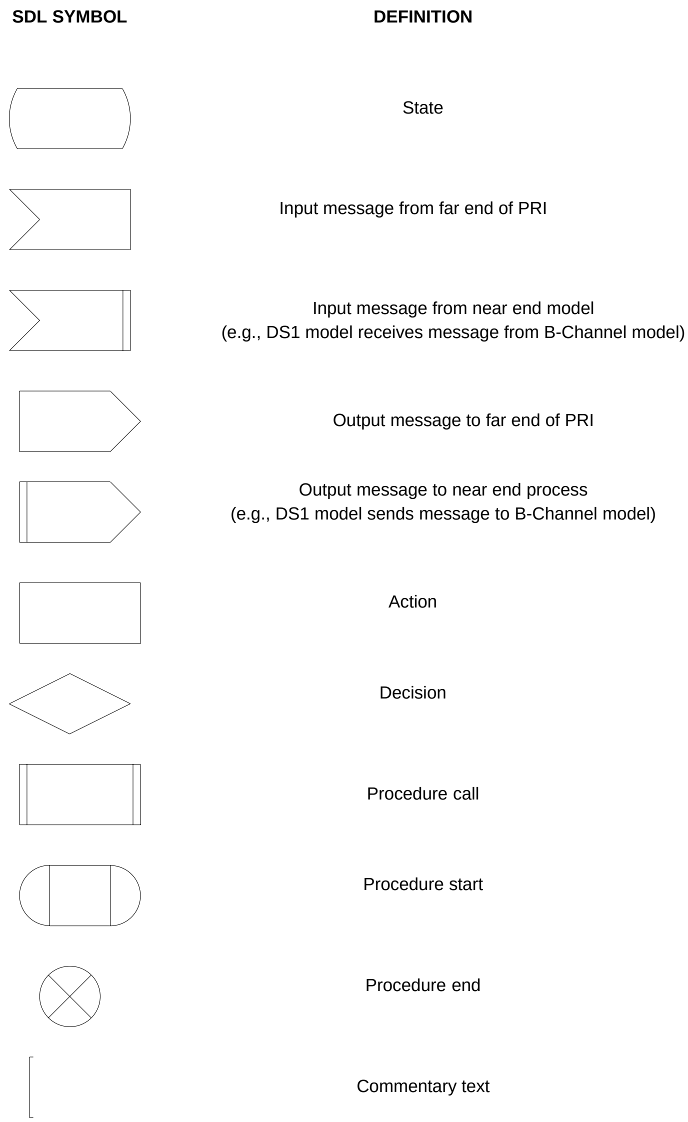


Figure 9.3-25 — Legend for SDL Diagrams: National ISDN PRI with D-channel Backup

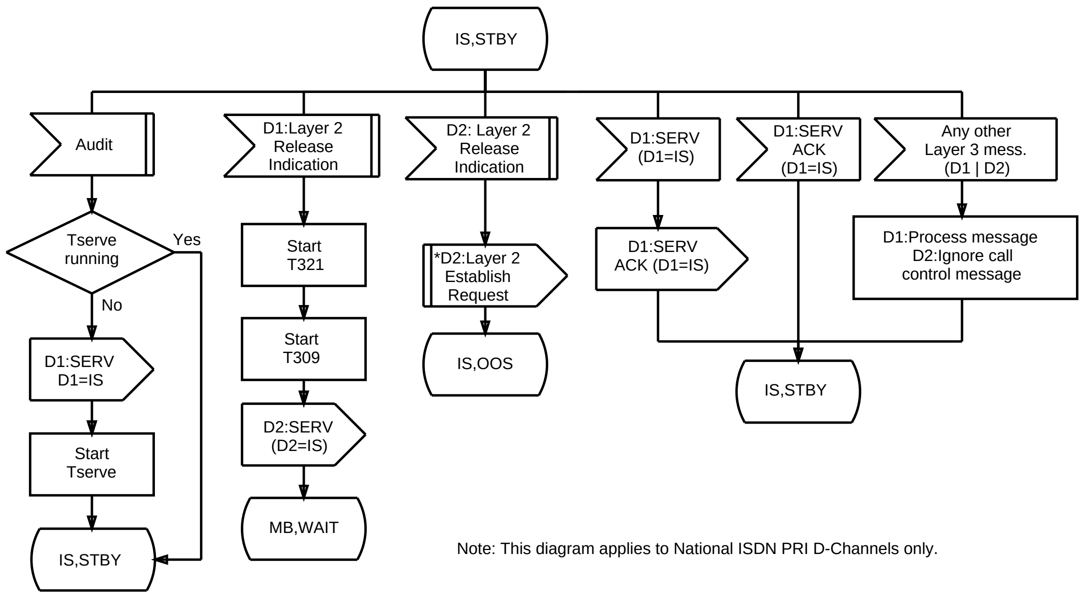
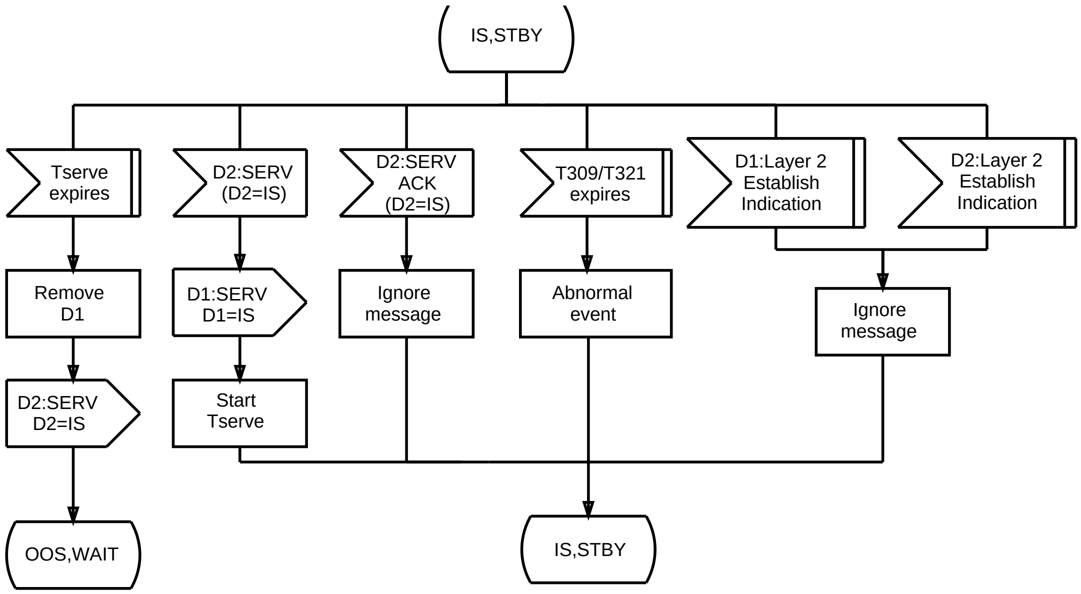
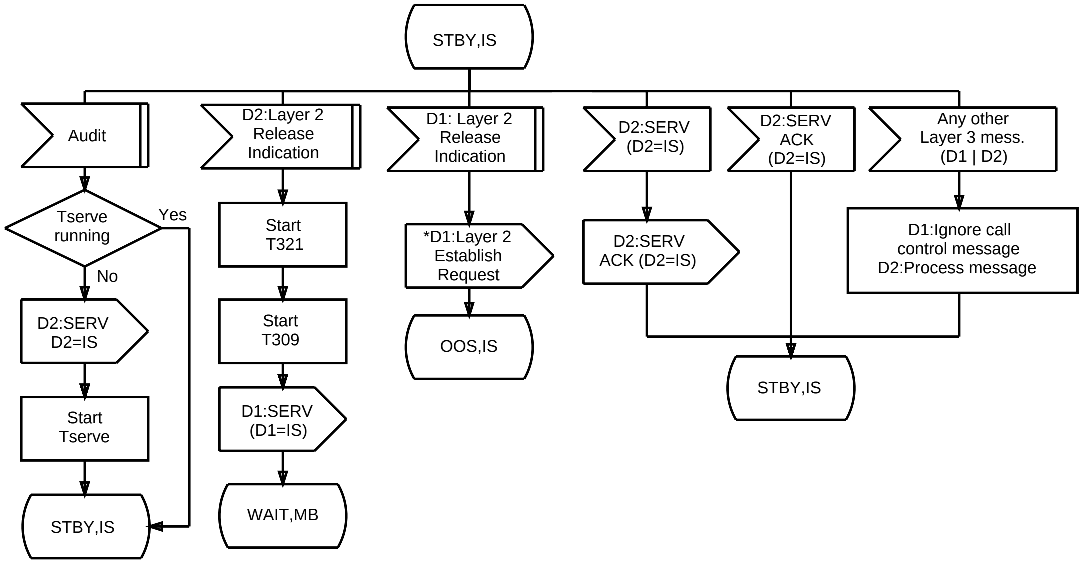


Figure 9.3-26 — National ISDN PRI with D-channel Backup: In Service, Standby (1 of 2)



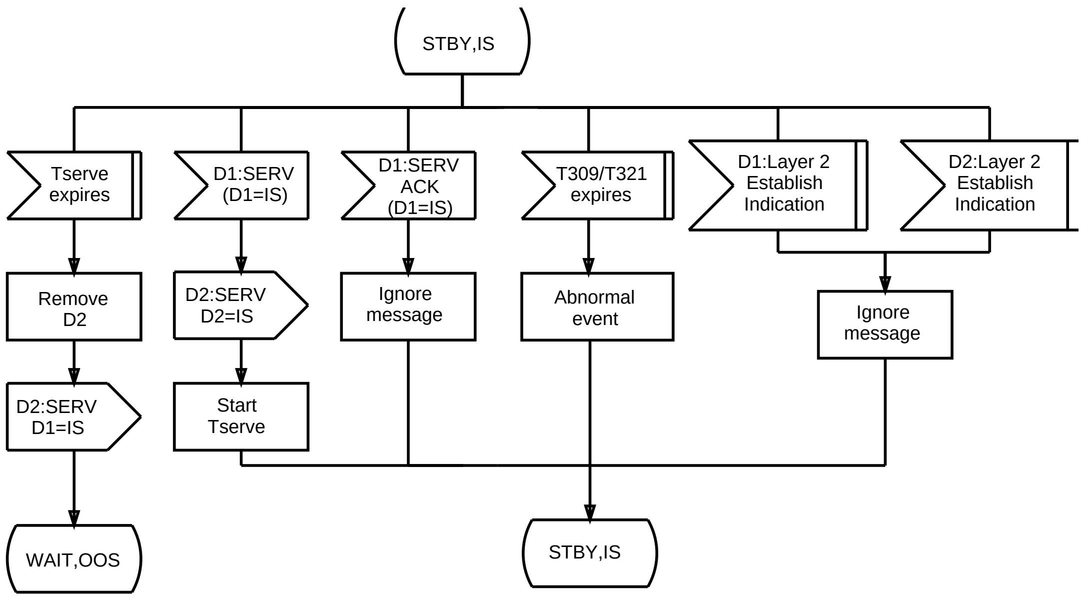
Note: This diagram applies to National ISDN PRI D-Channels only.

Figure 9.3-26 — National ISDN PRI with D-channel Backup: In Service, Standby (2 of 2)



Note: This diagram applies to National ISDN PRI D-Channels only.

Figure 9.3-27 — National ISDN PRI with D-channel Backup: Standby, In Service (1 of 2)



Note: This diagram applies to National ISDN PRI D-Channels only.

Figure 9.3-27 — National ISDN PRI with D-channel Backup: Standby, In Service (2 of 2)

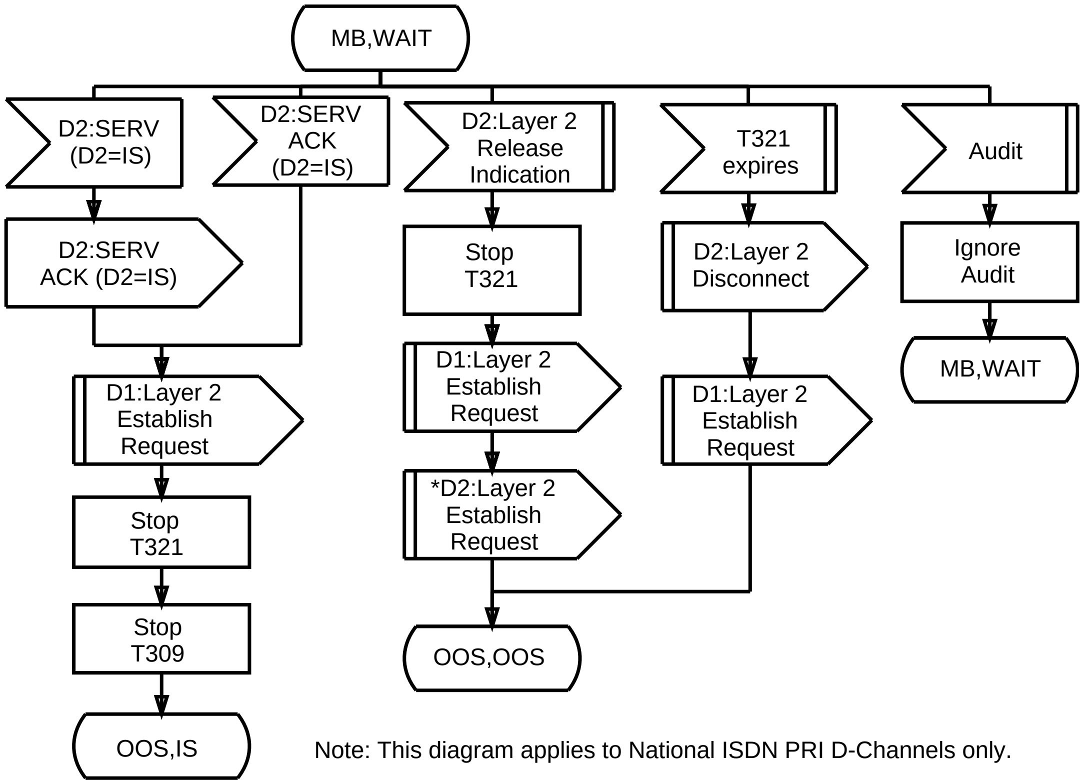
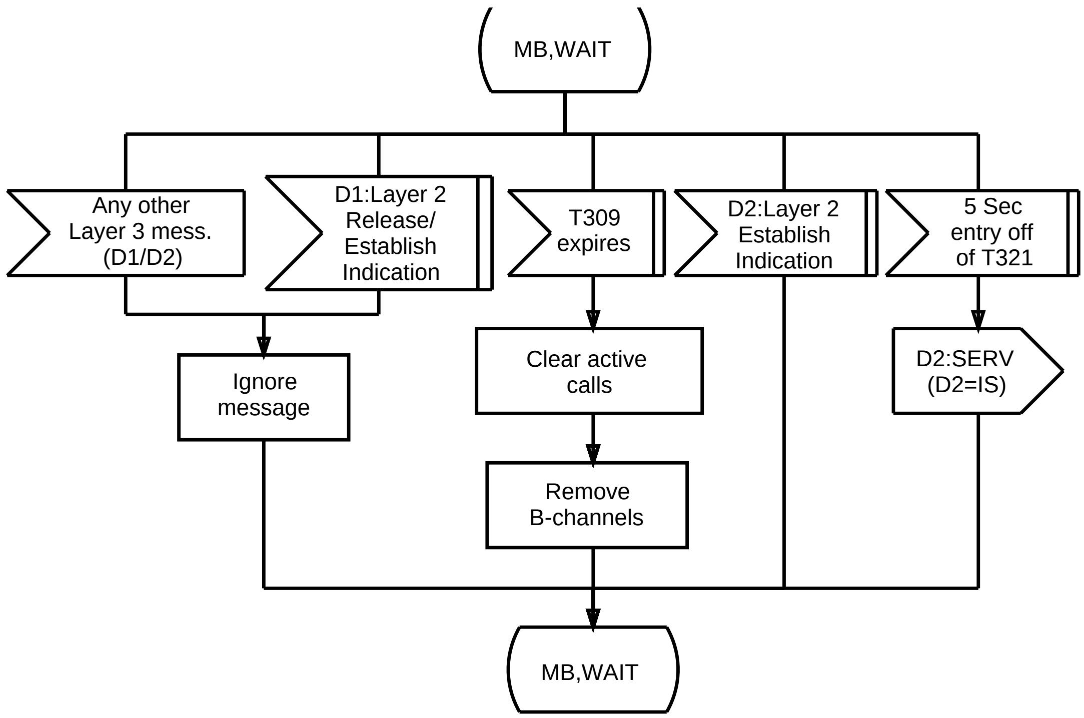
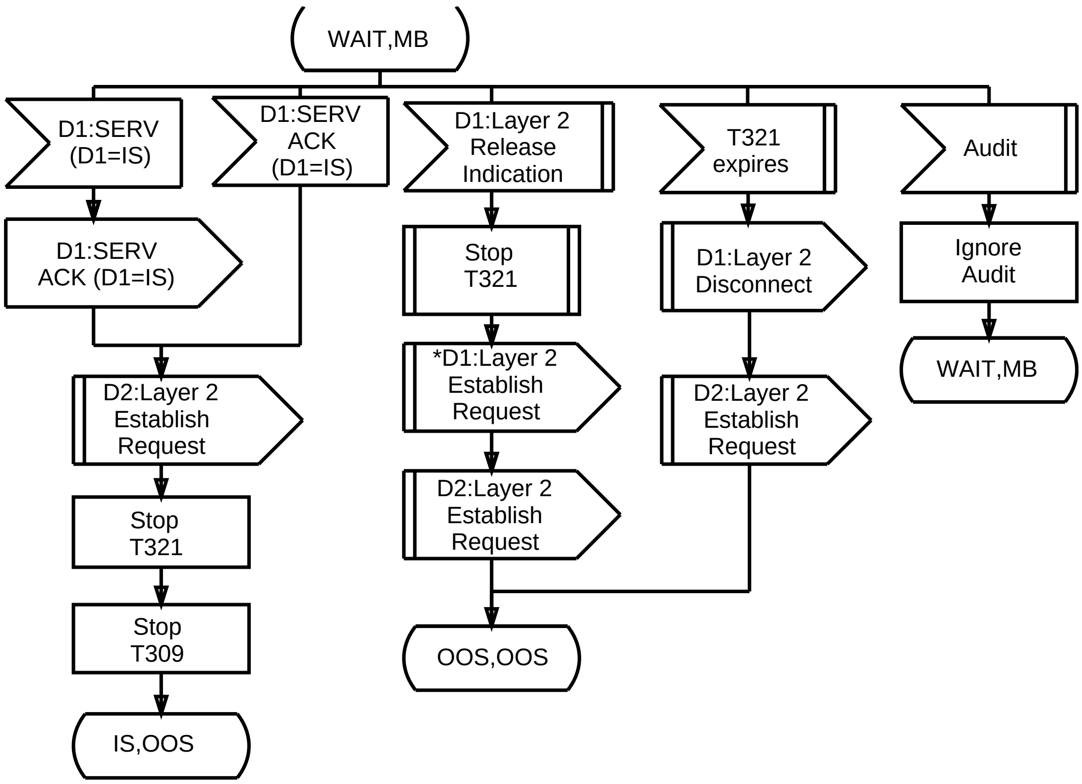


Figure 9.3-28 — National ISDN PRI with D-channel Backup: Maintenance Busy, WAIT (1 of 2)



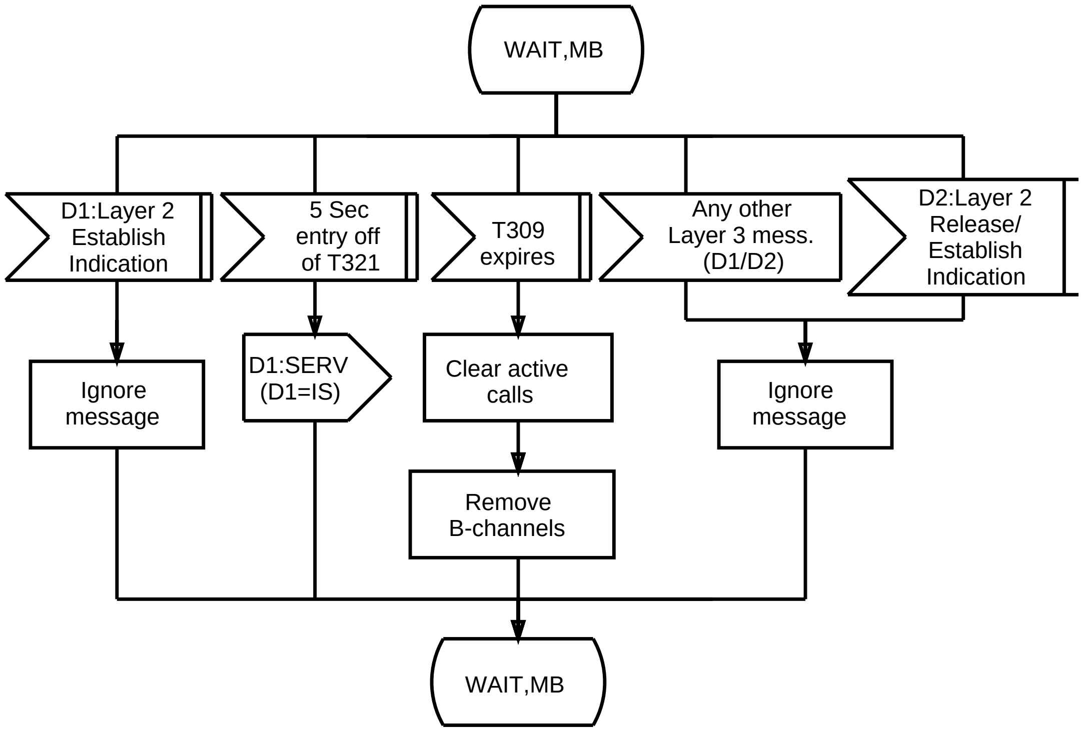
Note: This diagram applies to National ISDN PRI D-Channels only.

Figure 9.3-28 — National ISDN PRI with D-channel Backup: Maintenance Busy, WAIT (2 of 2)



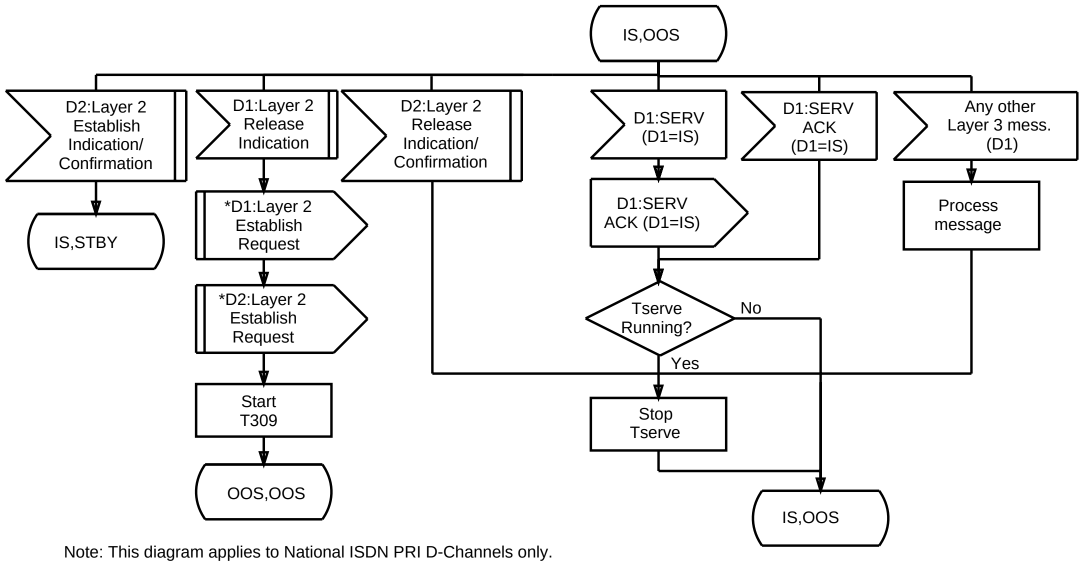
Note: This diagram applies to National ISDN PRI D-Channels only.

Figure 9.3-29 — National ISDN PRI with D-channel Backup: WAIT, Maintenance Busy (1 of 2)



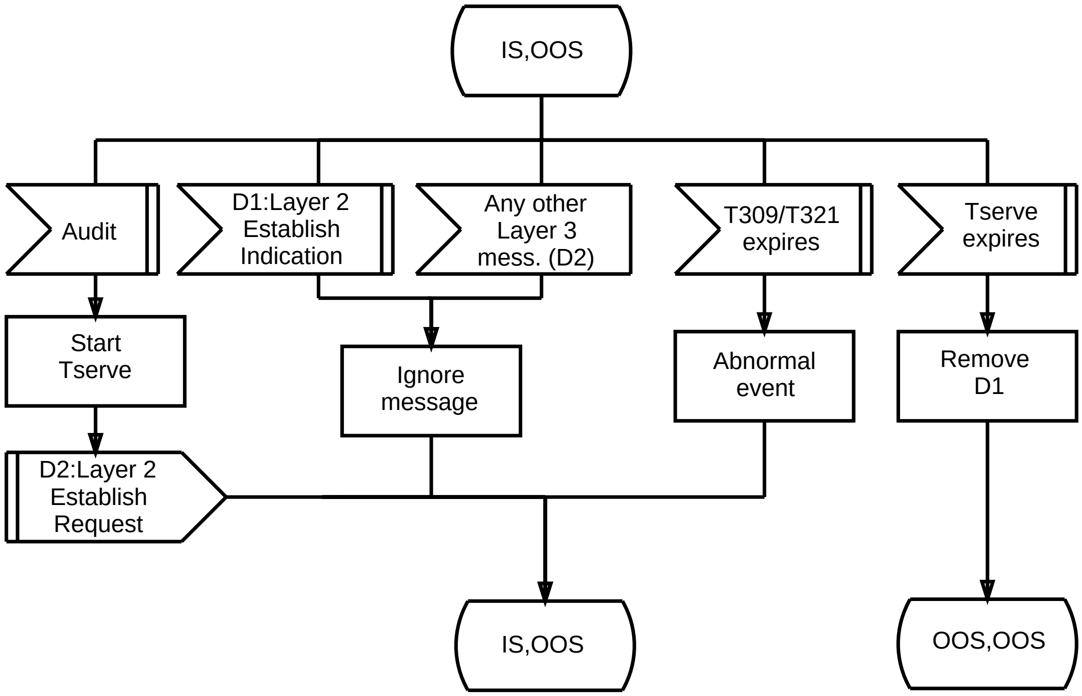
Note: This diagram applies to National ISDN PRI D-Channels only.

Figure 9.3-29 — National ISDN PRI with D-channel Backup: WAIT, Maintenance Busy (2 of 2)



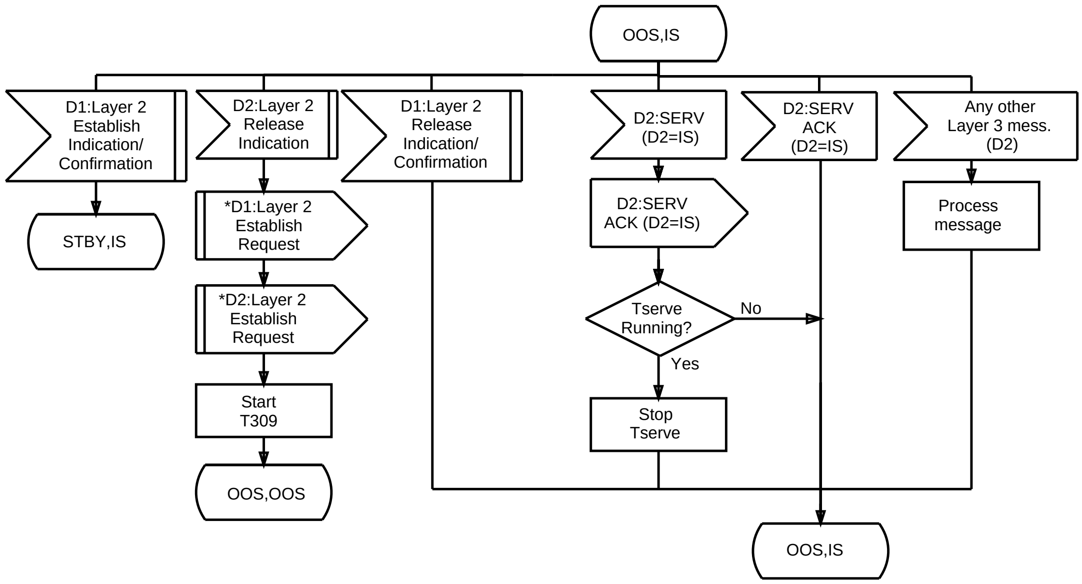
Note: This diagram applies to National ISDN PRI D-Channels only.

Figure 9.3-30 — National ISDN PRI with D-channel Backup: In Service, Out of Service (1 of 2)



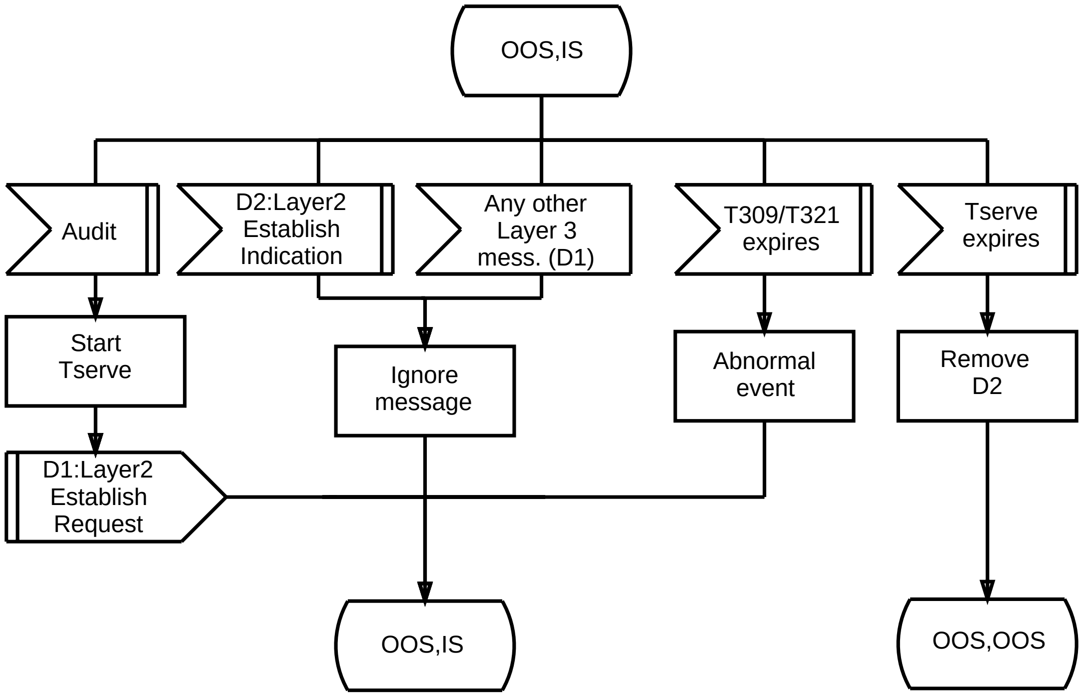
Note: This diagram applies to National ISDN PRI D-Channels only.

Figure 9.3-30 — National ISDN PRI with D-channel Backup: In Service, Out of Service (2 of 2)



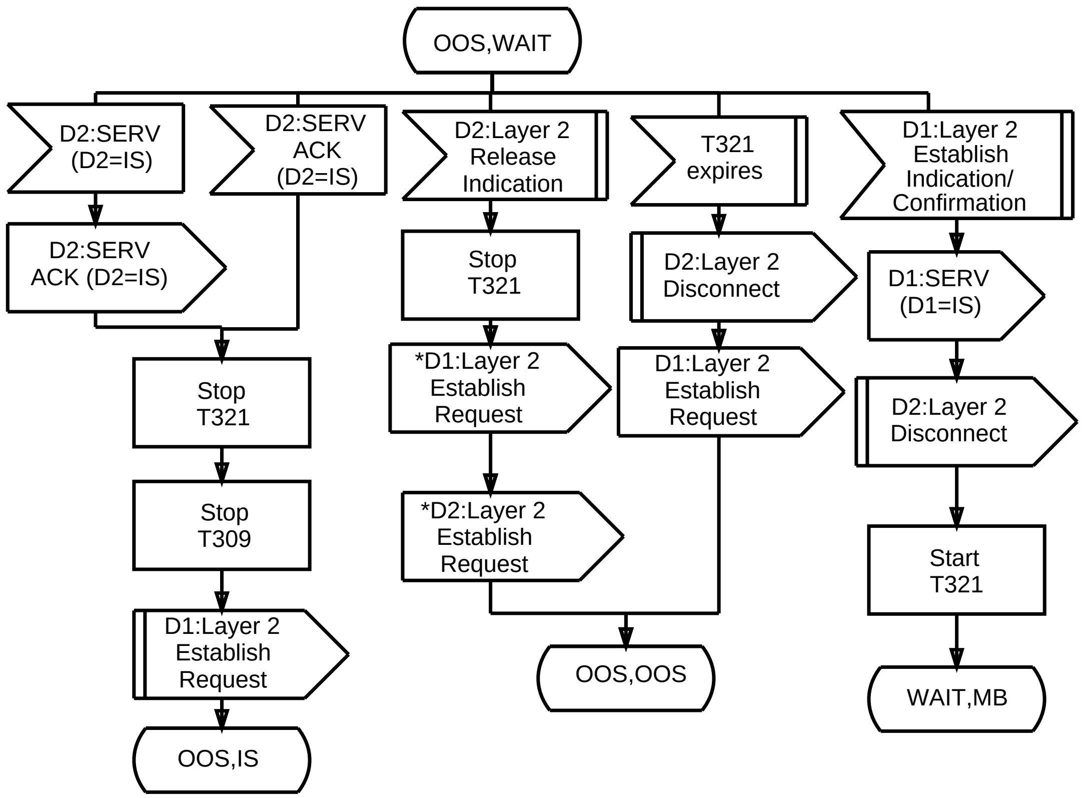
Note: This diagram applies to National ISDN PRI D-Channels only.

Figure 9.3-31 — National ISDN PRI with D-channel Backup: Out of Service, In Service (1 of 2)



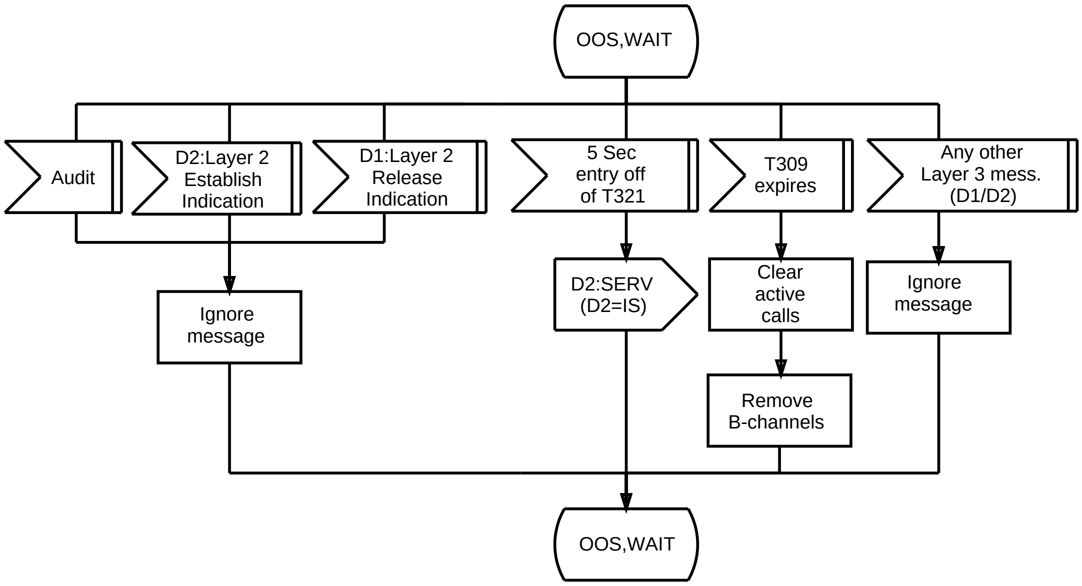
Note: This diagram applies to National ISDN PRI D-Channels only.

Figure 9.3-31 — National ISDN PRI with D-channel Backup: Out of Service, In Service (2 of 2)



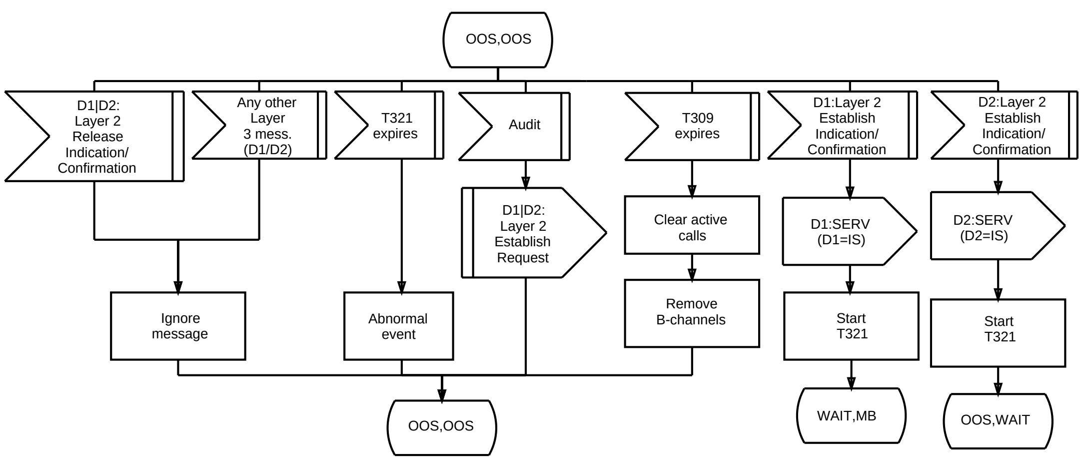
Note: This diagram applies to National ISDN PRI D-Channels only.

Figure 9.3-32 — National ISDN PRI with D-channel Backup: Out of Service, WAIT (1 of 2)



Note: This diagram applies to National ISDN PRI D-Channels only.

Figure 9.3-32 — National ISDN PRI with D-channel Backup: Out of Service, WAIT (2 of 2)



Note: This diagram applies to National ISDN PRI D-Channels only.

Figure 9.3-33 — National ISDN PRI with D-channel Backup: Out of Service, Out of Service

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10. NON-FACILITY ASSOCIATED SIGNALING AND D-CHANNEL BACKUP

10.1 GENERAL

10.1.1 NON-FACILITY ASSOCIATED SIGNALING

Non-Facility Associated Signaling (NFAS, also called “Multiple DS1 Facilities Controlled by a Single D-channel”) allows the D-channel to establish, control, and maintain B-channels on a DS1 facility other than the facility containing the D-channel. This feature, *supported on only the* **5ESS®** *switch National ISDN PRI*, permits a single D-channel to control the B-channels on as many as 20 DS1 facilities (up to 479 B-channels). These facilities may be T1 carriers, DNU-Ss, or combinations of T1 carriers and DNU-Ss, but all facilities must terminate on the same switching module of the *5ESS* switch. A related feature, D-channel Backup, permits a D-channel from one of the DS1 facilities to be used as a backup to the controlling D-channel.

A B-channel can be controlled by only one D-channel (with the understanding that the D-channel may have a backup, as described in the following paragraphs), and the D-channel cannot control multiple PRI groups. Also, the D-channel must continue to occupy the 24th time-slot on the DS1 facility on which it resides.

The protocol messages and information elements (IEs) defined in previous sections support NFAS primarily through the Channel ID IE, which is expanded to accommodate B-channels on other DS1 facilities.

10.1.2 D-CHANNEL BACKUP

When NFAS is employed, the reliability of the signaling for the PRI will be improved by the use of a standby, or backup, D-channel. The remainder of this section is a description of the protocol, procedures, and operation of the NFAS primary D-channel and its backup, or secondary D-channel.

Note: D-channel backup is supported on only the *5ESS* switch National ISDN PRI.

The primary and secondary D-channels are designated at provisioning time at both sides of the interface. The primary D-channel (labeled D1) and secondary D-channel (labeled D2) are each on the 24th time-slot of different DS1 facilities; D1 and D2 cannot be on the same DS1 facilities. The DS1 facilities on which the primary and secondary D-channels reside may be T1 carriers or DNU-S units; one D-channel may be on a T1 carrier and the other D-channel may be on a DNU-S unit. When both D-channels are out of service, the primary D-channel has priority in reestablishing service. If D1 service cannot be established, then D2 is chosen. (See the following procedures.)

While one of the D-channels (D1 or D2) is the active D-channel, it is used to send signaling messages across the user-network interface for B-channels on multiple DS1s, including all B-channels on the DS1 containing the standby D-channel. The other D-channel (D1 or D2) serves as the standby D-channel and is active at Layer 2 only, supporting SAPI 0 messages. No Layer 3 call-control signaling is sent on the standby channel while the active channel conveys signaling messages; only the SERVICE message can be received on the standby channel at Layer 3. All other Layer 3 messages received on this channel are ignored. A link audit frame will be sent on the standby D-channel, following normal Layer 2 procedures, at intervals determined by the appropriate Layer 2 timer associated with SAPI 0.

The pair D1 and D2 provide signaling for a predefined set of B-channels and cannot back up any other D-channel in a different PRI group. Since at any given time, one of the D-channels (D1 or D2) is in a standby role, load sharing between D1 and D2 is not possible. Neither D1 nor D2 can serve as a B-channel while designated as either an active or a standby D-channel.

When a transition occurs, those calls in the Active state (Call State 10), will be preserved, although Message-Associated, User-to-User Information may be lost.

10.2 D-CHANNEL STATES

For the D-channel backup procedures, the following states at Layer 3 apply to either D1 or D2:

1. In-Service (IS)

   A D-channel is said to be in the IS state (or Active state) when it is carrying call control information and its Layer 2 state is as follows:

   a. In the Multiple Frame Establish, Timer Recovery, or Release Wait state

   b. In the Establish Wait state due to timer recovery procedures.

2. Standby (STBY)

   A D-channel is said to be in the STBY state when it is NOT carrying call control information and its Layer 2 state is as follows:

   a. In the Multiple Frame Establish, Timer Recovery, or Release Wait state

   b. In the Establish Wait state due to timer recovery procedures.

   All Layer 3 call control messages received in this state will be ignored; only the SERVICE message will be handled.

3. Out-of-Service (OOS)

   A D-channel is said to be in OOS state when its Layer 2 state is as follows:

   a. TEI Assigned or TEI Unassigned with transmission/reception hardware active

   b. In the Establish Wait state due to link establishment procedures.

   In this state, a request is made periodically by Layer 3 to attempt to reestablish Layer 2 by transmitting a SABME message.

4. Manual Out-of-Service (MOOS)

   A D-channel is said to be in the MOOS state when a nonsignaling/external entity (usually a technician) has removed it from service. A D-channel in MOOS condition has its transmission/reception hardware turned off, all incoming frames are ignored, and no attempts are made by Layer 3 to establish Layer 2.

5. Maintenance Busy (MB)

   A D-channel is said to be in the MB condition when its transmission/reception hardware is turned off, all incoming frames are ignored, and no attempts are made by Layer 3 to establish Layer 2.

   The MB state is a transient state entered automatically when a D-channel in the IS state is declared failed, and an attempt is made to switch to the standby D-channel. (However, if the active and standby states are IS and MOOS, respectively, and the active D-channel is declared failed, then the states transition automatically to OOS and MOOS to ensure that the D-channel not in the MOOS state can be returned to service when possible.) The MB state is also used when both D-channels are OOS during initialization and the primary D-channel transitions to WAIT when Layer 2 is established. At this time, the secondary D-channel moves to MB to prevent it from coming into service while the primary D-channel is establishing Layer 3.

6. WAIT

   A D-channel is said to be in the WAIT state when an attempt has been made by the switch to establish Layer 3 peer-to-peer communication on the channel as part of the process of going to the IS state. A D-channel is placed in the WAIT state only after a SERVICE message has been sent for that D-channel.

These Bellcore-defined states largely cover the D-channel states used internally in the *5ESS* switch. However, the states do not address conditions where hardware has been automatically removed from service or protocol processing discontinued because of apparent malfunction. If the state is entered because of an apparent hardware malfunction, it is similar to the MOOS state described above; that is, external intervention is necessary to restore service (but the condition is entered automatically, rather than manually as noted in the definition of MOOS). If the condition is entered because of an apparent software failure, the D-channel will not respond to external communication attempts, but may actively try to reestablish communications on a periodic basis.

To cover these states, the following text will use the term Auto-Out-Of-Service (AOOS). This term is an abbreviation for a number of actual states used in the switch but with no counterpart in Bellcore terminology. For the purposes of describing the actions of the interface, it is sufficient to understand that AOOS is a condition in which the *5ESS* switch will not communicate, at Layer 2 or Layer 3 until external action is taken or the automatic switch maintenance procedures prompt a retry.

10.3 OPERATIONAL DIFFERENCE BETWEEN IS AND STBY D-CHANNELS

During normal operation, the IS D-channel carries all call-control signaling at Layer 3. The standby D-channel carries only Layer 2 audit messages, using Timer T203 (value: 30 seconds). Figure 10-1 depicts normal connection verification on either the active or a standby D-channel.

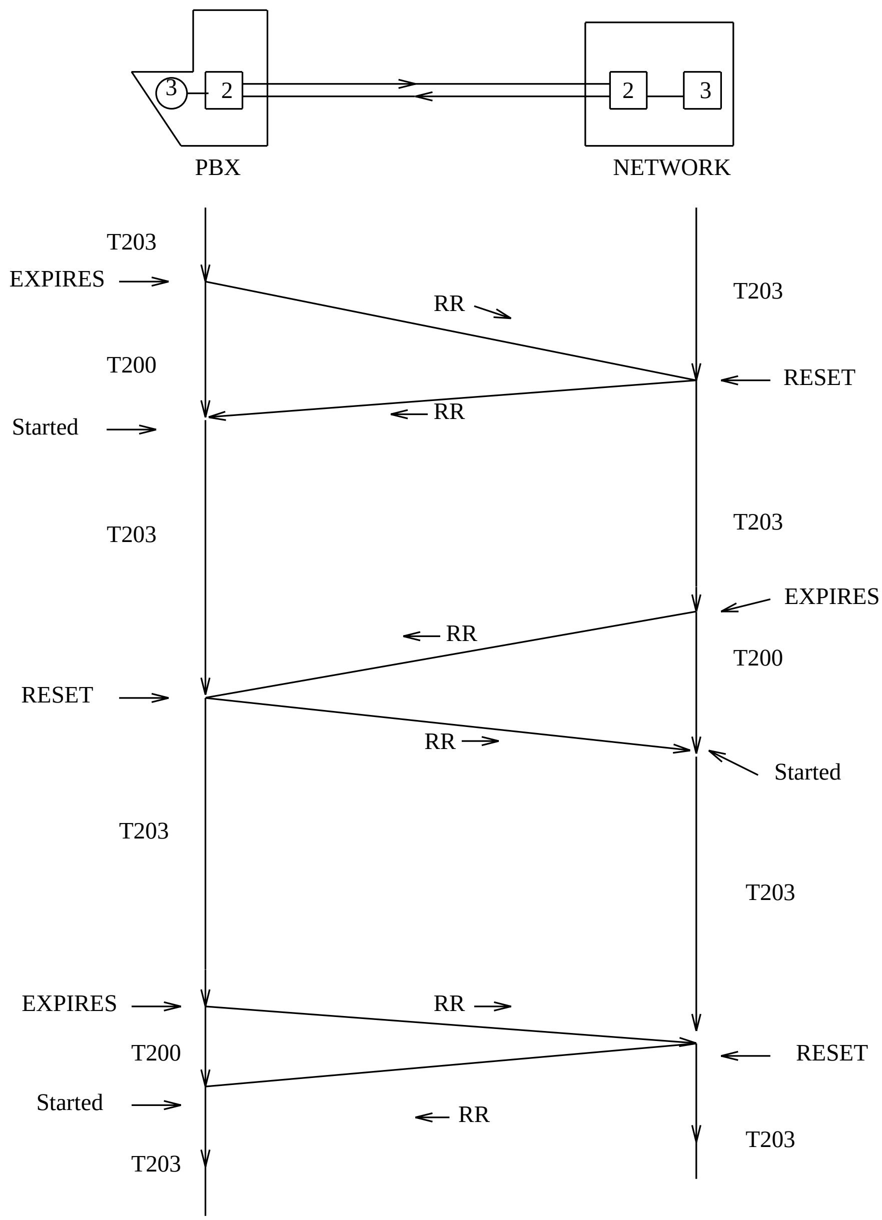

Figure 10-1 — Connection Verification Procedure on D2

10.4 D-CHANNEL BACKUP RULES

The following rules provide a high-level description of the procedures. As an abbreviation, the states of D1 and D2 are represented as (D1 state, D2 state). For example while D1 is active and D2 is standby, the notation is (IS, STBY).

The high-level rules are as follows:

1. A switch-over is allowed only when one of the D-channels is IS and the other is STBY. If D1 and D2 are (IS, STBY) or (STBY, IS) and the IS D-channel Layer 2 fails, Layer 3 will switch to the STBY D-channel using the procedures described in “Switch-over,” Section 10.5.

2. If the states are (OOS, OOS), precedence is given to establishing D1 following the procedure described in “Switch-over,” Section 10.5. Also, if D2 is brought up at Layer 2 followed by D1, D1 will still be given precedence in establishing Layer 3 (see Figure 10-2).

3. To ensure coordinated D-channel initialization, both ends of the PRI must agree on the same D-channel as the primary D-channel. Furthermore, to ensure that a Layer 2 path is available for Layer 3 messages during initialization, it is necessary for Layer 2 to be functioning (that is, the SABME/UA exchange has occurred), the SERVICE message has been sent, and the D-channel has transitioned to a WAIT, *before* the other D-channel moves to MB. (This avoids a situation known as “deadlock” in Bellcore documentation.)

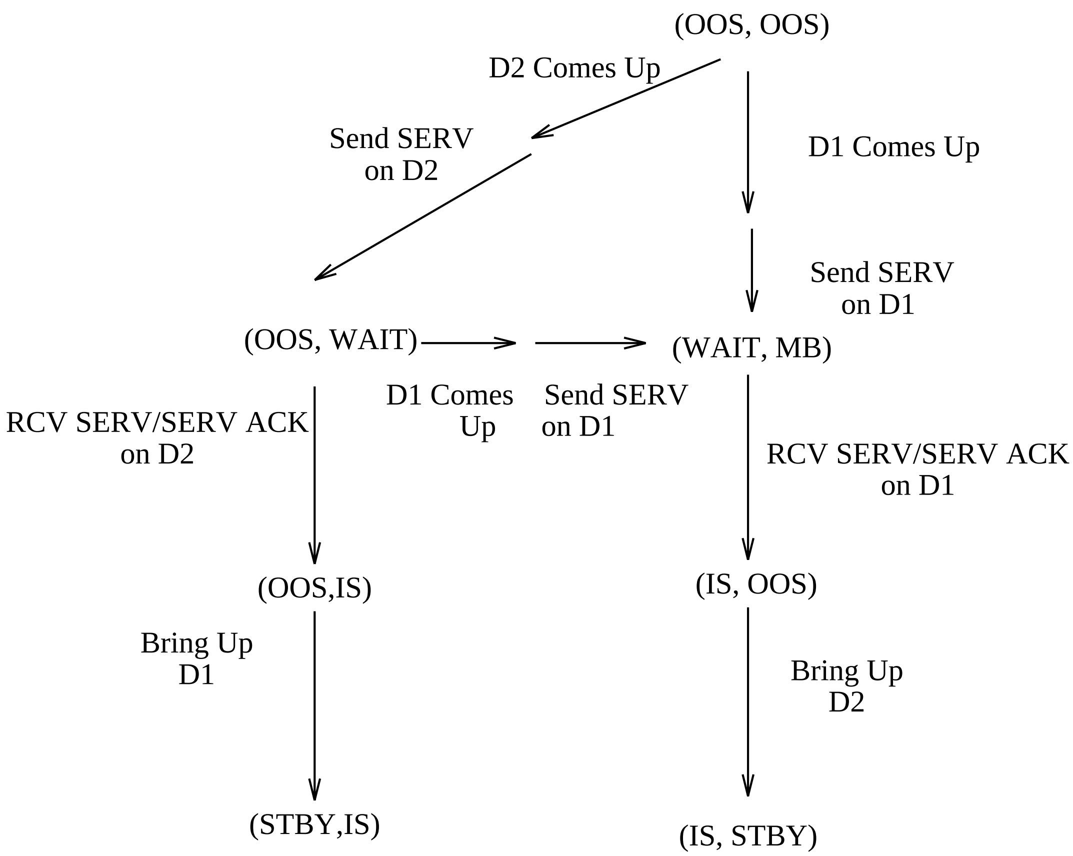

Figure 10-2 — Initialization Procedure

10.5 SWITCH-OVER

If the initial state is (IS,STBY), the switch-over will occur after the following sequence. The same procedure applies if the initial state is (STBY,IS), but the references to D1 and D2 are exchanged.

1. D1 is placed in the maintenance busy (MB) condition, D2 is placed in WAIT, and Timers T309 and T321 are started.

2. All the transient calls will be lost without exchange of any Layer 3 (Q.931) messages. Layer 3 will clear the transient calls toward the network side by sending the appropriate call-clearing message with cause code value of 41 “Temporary Failure.”

3. A SERVICE message is sent on D2 with the indication that D2=IS (abbreviated as SERV (D2=IS)), D2 moves to the WAIT state, and one of the following events is expected to occur:

   a. If Layer 3 receives a SERV or SERV ACK message (D2=IS) on D2, Layer 3 stops the T321 and T309 timers. If a SERV message is received, Layer 3 also sends back a SERV ACK message. When the T309 timer is stopped, a STATUS ENQUIRY message is sent to the other end for all stable calls to make sure the call states are the same at both sides of the interface.

      Layer 3 transitions D2 to IS and D1 to OOS, MOOS, or AOOS (where AOOS is defined in “D-channel States,” Section 10.2, as an abbreviation for an internal *5ESS* switch state) depending on the stimulus causing the switch-over. The transition in this scenario will be (IS, STBY) to (MB, WAIT) to (OOS [or MOOS, or AOOS], IS). Transitioning D2 to IS allows Layer 3 call control signaling to be accepted and sent on that channel.

   b. If T321 is still running and Layer 3 has received no SERV/SERV ACK response within 5 seconds, a SERV (D2=IS) message is retransmitted on D2, and D1 and D2 remain in (MB, WAIT). This SERV (D2=IS) message is retransmitted on the D2 every 5 seconds until a SERV/SERV ACK is received or T321 expires. If the T321 timer expires, Layer 3 transitions D1 and D2 to (OOS [or MOOS, or AOOS], OOS) and begins the initialization procedure.

      If no D-channel service is established before T309 expires, then call-clearing procedures are begun for all calls on the PRI.

   c. If Layer 3 receives any other Q.931 message on D2, D2 remains in WAIT and Layer 3 ignores the message.

   d. If Layer 2 fails, an indication is sent to Layer 3, which will will stop T321 and place the D-channels in (OOS [or MOOS, or AOOS], OOS).

Figure 10-3 gives a high-level description of the normal switch-over message flow from the primary D-channel (D1) to the secondary D-channel (D2), and gives the sequence of D-channel states for this switch-over.

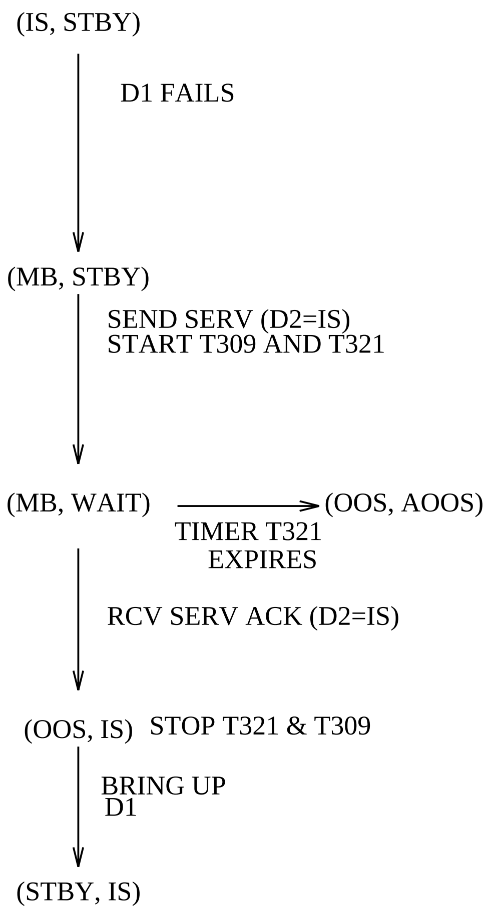

Figure 10-3 — Normal Switch-Over

10.6 REMOVAL OF STBY D-CHANNEL

If D1 and D2 are (IS, STBY) or (STBY, IS) and the STBY D-channel fails at Layer 2, Layer 3 will transition the STBY D-channel to OOS. That is, if D1 and D2 are (IS, STBY), then they will transition to (IS, OOS [or AOOS, or MOOS]). Periodic attempts will be made to bring the out-of-service D-channel to STBY if its removal was scheduled automatically by *5ESS* switch software.

10.7 REMOVAL OF LAST D-CHANNEL

If D1 and D2 are (IS, OOS), (OOS, IS), (IS, MOOS), (MOOS, IS), (IS, AOOS), or (AOOS, IS) and the IS D-channel fails at Layer 2, Layer 3 will perform as follows.

1. If the removal was requested automatically by *5ESS* switch software due to failure of Layer 2, then:

    a. The IS D-channel is transitioned to OOS.

    b. Timer T309 is started.

    c. If the second channel is OOS, the restoration of Layer 2 on the second channel is triggered and normal initialization procedures are followed when Layer 2 is established.

d. If the second channel is MOOS or AOOS, it will remain in that state until the switch maintenance software recovers the channel (AOOS) or until a technician intervenes (MOOS). While T309 is running, the switch will attempt to re-establish Layer 2 on the OOS channel (the channel that initially failed) at 30-second intervals. If T309 expires routine attempt to establish Layer 2 on the OOS channel will continue, but less frequently.

2. If the removal was requested by manual intervention, then:

   a. The IS D-channel is transitioned to MOOS.

   b. The restoration of Layer 2 on the OOS D-channel is triggered and normal initialization procedures are followed when Layer 2 is established. If the second D-channel is MOOS [that is, if the initial state is (IS, MOOS) or (MOOS, IS)], the second D-channel cannot be initialized and both channels will remain MOOS until a technician intervenes.

   c. If the second D-channel is AOOS, then the second channel cannot be initialized, and the channels will remain in (MOOS, AOOS) or (AOOS, MOOS) until the switch maintenance software recovers the AOOS channel or a technician intervenes.

3. If the removal was caused by hardware or software problems, then:

   a. The IS D-channel is transitioned to AOOS.

   b. Timer T309 is started.

   c. The restoration of Layer 2 on the OOS D-channel is triggered and normal initialization procedures are followed when Layer 2 is established. If the second D-channel is MOOS or AOOS, the second D-channel cannot be initialized, and the channels will remain AOOS and/or MOOS until a technician intervenes or the switch maintenance software recovers the AOOS channel.

10.8 RESTORATION OF OOS D-CHANNEL WHEN OTHER D-CHANNEL IS IN-SERVICE

If D1 and D2 are (IS, OOS) or (OOS, IS) and the OOS D-channel reestablishes Layer 2 (either autonomously or using a request from Layer 3), Layer 3 will transition the OOS D-channel to STBY. That is, if D1 and D2 are (IS, OOS), then they will transition to (IS, STBY).

10.9 SERVICE MESSAGE AND INFORMATION ELEMENTS WITH D-CHANNEL BACKUP

With the National ISDN PRI, the SERVICE and SERVICE ACKNOWLEDGE messages are used only to control and monitor the D-channel state. Unlike their use on the Custom interface, the SERVICE and SERVICE ACKNOWLEDGE messages do not have any affect on the state of the B-channels. SERVICE and SERVICE ACKNOWLEDGE messages are used for the following purposes:

- To bring D-channel in the WAIT state to an IS condition
- To perform an audit on an IS D-channel to ensure it is operating properly, and to avoid any possible deadlock conditions.

The SERVICE and SERVICE ACKNOWLEDGE messages, and all related information elements and their use are described in “Layer 3 Maintenance Messages,” Section 9.1.3.

10.9.1 ROUTINE CHECKING OF D-CHANNEL

At intervals determined by routine port conditioning, the following procedure is performed to audit the active D-channel when DCBU is provisioned. A SERVICE message is sent out on the active D-channel. When the message is sent out, the Timer TSERV is started. TSERV has a duration of 5 minutes. While TSERV is running, the SERVICE message is resent at 1-minute intervals. If a SERVICE ACKnowledge message has not been received by the time TSERV has expired, the active and standby D-channels are switched, and the formerly-active D-channel is taken out of service. These routine checks are performed whether or not calls are active.

The procedure of sending the SERVICE message and starting the TSERV timer is also initiated if a SERVICE message or a SETUP message is received on the standby D-channel.

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11. PRI SERVICE-SPECIFIC INFORMATION

11.1 BASIC SERVICES

The following procedures are common to both the central office-private branch exchange (CO-PBX) and PBX-PBX cases.

Basic services supported include the following:

- Basic voice
- 3.1-kHz audio
- 64-kbps clear/restricted
- Interworking with switched 56-kbps services
- X.31 packet transport mode over provisioned B-channels.

11.1.1 BASIC VOICE

To request a basic circuit mode voice service, the user shall use the bearer capability IE in the following manner:

- The information transfer capability is set to speech.
- The information transfer rate is set to 64 kbps.

11.1.2 3.1-kHz AUDIO

To request a 3.1-kHz audio service, the user shall use the bearer capability IE in the following manner:

- The information transfer capability is set to 3.1-kHz audio.
- The information transfer rate is set to 64 kbps.

The 3.1-kHz audio bearer capability provides a way for the network to segregate voice-band data services (facsimile and modem) from low grade voice services. Low grade voice services are subject to treatments such as echo cancellation and control for voice transport, signal compression by hardware, time assignment speech interpolation mechanisms, and low bit rate voice (LBRV) mechanisms, each of which is either undesirable or unacceptable for data services due to distortion created in the data.

A 3.1-kHz audio call terminating to the *5ESS*® switch over a primary rate interface (PRI) may be routed as a speech call or a 3.1-kHz audio call by the switch, depending on switch provisioning. However, the 3.1-kHz bearer capability will be passed as the bearer capability to the end-point.

All calls originating on the switch from in-band facilities [analog lines, multi-frequency (MF) trunks, or dial pulse (DP) trunks] and terminating to a PRI will be coded as 3.1-kHz audio calls when they are delivered to the PRI. Calls originating on the switch from out-of-band signaling facilities [PRI, basic rate interface (BRI), or common channel signaling (CCS)] and terminating to a PRI will pass the received bearer capability in the SETUP message when delivered to the PRI.

Customer premises equipment (CPE) connected to the *5ESS* switch over a PRI must be capable of handling either coding for voice traffic.

11.1.3 64-kbps CLEAR/RESTRICTED

With a 64-kbps restricted (64R) switched end-to-end digital connection, the customer is responsible for ensuring that the all-zero octet is not transmitted. If the all-zero octet is transmitted, one of the bits will be changed to a one, corrupting the information. The 64-kbps clear (64C) channel connections will be supported on T1 carrier where bipolar with 8 zero substitution (B8ZS) coding and the extended superframe (ESF) format are available end-to-end. The 64C allows user information transfer at 64 kbps with no restrictions on the content. The 64C is supported on the digital networking unit (DNU) – synchronous optical network (SONET), referred to as DNU-S, facilities. B8ZS coding is not applicable to DNU-S facilities.

To request a 64-kbps clear/restricted channel, the user shall use the bearer capability IE in the following manner.

- The information transfer capability is set to unrestricted/restricted digital information.
- The information transfer rate is set to 64 kbps.

When the exchange offers this 64-kbps clear/restricted call, it follows the same procedure.

11.1.4 OTHER DATA SERVICES

The procedures to request a 56-kbps call or an X.31 packet transport mode call are described in “Data Services,” Section 11.10.

11.1.5 CAUSE CODES INVOKED BY PRI BASIC SERVICES

The following cause codes may be produced during call processing of PRI calls.

- Cause code value 17 “user busy”

  If the called party is busy, the switch will release the call with a cause code value of 17 “user busy.”

- Cause code value 18 “no user responding”

  For end-to-end ISDN calls, if the far end (FE) fails to respond to the offered call, then the call is released on the PRI with a cause code value of 18 “no user responding.”

- Cause code value 28 “invalid number format”

  If a called party number is invalid or if it exceeds the maximum number of digits, the call is released with a cause code value of 28 “invalid number format.”

- Cause code value 31 “normal, unspecified”

  For internal errors, general call clearing, and some tones and announcements, the switch will include a cause code value of 31”normal, unspecified” in the applicable message.

- Cause code value 44 “requested circuit or channel unavailable”

  If the requested channel is not available due to SETUP glare or the channel is out of service (OOS) or currently allocated to another call in progress, the switch will release the call with a cause code value of 44 “requested circuit or channel unavailable.”

- Cause code value 57 “bearer capability not authorized”

If the requested bearer capability is implemented, but the user is not authorized to use it, the switch will deny the call request with a cause code value of 57 “bearer capability not authorized.”

- Cause code value 65 “bearer capability not implemented”

  If the requested bearer capability is not implemented, the switch will deny the call request with a cause code value of 65 “bearer capability not implemented.”

- Cause code value 82 “identified channel does not exist”

  If the requested channel does not exist for the PRI, the switch will release the call with a cause code value of 82 “identified channel does not exist.”

- Cause code value 96 “mandatory information is missing”

  If an information element (IE) designated as mandatory is missing, the switch will release the call with a cause code value of 96 “mandatory information is missing.”

- Cause code value 97 “message type nonexistent or not implemented”

  For messages received that contain a message type that is not recognized by the *5ESS* switch, a STATUS message is returned with a cause code value of 97 “message type nonexistent or not implemented.”

- Cause code value 98 “message not compatible with the call state”

  For Custom PRI calls, if a message is received that is not expected for the call state, then the switch will send a STATUS message with a cause code value of 98 “message not compatible with the call state.”

- Cause code value 100 “invalid information element contents”

  If an IE designated as mandatory is coded incorrectly, the switch will release the call with a cause code value of 100 “invalid information element contents.”

  If the channel identification IE included in the first response to the SETUP message does not match, the switch will release the call with a cause code value of 100 “invalid information element contents.”

- Cause code value 101 “message not compatible with the call state”

  For National ISDN PRI calls, if a message is received that is not expected for the call state, then the switch will send a STATUS message with a cause code value of 101 “message not compatible with the call state.”

11.2 DEDICATED SERVICE ACCESS

The PRI B-channels are treated as trunk group members and thereby can be provisioned for dedicated services. Typically, a number of B-channels are dedicated for each desired service such as originating POTS (OPOTS), terminating POTS (TPOTS), outward wide area telecommunications service (OUTWATS), or inward wide area telecommunications service (INWATS). Provisioned in this manner, B-channels assigned for one type of service cannot be used for another type of service. A more efficient use of B-channel resources is obtainable by using call-by-call service selection. Details on the provisioning of B-channels can be found in document 235-190-104, **5ESS** *Switch ISDN Feature Descriptions*.

11.3 PRI CALL-BY-CALL SERVICE SELECTION

11.3.1 DEFINITION

By using the appropriate code points in the network specific facilities (NSF) IE in the Q.931 SETUP message, the user can indicate to the network, on a call-by-call basis, which service (for example, OUTWATS) is desired on a B-channel call. This is in addition to specifying the bearer service in the bearer capability IE. Similarly, the network, when offering a call to a user, can indicate on a call-by-call basis the service type of the incoming call. Call-by-call Service Selection eliminates the need for dedicated channels for each service; if the customer desires dedicated channels, however, they can be provided.

11.3.2 SERVICE PROVISIONING OPTIONS

The customer may specify, at service provisioning, that all of the (switched) channels or a subset will be service-independent and used on a call-by-call basis. The customer may specify, at subscription time, the maximum number of channels that can be used simultaneously for a given service. This will prevent all the B-channels in a call-by-call (CBC) pool from being used by one service, which would result in blockage of other services. The sum of the limits for all the services assigned to that pool may exceed the total number of B-channels in the pool.

11.3.3 SUBSCRIPTION SCREENING

The network will screen calls placed over a CBC pool of channels. If the caller has not subscribed to the service requested, the call will be rejected.

11.3.4 CALL-BY-CALL SERVICE SELECTION FOR FX AND TIE

These services are available on both the National ISDN PRI and the Custom PRI.

11.3.4.1 FX Service Selection

This service provides PRI Call-by-Call Service Selection to originate PRI calls over foreign exchange (FX) facilities and to terminate calls from FX facilities to a PRI. The FX facilities must be non-ISDN private facilities that connect one CO (normal service area) with another CO (the FE). The PRI trunks can be either National ISDN PRIs or Custom PRIs. The called party number is interpreted at the FX office, not at the local office.

An FX origination is defined as a call originating from the PRI and terminating on an FX facility.

11.3.4.1.1 Coding of the SETUP Message for FX Origination

The IEs in the SETUP message received by the *5ESS* switch for an FX origination are expected to be specified as follows:

- The protocol discriminator element is to indicate Q.931.
- The call reference element is to be a valid value.
- The message type is to be SETUP.
- The bearer capability is to indicate one of the following types:
  - — speech
  - — 3.1-kHz audio
  - — unrestricted 64-kbps circuit-mode data rate adapted from 56 kbps

- The channel identification is to be specified.
- The called party number.
  - — The type of number/numbering plan identification (TN/NPI) must be one of the following allowed values.
    - international number in ISDN numbering plan
    - national number in ISDN numbering plan
    - local (subscriber) number in ISDN numbering plan
    - unknown number in unknown numbering plan
  - — Number digits.
- The network specific facilities.
  - — The network identification plan (NIP) must indicate the local service provider.
  - — The following field can be coded as a parameterized/binary field or as an extension field.[1]
    - If coded as a parameterized/binary field, it is to indicate “parameterized.”
    - If coded as an extension field, it is to indicate “last octet of field.”
  - — The feature/service field is to indicate “service.”
  - — The parameterized facility coding value field is to indicate “foreign exchange.”
  - — The service parameters field (Octet 5 and repetitions) is to indicate FX facility number (up to 5 IA5 characters). Note that leading zeros are suppressed; for example, “0003” is equivalent to “3”.

11.3.4.1.2 Coding of the SETUP Message for FX Termination

An FX termination is defined as a call originating from an FX facility and terminating on a PRI. The IEs in the SETUP message that is sent out by the *5ESS* switch for an FX termination are the same as for an FX origination except for the following IEs:

- The bearer capability IE will indicate one of the following types:
  - — 3.1-kHz audio
  - — unrestricted 64-kbps circuit-mode data rate adapted from 56 kbps
- The progress indicator IE will be coded for Progress Descriptor 1, “call not end-to-end ISDN (location: public network serving the local user).”
- The CgPN. If the calling party number/billing number (CgPN/BN) delivery feature is subscribed to at the called PRI, the TN/NPI (Octet 3) and the presentation/screening indicator (Octet 4) will be coded according to the present implementation of the *5ESS* switch CgPN/BN feature. Otherwise, the CgPN is not included in the SETUP message.

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1. Interpretation of this field by the *5ESS* switch is based on a provisioning option. If STD NSF IE is YES on Recent Change View 5.2, then it is interpreted as an extension field; if this IE is NO, it is interpreted as a parameterized/binary field.

- The called party number will be coded in the TN/NPI field to be “unknown number in unknown numbering plan.” No digits are included in the digits field.

11.3.4.2 Tie Service Selection

This service provides PRI Call-by-Call Service Selection to originate PRI calls over tie facilities and to terminate calls from tie facilities to a PRI. The tie facilities must be non-ISDN private facilities that connect a CO (normal service area) with a distant PBX or private network.

11.3.4.2.1 Coding of the SETUP Message for Tie Originations

The call origination information for routing over a tie trunk is contained in a SETUP message that is received by the switch from the originating PBX over a PRI. The IEs in the SETUP message for a tie origination are specified as follows:

- The protocol discriminator element is to indicate Q.931.
- The call reference element is to be a valid value.
- The Message type is to be SETUP.
- The bearer capability is to indicate one of the following types:
  - — speech
  - — 3.1-kHz audio
  - — unrestricted 64-kbps circuit-mode data rate adapted from 56 kbps
- The channel identification is to be specified.
- The called party number.
  - — TN/NPI: “unknown number in unknown numbering plan” or “subscriber number in private numbering plan”
  - — number digits (for senderized case)
- The NSF.
  - — The network identification plan (NIP) is to indicate the local service provider.
  - — The following field can be coded as a parameterized/binary field or as an extension field.[2]
    - If coded as a parameterized/binary field, it is to indicate “parameterized.”
    - If coded as an extension field, it is to indicate “last octet of field.”
  - — The feature/service field is to indicate “service.”
  - — The parameterized facility coding value field is to indicate “tie trunk.”
  - — The service parameters field (Octet 5 and repetitions) is to indicate tie trunk facility number (up to 5 IA5 characters). Note that leading zeros are suppressed; for example, “0003” is equivalent to “3”.

2. Interpretation of this field by the *5ESS* switch is based on a provisioning option. If STD NSF IE is YES on Recent Change View 5.2, then it is interpreted as an extension field; if this IE is NO, it is interpreted as a parameterized/binary field.

11.3.4.2.2 Coding of the SETUP Message for Tie Termination

A tie termination is defined as a call originating from a tie facility and terminating on a PRI. The IEs in the SETUP message that is sent out by the *5ESS* switch for a tie termination is the same as for a tie origination except for the following IEs:

- The bearer capability IE shall indicate one of the following types:
  - — 3.1-kHz audio
  - — unrestricted 64-kbps circuit-mode data rate adapted from 56 kbps
- The progress indicator IE shall be coded for Progress Descriptor 1, “call not end-to-end ISDN (location: public network serving the local user).”
- The CgPN. If the CgPN/BN feature is subscribed to at the called PRI, the TN/NPI (Octet 3) shall be coded as “unknown” and presentation/screening indicator (Octet 4) shall be coded as “number unavailable”; otherwise, the CgPN is not included in the SETUP message.
- The called party number. The TN/NPI shall be coded as “unknown number in unknown numbering plan.”
  - — Senderized mode. The switch shall collect digits from the tie trunk, apply screening procedures to verify that the number of digits is between the minimum and the maximum allowed, and include the digits in the digits field.
  - — Cut-through mode. No digits are included in the digits field.

11.3.5 CAUSE CODES INVOKED BY FX AND TIE SERVICE SELECTION

The following cause codes may be produced during call processing of FX and tie calls:

- Cause code value 28 “invalid number format”

  If the following transit network selection (TNS) IE is present in a tie origination, the switch sends a RELEASE COMPLETE message to the digital private branch exchange (DPBX) containing a cause code value of 28 “invalid number format” (location: public network serving the local user).

  If the called party number IE contains an invalid TN/NPI value for the requested call-by-call service, the switch rejects the call using existing call clearing procedures and uses a cause code value of 28 “invalid number format” (location: public network serving the local user).

  If the called party number IE contains a TN/NPI value coded to “unknown number in unknown numbering plan” or “subscriber number in private numbering plan,” and the maximum number of digits has been exceeded, the switch rejects the call using existing call clearing procedures and uses a cause code value of 28 “invalid number format” (location: public network serving the local user).

  If the called party number format check for an FX origination fails, the call is rejected by sending a RELEASE COMPLETE message to the PBX with a cause code value of 28 “invalid number format” (location: public network serving the local user).

  For an originating tie call, if the maximum number of digits in the called party number IE is exceeded, the call is rejected by sending a RELEASE COMPLETE message with a cause code value of 28 “invalid number format” (location: public network serving the local user).

If any of the mandatory information in the called party number IE for tie originations is invalid, the call shall be rejected by sending a RELEASE COMPLETE message to the DPBX with a cause code value of 28 “invalid number format” (location: public network serving the local user).

If digits are present in the called party IE for a call to be routed over a cut-through tie trunk facility, the call is rejected sending a RELEASE COMPLETE message with a cause code value of 28 “invalid number format” (location: public network serving the local user).

If no digits are present in the called party IE, for a call to be routed over a senderized tie trunk facility, the call is rejected using a cause code value of 28 “invalid number format” (location: public network serving the local user).

- Cause code value 34 “no circuit/channel available”

  If PRI simulated facility group (SFG) overflow handling indicates that an originating FX/tie call should be cleared, the switch shall reject the call request using a cause code value of 34 “no circuit/channel available” (location: public network serving the local user).

- Cause code value 43 “access information discarded”

  If any access information has been discarded from the SETUP message for FX or tie originations, a cause code value of 43 “access information discarded” (location: public network serving the local user, diagnostic: information element identifier) is included when the PROGRESS message is sent. There is a limit of one diagnostic per cause code value and one PROGRESS message is sent.

- Cause code value 50 “requested facility not subscribed”

  If a network-specific facilities IE specifying FX or Tie Service Selection is contained in a SETUP message that is received on a PRI that is not provisioned for CBC service, the switch rejects the call using existing call clearing procedures and uses a cause code value of 50 “requested facility not subscribed” (location: public network serving the local user).

- Cause code value 57 “bearer capability not authorized”

  If the bearer capability in the SETUP message for FX or tie originations is not supported by the requested call-by-call service, the switch rejects the call using existing call clearing procedures and uses a cause code value of 57 “bearer capability not authorized.”

- Cause code value 96 “mandatory information is missing”

  If any mandatory information that is needed to form the called party number that is outpulsed on an FX or tie origination is missing, the call is rejected by sending a RELEASE COMPLETE message to the DPBX with a cause code value of 96 “mandatory information is missing.”

- Cause code value 100 “invalid information element contents”

  If the NSF IE coding is invalid, or the fields in the NSF IE are inconsistent for FX or tie originations, the switch rejects the call using existing call clearing procedures and uses a cause code value of 100 “invalid information element contents” (location: public network serving the local user); (diagnostic: NSF IE identifier).

If the NSF IE contains an origination request for a service that is applicable only on call terminations, the switch rejects the request, clears the call using existing call clearing procedures, and uses a cause code value of 100 “invalid information element contents” (location: public network serving the local user); (diagnostic: NSF IE identifier).

If the switch receives a SETUP message over an Custom PRI and the facility coding value in the SETUP message is supported by only a National ISDN PRI, the request is rejected by sending a RELEASE COMPLETE message with a cause code value of 100 “invalid information element contents” (location: public network serving the local user).

If any mandatory information, which is needed to form the called party number that is outpulsed on an FX origination, is invalid, the call is rejected by sending a RELEASE COMPLETE message to the DPBX with a cause code value of 100 “invalid information element contents.”

In case of routing failure on an FX or tie origination, for example, due to invalid facility number or improper permission, the switch sends a RELEASE COMPLETE message with a cause code value of 100 “invalid information element contents” (location: public network serving the local user).

11.3.6 CALL-BY-CALL SERVICE SELECTION FOR NATIONAL ISDN INWATS AND OUTWATS

As part of National ISDN-2, Bellcore introduced new facility coding values of the NSF IE for INWATS and OUTWATS Service Selection (see Bellcore TR-NWT-001270). These Bellcore facility coding values are supported on both the National ISDN PRI and the Custom PRI.

Three new services are supported for INWATS and OUTWATS on the National ISDN PRI.

- National ISDN INWATS

  This service is functionally the same as that of the existing INWATS service, which is supported on the Custom and National ISDN PRI. It is identified by the new facility coding value.

- National ISDN banded OUTWATS

  This service is functionally the same as that of the existing OUTWATS service, which is supported on the Custom and National ISDN PRI. It is identified by the new facility coding value. Depending on the value of the band parameter, this service corresponds to two Bellcore-defined OUTWATS services.

  For Band = 0, the national ISDN banded OUTWATS corresponds to “OUTWATS” in Bellcore TR-NWT-001270.

  For Band = 1 – 9, the national ISDN banded OUTWATS corresponds to “OUTWATS as per TR-601” in Bellcore TR-NWT-001270.

- National ISDN unbanded OUTWATS

This service is functionally the same as that of the existing MAXOWATS service, OUTWATS with maximal band value, which is supported on the Custom and National ISDN PRI. It is identified by the new facility coding value. There is no band value associated with this service. This service corresponds to Bellcore-defined “Inter-LATA OUTWATS” service in Bellcore TR-NWT-001270.

11.3.7 CALL-BY-CALL SERVICE SELECTION FOR HOTEL/MOTEL AND SCOCS SERVICES

PRI CBC access to these services was introduced as part of National ISDN-3. These services are available on the National ISDN PRI and on the Custom PRI.

11.3.7.1 Descriptions of Existing Hotel/Motel Service and SCOCS Service

Hotel/Motel (HM) service is an existing service that enables a hotel or motel to receive services from an operator service system (OSS). Typically, the OSS identifies the guest room from which a call originates, and transmits the room number to an associated billing system that sends billing information about the call to the hotel or motel when the call ends.

Selective Class of Call Screening (SCOCS) service is an existing service that allows a call from a location such as a hospital, prison, or dormitory to be screened by an OSS to determine all calling or billing restrictions to be applied. These services were previously accessible over dedicated trunks. A call identified by the PBX as an HM or SCOCS call is routed from the *5ESS* switch to the OSS, and the corresponding ANI or ANI II digits are signaled on the trunk to the OSS.

11.3.7.2 CBC Access to HM and SCOCS Services

PRI CBC Service Selection for HM and SCOCS services enables access to these services over PRIs on a CBC basis. CBC Service Selection provides more flexible and efficient use of B-channels than dedicated PRI service provides. Simulated facility groups (SFGs) can be provisioned to effect software limits on the number of B-channels that can be occupied for each service type. Existing *5ESS* switch SFG overflow mechanisms can be employed to provide flexibility in handling higher-traffic situations.

A request for HM or SCOCS service is identified by the coding of the NSF IE in the SETUP message that is sent from the PBX to the *5ESS* switch.

11.3.7.3 Coding of the SETUP Message for HM and SCOCS Calls

The IE in the SETUP message received by the *5ESS* switch for an HM SCOCS origination is expected to be specified as follows:

- protocol discriminator element is to indicate Q.931
- call reference element is to be a valid value
- message type is to be SETUP
- bearer capability is to indicate one of the following types:
  - speech
  - 3.1-kHz audio
  - unrestricted 64-kbps circuit-mode data rate adapted from 56 kbps
  - unrestricted 64-kbps circuit-mode data
- channel identification is to be specified

- called party number
  - — The TN/NPI is one of the following allowed values:
    - international number in ISDN numbering plan
    - national number in ISDN numbering plan
    - local (subscriber) number in ISDN numbering plan
    - unknown number in unknown numbering plan
  - — Number digits
- NSF
  - — network identification plan (NIP) is to indicate local service provider or a valid carrier identification code
  - — The following field can be coded as a parameterized/binary field or as an extension field.[3]
    - If coded as a parameterized/binary field, it is to indicate “parameterized” for SCOCS service, “binary” for HM service.
    - If coded as an extension field, it is to indicate “last octet of field.”
  - — feature/service field indicates “Service”
  - — facility coding value field indicates “HM” service or “SCOCS” service
  - — parameterized field (Octet 5) for SCOCS service indicates SCOCS service parameters (up to 5 IA5 characters)

11.3.7.4 Cause Codes Invoked by HM and SCOCS Service Selection

- Cause code value 34 “no circuit/channel available”

  If PRI simulated facility group (SFG) overflow handling indicates that an originating HM/SCOCS call should be cleared, the switch shall reject the call request using a cause code value of 34 “no circuit/channel available” (location: public network serving the local user).

- Cause code value 50 “requested facility not subscribed”

  If a PRI that is provisioned for CBC service receives a SETUP message with the NSF IE specifying a service unprovisioned on the PRI, the switch rejects the call using existing call clearing procedures with a cause code value of 50 “requested facility not subscribed” (location: public network serving the local user). This treatment applies not only to HM and SCOCS service requests, but to any request for an unprovisioned service.

  If a PRI that is not provisioned for CBC service receives a SETUP message with a NSF IE containing a request for HM or SCOCS service, the switch rejects the call using existing call clearing procedures with a cause code value of 50 “requested facility not subscribed” (location: public network serving the local user).

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3. Interpretation of this field by the *5ESS* switch is based on a provisioning option. If STD NSF IE is YES on Recent Change View 5.2, then it is interpreted as an extension field; if this IE is NO, it is interpreted as a parameterized/binary field.

If the bearer capability IE indicates a bearer capability that is valid for the requested HM or SCOCS service and assigned to the PRI, but not subscribed to by the customer for the requested service, the switch rejects the call using existing call clearing procedures with a cause code value of 50 “requested facility not subscribed” (location: public network serving the local user).

- Cause code value 51 “bearer capability incompatible with service request”

  If the NSF IE indicates a request for a HM or SCOCS call, and the bearer capability IE indicates a valid bearer capability that is assigned to the PRI, but other than the values allowed for a HM or SCOCS call, the switch rejects the call using existing call clearing procedures and uses a cause code value of 51 “bearer capability incompatible with service request” (location: public network serving the local user).

- Cause code value 57 “bearer capability not authorized”

  If the bearer capability IE indicates a bearer capability that is not assigned to the PRI, the switch rejects the call using existing call clearing procedures and uses a cause code value of 57 “bearer capability not authorized” (location: public network serving the local user). This treatment applies to all PRI calls, not to only HM/SCOCS calls.

- Cause code value 63 “service or option not available, unspecified”

  If the called party number digits match dial-code Automatic Route Selection (ARS) codes or Private Facilities Access (PFA) codes, the switch rejects the call using existing call clearing procedures and uses a cause code value of 63 “service or option not available, unspecified” (location public network serving the local user).

- Cause code value 69 “requested facility not implemented”

  If Octet 4 of the NSF IE contains an untranslatable or invalid coding, the switch rejects the call using existing call clearing procedures with a cause code value of 69 “requested facility not implemented” (location: public network serving the local user). Beginning with the 5E11 software release, this treatment applies to all PRI calls, not to only HM/SCOCS calls.

- Cause code value 100 “invalid information element contents”

  If Octet 3 or Octet 5 of the NSF IE contains an invalid coding or an invalid combination of codings, the switch rejects the call using existing call clearing procedures with a cause code value of 100 “invalid information element contents” (location: public network serving the local user). On the National ISDN PRI, the following diagnostic is included, “diagnostic: Network-Specific Facilities information element identifier.”

  The following cases of invalid codings or combinations of codings of the NSF IE receive this treatment.

  — Type of network identification field in Octet 3.1 is a non-null value that is not “National Network” (code 010).

  — Network identification plan field in Octet 3.1 is specified and is not set to “Carrier Identification Code” (code 0001).

— Network identification field in Octet 3.2 is specified and either is more than 4 digits long or is 1 or 2 digits long.

— Less than 1 or more than 5 service parameters in Octet 5 when Octet 4 indicates SCOCS service.

— A service parameter value of “zero” in Octet 5 when Octet 4 indicates SCOCS service. A zero value may be 0, 00, 000, 0000, or 00000.

— Non-numeric service parameter values in Octet 5 when Octet 4 indicates SCOCS service.

— Inclusion of service parameters in Octet 5 when Octet 4 indicates HM service.

11.4 ISDN ACCESS TO IC SERVICES

This feature deals with a *5ESS* switch CO providing an ISDN PBX-switched access to an interexchange carrier (IC).

By providing ISDN access to an IC, a local exchange carrier (LEC) is able to provide an access and transport capability with end-to-end ISDN connectivity to its customers for internetworking IC services among their geographically dispersed locations. With this feature, both PBX-based networks and CENTREX-based networks can interwork together through an IC-provided service.

The following circuit-switched voice and circuit-switched data services provided by the network can be accessed through the *5ESS* switch PRI using the NSF IE as described in “Network Specific Facilities,” Section 4.3.3.15, of this specification.

11.4.1 CIRCUIT-SWITCHED VOICE SERVICES

Access to voice services such as the following is available by subscription from the user’s telephone company.

- An IC’s virtual private network (VPN), such as the Software Defined Network (SDN), which allows private use of the public-switched network by large multilocation subscribers.
- OUTWATS, which provides a substantial amount of voice-grade outward calling to stations in the subscriber’s selected service area from stations at diverse geographical points.
- INWATS, which is a terminating service.

11.4.2 CIRCUIT-SWITCHED DATA SERVICES

Access to circuit-switched data services such as the following is available by subscription from the user’s telephone company.

- An IC’s VPN, such as SDN.
- Circuit-switched data long distance service (LDS), such as AT&T Switched Digital Services (ASDS) and International Switched Digital Services (ISDS).
- Full-duplex, switched digital transmission facilities, such as those provided by AT&T’s *ACCUNET*[4] Switched 56- or 64-kbps Service.

The procedures used for accessing the IC services are the same whether they are circuit-switched voice or circuit-switched data.

4. Registered servicemark of AT&T.

Once a user has subscribed to an outgoing service (for example, access to VPN), the request for that service is made by including the NSF IE with the appropriate code point in the SETUP message. The code points are shown in “Network Specific Facilities,” Section 4.3.3.15. Incoming services (for example, INWATS) are identified to the user by the *5ESS* switch in the same manner by including the NSF IE with the appropriate code point in the incoming SETUP message.

Requests for circuit switched data services can be made in much the same way as those for circuit-switched voice services. An inter-LATA, circuit-switched data call is distinguished from an inter-LATA, circuit-switched voice call by looking at the bearer capability IE.

In summary, by examining the NSF IE, the *5ESS* switch knows the IC by which the call will be processed and the service requested. By examining the bearer capability IE, the *5ESS* switch knows the type of facility (that is, voice-grade trunk, 64C kbps) over which the call is to be routed.

In addition, the user will be required to include the called party number IE, which includes the terminating (or called) number, in order for the IC to appropriately route the call. The user may also include other information for transport to the terminating switch or user, such as the CgPN or Message-associated User-to-User Information (MAUUI).

11.5 DELIVERY OF CALLING PARTY NUMBER/BILLING NUMBER

Two different types of services are available. One of these is the “Individual Calling Line Identification (ICLID)” service for the delivery of the CgPN and the other is the “Delivery of CgPN/BN (Billing Number) to Terminating User” service for the delivery of CgPN or BN to the called PRI CPE. However, both these services operate the same way on the originating interface, but differ on the terminating side in terms of the options available to the called PRI CPE. Both these services are described in the following paragraphs. If a customer subscribes to both these services, the CgPN/BN service will take precedence.

11.5.1 ORIGINATING INTERFACE

The information provided by the originating PRI CPE is the same for both the services identified previously. This information consists of the calling directory number (DN), also referred to as station identification (SID) included in the CgPN IE in the SETUP message. Also included in this IE is the presentation indicator indicating whether presentation of the calling DN to the called party is allowed. If the originating PRI CPE does not include the calling DN, the originating CO may provide a default value that applies to the entire PRI.

The BN is a number that is always provided by the network switch serving the calling CPE and is used for the purpose of billing identification. The BN may or may not be a dialable number.

The various fields in the CgPN IE that are filled in by the calling CPE are shown in “Calling Party Number,” Section 4.3.3.7, and are discussed here.

Under “type of address,” subscriber number (7-digit number) or national number (10-digit number) is allowed. If the international number is used, the originating CO will assume the default DN applicable for that PRI.

Under numbering plans, both the ISDN numbering plan and the telephony numbering plan are supported. If the numbering plan identification in the CgPN IE is set to "private numbering plan" by the calling party, the switch will drop this user-provided CgPN and instead will provide the default CgPN.

The originating PRI CPE provides the presentation indicator to indicate whether presentation of the calling DN to the called party is allowed. The possible values are as follows:

- presentation allowed
- presentation restricted
- number not available due to interworking.

Only the first two values are allowed to be used by the calling CPE. The presentation indicator value provided in the SETUP message will override the user subscribed or the default value stored in the switch. If the presentation indicator field is absent in the SETUP message, or the calling party has not subscribed to the presentation restriction feature, the "presentation allowed" default is assumed. The user is not allowed to set this indicator to "number not available due to interworking" and if this value is used, the switch will assume the default value.

The following four values are supported for the screening indicator:

- user provided, not screened
- user provided, passed verification
- user provided, failed verification
- network provided

Only the first value is to be used by the originating CPE. However, the network, after processing, will set this value before it is forwarded to the terminating interface.

11.5.2 TERMINATING INTERFACE

If the CgPN and/or BN is not available when a call arrives at the terminating switch, the terminating switch will not attempt to get the missing number.

11.5.2.1 Individual Calling Line Identification (ICLID)

With the ICLID feature, the terminating CO delivers the CgPN to a PRI CPE on intraswitch and interswitch calls in the CgPN IE in the SETUP message.

11.5.2.2 Delivery of CgPN/BN to Terminating User

This feature provides the CgPN or BN of the calling party to the called party over a PRI.

With this feature, the terminating ISDN user can subscribe to receive CgPN or BN on an exclusive (CgPN only or BN only) or preferred (CgPN preferred or BN is preferred) basis on all incoming calls. The CgPN preferred means, if CgPN is not available, BN is acceptable. CgPN or BN will be delivered in the CgPN IE of the SETUP message through this subscription option.

If both the Individual Calling Line Identification and Delivery of CgPN/BN to Terminating User services are subscribed to by a customer, the CgPN/BN feature will take precedence.

In delivering the CgPN to the called CPE, the terminating CO may use any of the values identified for the presentation indicator and the screening indicator. If the CgPN is "presentation restricted," the switch will send a CgPN IE with no calling DN in the SETUP message and the presentation indicator set to “presentation restricted.” If the CgPN and/or BN is not available when the call arrives at the terminating switch, the terminating switch will not attempt to get the missing number. In this case, the presentation indicator will be set to “number not available due to interworking.”

When the terminating switch receives a CgPN IE with the numbering plan identification set to “private numbering plan” from another switch, it (the terminating switch) will deliver this number to the called party as such, that is, the numbering plan identification will be set to “private numbering plan.”

At the terminating switch, the value for the presentation indicator for the BN is determined by the value indicated for the CgPN because a separate presentation indicator is not supported for the BN.

11.6 USER-TO-USER SIGNALING SERVICE

User-to-User Signaling provides a means of communication between two customers by using, as a basis, the Layer 3 protocol defined in this document. User-to-User Signaling is used to exchange information between two users to provide, for example, additional facilities not described in this specification.

This service is requested on a per-call basis. Only call-associated User-to-User Signaling in association with a circuit-switched connection is provided for in this offering. This capability is also referred to as Message-associated User-to-User Information (MAUUI).

The MAUUI refers to the UUI included in Q.931 messages in the user-user IE and the end-to-end IEs mentioned in the following text. The MAUUI is contained in the SETUP, ALERTING, CONNECT, and DISCONNECT messages.

The support of MAUUI on a call depends upon the availability of appropriate network resources. User-to-User Signaling is not possible when the call encounters a non-ISDN signaling system in the network. If this occurs, a STATUS message will be sent to the user with a cause code value of 43 “access information discarded.” Both the originating and terminating users must subscribe to this service; otherwise, the UUI will not be delivered.

For MAUUI, if the originating user potentially desires UUI to be transported in the ALERTING, CONNECT, or DISCONNECT messages but has no UUI to send in the SETUP message, the originating user should still place an empty UUI-type IE in the SETUP message in order to obtain a suitable network connection.

The total length of the following IEs, including the two octets containing the IE identifier and length, may not exceed 64 octets in length in any message. If this limit is exceeded, none of these IEs will be delivered. IEs that may be passed end-to-end (that is, transport is provided transparently; no switch processing is done) are as follows:

- connected number
- redirecting number
- low layer compatibility
- user-user
- locking shift to Codeset 7

- user-specific (Codeset 7).

If the total length of the previously mentioned IEs exceeds 64 octets, none of the IEs will be transmitted and a STATUS message will be sent to the user with a cause code value of 43 “user info discarded.”

11.7 FRACTIONAL DS1 SWITCHING

Fractional DS1 Switching, also known as Fractional DS1/ISDN or NXDS0, gives end-users the ability to establish circuit-switched wideband calls with other end-users at rates from 128 kbps to 1536 kbps. This feature on the *5ESS* switch provides the bandwidth needed end-to-end for customers to perform point-to-point applications such as video conferencing, distributed data base management, imaging, and private backbone networks. Calls are switched through the *5ESS* switch fabric and the desired bandwidth is provided on demand, on a call-by-call basis, over the National ISDN PRI. End-users may set up wideband calls in the same manner as any circuit-switched ISDN call and may make and receive calls at the selected rate with another end-user using CPE appropriate for the application.

This feature is part of National ISDN-2 offering and is based on Bellcore TR-NWT-0001203.

This feature requires clear channel capabilities. The facilities must operate in the extended superframe format (ESF). This feature operates also on DS1 facilities terminating on DNU-S. The Fractional DS1/ISDN feature supports the standard H_0 and H_{11} information transfer rates defined by ITU-T and ANSI for 384- and 1536-kbps calls, respectively, and the multirate standard, which includes all rates from 128 to 1536 kbps. Refer to “Bearer Capability,” Section 4.3.3.4, for coding of the bearer capability IE requesting the desired information transfer. As required in Bellcore TR-NWT-001203, Fractional DS1/ISDN also allows end-users to subscribe to the data rate(s) needed for their application and supported by their CPE.

- 384 kbps (H_0 coding only)
- 1536 kbps (H_{11} coding only)
- 384 and 1536 kbps (H_0 and H_{11} codings)
- multirate: from 2 to 24 times 64 kbps (users who subscribe to multirate service may present 384- and 1536-kbps calls with the H_0/H_{11} or multirate bearer capability)

In addition, the feature supports three types of time slot assignment (TSA) schemes on the access interface. A TSA scheme refers to the method of allocating the multiple time slots needed for the data rate of the call.

- ***Fixed.*** A TSA scheme in which the time slots necessary to support a wideband call are assigned in consecutive, ascending order (contiguously) and the position of the first time slot is fixed. This scheme is used for all H_0 and H_{11} calls. A 384-kbps call must reside on the same DS-1 facility and must occupy fixed Time Slots 1-6, 7-12, 13-18, and 19-24 (the last set of six time slots is available only if Time Slot 24 is not used for a D-channel). A 1536-kbps call must reside on the same DS-1 facility and must occupy Time Slots 1-24.
- ***Floating.*** The time slots for a multirate call are contiguous, but the position of the first time slot may float to occupy any time slot, provided enough time slots remain to support the call. All time slots must reside on the same DS-1 facility. The floating TSA scheme applies to only multirate calls.

- ***Flexible.*** A time slot assignment scheme in which the call may occupy noncontiguous time slots, but all must reside on the same DS-1 facility. The pattern of time slots selected may be contiguous, noncontiguous, or a combination, that is, any possible grouping of time slots is acceptable. The flexible TSA scheme applies to only multirate calls.

The time slots are assigned through the slot map in the channel identification IE. Refer to “Channel Identification,” Section 4.3.3.9, for codings in the channel identification IE needed for wideband calls.

A major advantage of Fractional DS1/ISDN is that it is strictly a software feature; it operates on the switching module (SM) using existing hardware interfaces. National ISDN PRI and ISDN user part (ISUP) interoffice wideband trunk groups terminate on on digital facility interfaces (DFIs) on the digital line and trunk units (DLTUs or DLTU2s) currently in the field. This feature operates on DNU-S terminations to SM-2000 SMs. The feature also uses the existing capabilities of the administrative module (AM) and communications module (CM) to switch calls at wideband data rates. The only dependencies are the CPE and its associated functionality and, if the full 1536-kbps rate is required, nonfacility associated signaling (NFAS). Refer to document 235-190-104, **5ESS** *Switch ISDN Feature Descriptions*, for further information.

11.7.1 CAUSE CODES INVOKED BY FRACTIONAL DS1/ISDN

The following cause codes may be produced during call processing of wideband calls.

- Cause code value 17 “user busy”

  If bandwidth is not available in the terminating PRI and no alternate routes are specified, the switch will release the call with a cause code value of 17 “user busy.”

- Cause code value 28 “invalid number format”

  If a called party number exceeds the maximum number of digits, the call is released with a cause code value of 28 “invalid number format.”

- Cause code value 34 “no circuit available”

  If bandwidth is not available in the originating PRI or in the interoffice facilities, the switch will release the call with a cause code value of 34 “no circuit available.”

  If there are not enough originating or terminating simulated facilities groups (SFGs) [OPOTS/TPOTS, electronic switch services (ESSX)] available to route a wideband call, the switch will release the call with a cause code value of 34 “no circuit available.” (One SFG member is seized for each channel of a wideband call.)

- Cause code value 41 “temporary failure”

  If the number of network time slots need for a call are not available, the switch will release the call with a cause code value of 41 “temporary failure.”

- Cause code value 44 “requested circuit or channel unavailable”

  If some of the B-channels being requested in the SETUP message are in the OOS MTCE state, the switch will release the call with a cause code value of 44 “requested circuit or channel unavailable.”

- Cause code value 54 “incoming call barred”

  If one or more of the B-channels being requested in the incoming SETUP message are not yet in service (IS) and are undergoing RESTART procedures, the switch will release the call with a cause code value of 54 “incoming call barred.”

- Cause code value 57 “bearer capability not authorized”

  If the calling party or called party’s PRI is provisioned as “Custom,” the switch will clear the call with a cause code value of 57 “bearer capability not authorized.”

  If the PRI calling party requests a bandwidth that is not provisioned, the switch will release the call with a cause code value of 57 “bearer capability not authorized.” For example, if a multirate call is presented on a PRI with only 384 kbps, only 1536 kbps, or both 384 and 1536 kbps assigned, then the switch will release the call with a cause code value of 57.

  If the data rate of a call is not consistent with the data rate of the outgoing or terminating PRI, the switch will release the call with a cause code value of 57.

- Cause code value 65 “bearer capability not implemented”

  If a wideband call cannot be routed to its destination because an intermediate switch or the destination switch does not support the data rate requested, the switch will release the call with a cause code value of 65 “bearer capability not implemented.”

  If a call is presented that would terminate to a test facility, then the switch will release the call with a cause code value of 65 “bearer capability not implemented.”

- Cause code value 100 “invalid information element contents”

  If a multirate call has a transfer rate multiplier of 1 or greater than 24, then the switch will release the call with a cause code value of 100 “invalid information element.”

  If the number of time slots in the slot map is not equal to the value of the transfer rate multiplier, the switch will release the call with a cause code value of 100 “invalid information element contents.”

  If a PRI call-by-call service is selected by coding the NSF field to any value other than “blank,” the switch will release the call with a cause code value of 100 “invalid information element contents.”

  If an incoming SETUP message has incorrect or inconsistent codings (Bit 5 of Octet 3.2 does not equal 1 or Bits 4-1 of Octet 3.2 are not “0011” to indicate a B-channel slot map), then the switch will release the call with a cause code value of 100 “invalid information element contents.” Because Octet 3.2 is not used for 1536-kbps calls, the previously mentioned errors do not apply. However, if Octet 3.2 and Octet 3.3 are included for 1536-kbps calls and all other codings are correct, the octets are ignored and the call succeeds.

  If the time slots selected for a wideband call are not all in the same trunk group, the switch will release the call with a cause code value of 100 “invalid information element.”

If a 384-kbps call using the H_0 bearer capability (except on a multirate trunk group) is presented and does not use the fixed time slot assignment scheme, then the switch will release the call with a cause code value of 100 “invalid information element contents.”

If a call is presented with noncontiguous time slots on a PRI that is assigned fixed or floating time slot assignment scheme, then the switch will release the call with a cause code value of 100 “invalid information element.”

11.8 METROHUB

The Metrohub feature provides two services.

- It allows the PRI to be assigned to terminal groups (centrex business groups).
- It applies Limited Intragroup Individual Calling Line Identification (LIGI) treatment to calls terminating to the PRI.

With this feature a terminal group may contain a mixture of ISDN lines, analog lines, and other trunks including PRI. The feature is assigned on a office-wide basis, making it applicable to all terminal groups in that office. When this feature is assigned to an office, normal terminal group restrictions and screening capabilities may be applied to the PRIs that are assigned to terminal groups. These restrictions include: call-transfer, call-forwarding and call-waiting restrictions, and distinctive ringing for intragroup calls.

The LIGI screens all calls terminating to a PRI on a switch to check for the trunk group identifier (TGID) of the called and calling parties. If the TGIDs do not match, the CgPN will be marked private and will not be displayed at the called party’s station. The LIGI is an option within the Metrohub feature and can be invoked on only those switches where it is required. The LIGI requires the use of terminal groups, but assigning a PRI to a terminal group (that is, using the basic capability of Metrohub) does not necessarily invoke LIGI for that PRI. However, when LIGI is used, it must be used on a switch-wide basis for all terminal groups on that switch.

The Metrohub feature can be assigned to either a National ISDN PRI or a Custom PRI. This feature neither alters the PRI protocol nor requires special PRI procedures for it to be invoked.

11.9 ELECTRONIC TANDEM NETWORKING (ETN) ON A PRI

This feature extends a subset of the ETN features [Automatic Route Select, Facility Restriction Levels (FRL), Uniform Numbering Plan, Traveling Class Marks (TMCs), Time of Day, Facilities Management, Traffic Data Systems, and Message Detail Recording] to the PRI (either National ISDN PRI or Custom PRI). The ETN calls can be supported over a PRI between a *5ESS* switch CO and a PBX (*5ESS* switch PBX or other PBX) or between two *5ESS* switches (PBX or CO). This feature will support circuit-switched voice and circuit-switched data on the PRI.

The ETS calls are available only between ETN nodes and make use of the TCM IE in selecting the appropriate route for a given call. This TCM IE is passed in the SETUP message from one ETN node to the next as the call progresses to its destination node. The TCM IE includes three items (octets) of information; these are FRL of the caller, satellite hop counter (SHC), and end-to-end ISDN connectivity indicator (EEICI).

The FRL is used to distinguish whether a call attempt is permitted as well as which routes are to be used or denied in the process of routing the call. The SHC will provide to each ETN node how many satellite hops, if any, the call has traversed up to that point. Network information (stored in each node) containing the permissible number of satellite hops and treatment conditions (no preference, end-to-end ISDN required, or end-to-end ISDN preferred) will then determine how to act upon this call. The EEICI will indicate which one of the following three treatments should be used on a given call: route exclusively using ISDN PRI facilities or, if none are available, clear the call (ISDN required); route using ISDN PRI facilities or, if none are available, use non-ISDN PRI facilities (ISDN preferred); route using ISDN PRI or other facilities (no preference).

The ETN calls may be offered using dedicated facilities or using the call-by-call trunk group. To offer the ETN call capability on a call-by-call basis, a code point is provided in the NSF IE. In either case, the originating SETUP should include the TCM IE, indicating the FRL, SHC, and EEICI. If a CBC trunk is requested, the SETUP should include the NSF IE with the service indicating ETS, SDS, SDN, or null and the called party number IE numbering plan equal to private numbering plan.

This feature is not applicable to wideband trunks or calls that invoke the National ISDN call-by-call to FX and tie feature.

11.10 DATA SERVICES

This section summarizes both packet- and circuit-mode data services available on the PRI and underlying DS1 facility. Individual channels on the DS1 facility are DS0s. The DS1 facility may be a T1 carrier or a DNU-S facility.

This section includes a summary of the protocol and procedures for the establishment, maintenance, and clearing of the following:

- virtual calls (VCs) and permanent virtual circuits (PVCs) on permanent packet transport mode access connections on the DS0 (that is, packet-switched by the network)
- circuit transport mode on-demand connections on the DS0 (that is, circuit-switched by the network).

The description is organized as follows: X.31 packet transport mode is specified in "X.31 Packet Transport Mode Specification (Provisioned B-channel Packet)," Section 11.10.1, circuit transport mode for data is specified in "Circuit-Mode Data Specification," Section 11.10.2, and interworking with switched 56-kbps data is specified in "Interworking with Switched 56-kbps Data Customer," Section 11.10.3.

11.10.1 X.31 PACKET TRANSPORT MODE SPECIFICATION (PROVISIONED B-CHANNEL PACKET)

The user and network establish permanent packet-mode access connections at the time of subscription.

Note: A B-channel or DS0 that is provisioned for permanent packet transport mode service will always be considered unavailable for other services (that is, the B-channel is considered in use for the purposes of choosing an available channel for voice or data circuit transport mode).

The user can subscribe to packet-mode service on any number of DS0 channels on a DS1 facility. If the 24th channel is not used for D-channel signaling, the user can also subscribe to packet service on that channel. The user and network use this type of data transport facility to convey VC and PVC data services. The signaling for VC establishment and clearing is accomplished through standard X.25 call setup procedures. The packet-handling function processes the VC control messages and provides logical channel switching.

Incoming VCs are routed to a specific B-channel (DS0 channel) based on the called number (for example, each channel can be assigned a unique directory number). B-channels may also be administered as a multi-line hunt group.

11.10.1.1 X.25 Procedures

This section assumes that a specific B-channel has been provisioned, and that the link has been established as specified in Section 2.4.4.1 of ITU-T Recommendation X.25 (1984). If either a B-channel cannot be selected or the link is not established, the network will not deliver an incoming call and the user cannot initiate an outgoing call.

The protocol supported by the *5ESS* switch conforms to ITU-T Recommendation X.25 (1984) Layer 3 specification for connecting packet mode data terminal equipment (DTE) to a packet handling function for virtual circuit and PVC services.

11.10.1.1.1 Virtual Call Setup and Clearing

ITU-T Recommendation X.25 specifies three basic interface attributes that networks provide to allow for packet switching access. The three X.25 basic attributes associated with VC setup and clearing are as follows:

- maximum user data field length of 128 octets (for fast select)
- packet sequence numbering modulo 8
- packet level window size of 2 and 3.

The VC setup and clearing procedures are described in Section 4.1 of ITU-T Recommendation X.25, “Procedures for Virtual Call Service.” Figures B-1, B-2, and B-3 in the same document show the state diagrams that define the events at the user-network interface. Annex B of ITU-T Recommendation X.25 provides details of the action the network side of the interface takes on the receipt of packets in each of Figures B-1, B-2, and B-3.

Note: It is possible for a clearing packet to pass data packets within the network. Therefore, when operating with the D-bit set to 0 (see the note that follows) it is possible for acknowledged packets to be dropped if the user transmits a clearing packet prior to delivery of the data packets to the far end.

Note that an escape code of 0 must be used when the calling party wishes to place a VC requiring an X.121 number in the called address field.

When the terminal includes diagnostic codes in clear, reset, or restart packets, the diagnostic code is passed transparently through the switch. If the cause code in a clear, reset, or restart packet is “DTE originated,” then the diagnostic code should be coded in accordance with ISO 8208.

Note: ISO 8208 is used in the ITU-T Recommendation X.25 section for cause codes.

11.10.1.1.2 Permanent Virtual Circuit Initialization

After the PVC setup has been completed within the network, the local DCE will send the local DTE a reset indication with a cause code of “network operational.” However, there is no assurance at this point that the PVC has been set up end-to-end (that is, DTE to DTE). If the DTE sends a data or a reset request packet before the PVC has been established end-to-end, the DTE will receive either no response or a reset indication packet with a cause code of “out-of-order” on that PVC. If the DTE sends a data or a reset request packet and the PVC has been established end-to-end, the data or reset packet will undergo the normal data transfer procedures. If the network has sent the DTE a reset indication with a cause code of “out-of-order,” the network will send a reset indication with a “network operational” cause to the DTE when the setup is complete.

11.10.1.1.3 Logical Channels

The X.25 logical channels are identified by a 4-bit logical channel group number and an 8-bit logical channel number. These channel numbers must appear in every X.25 packet except RESTART and DIAGNOSTIC.

Logical Channel 0 is reserved for control packets (RESTART and DIAGNOSTIC). As a subscriber option, 1 to 127 logical channels are supported for virtual circuits on a communication link carried by a B-channel.

Logical channel assignment is in accordance with X.25, Annex A. Logical channel numbers assigned for VCs and PVCs must be in the range of 1 to 127 on the communication link carried by a B-channel. The range of logical channels for PVCs is specified by service provisioning. This range of logical channels includes the assigned PVCs, as well as logical channels for future PVCs. The user must specify the logical channel number of each active PVC at subscription time.

11.10.1.1.4 Data/Interrupt Transfer

The procedures for data and interrupt transfer follow the procedures described in ITU-T Recommendation X.25, Section 4.3. The following paragraphs detail the significance of these procedures to the network side of the user-network interface and the particular features the *5ESS* switch supports.

- ***Delivery Confirmation Bit.*** The delivery confirmation bit (D-bit) indicates whether or not the user wishes to receive an end-to-end acknowledgment of delivery by means of the packet receive sequence number [P(R)]. The *5ESS* switch interprets the D-bit and passes it unaltered in the call request and call accepted packets during VC setup so each user is aware of the D-bit option selected by the other user.

  When a user sends a data packet with the D-bit set to 1, the switch withholds the P(R) acknowledgment until the destination user has given a P(R) acknowledgment for the data packet. On the other hand, if the D-bit is set to 0, acknowledgments do not necessarily have end-to-end significance. An acknowledgment can be a receive-ready or receive-not-ready packet carrying an incremented value in the P(R) field.

- ***Qualifier Bit.*** The *5ESS* switch does not act on the value of the qualifier bit (Q-bit). The Q-bit should be set to the same value in all data packets of a complete packet sequence. If this is not the case, the switch still accepts the packets and transfers the Q-bit values transparently.

- ***More Data Mark Bit.*** The *5ESS* switch does not perform packet fragmentation or recombination. The more data mark (M-bit) procedures are supported as specified in ITU-T Recommendation X.25, Section 4.3.4.

- ***Data Transfer.*** The *5ESS* switch data delivers packets to the terminating user side in the same sequence as the packets were transmitted by the originating user side without packet duplication.

- ***Interrupt Transfer.*** The *5ESS* switch follows the interrupt procedure described in ITU-T Recommendation X.25, Section 4.3.7.

11.10.1.1.5 Flow Control

The *5ESS* switch follows the standard flow control principles specified in Section 4.4.1.3 of ITU-T Recommendation X.25. If the switch receives a data packet containing a packet send sequence number [P(S)], which is out of sequence within the window, or which is outside of the window, the switch resets the virtual circuit. The switch does not pass these packets across the network to the terminating user side equipment.

The following flow control parameters can be set only at service provisioning time for PVCs and, if subscribed to by the user, they can also be negotiated on a per-call basis through X.25 facility negotiation for VCs.

- ***Virtual Circuit Throughput Class.*** The switch recognizes the following throughput classes for VCs on a B-channel: 75, 150, 300, 600, 1200, 2400, 4800, 9600, and 19200 bps.
- ***Packet Size.*** The switch supports a maximum size of 256 octets of user data. The default size is 128 octets of user data.
- ***Window Size.*** The switch supports window sizes of 2 or 3. The window size may be different on each direction of data and at each end of a logical channel. A default window size of 2 is associated with the VC if neither side requests a window size value.

11.10.1.1.6 DIAGNOSTIC Packet

The *5ESS* switch supports the use of DIAGNOSTIC packets to indicate error conditions under circumstances when the usual methods of indication (for example, reset, clear, and restart with cause and diagnostic codes) are inappropriate. The conditions under which the switch sends the DIAGNOSTIC packet are as specified in ITU-T Recommendation X.25, Section 3.4.1.

11.10.1.1.7 Effects of the Physical Level and the Link Level Failure

When the *5ESS* switch detects a failure on the physical level, the switch terminates VCs and transmits toward the far end (FE) user:

- a reset for each PVC
- a clear for each VC.

No D-channel messages are sent for any maintenance procedures, including link failure, for B-channels provisioned for permanent packet-mode service. The B-channels provisioned for packet-mode service operate independently from the PRI D-channel.

If the switch detects a link failure, the switch takes the same actions as for the case of a physical failure.

11.10.1.2 Data Link Layer Specifications for the B-channel

The Link Access Procedure-Balanced (LAPB) specified in ITU-T Recommendation X.25 (1984 X.25, Section 2) is used in the case of B-channel packet transport mode service. This section addresses only unspecified areas of LAPB, or those for which implementation option specifications are required.

The *5ESS* switch supports the LAPB single link procedures, but not the LAPB multilink procedures specified in Section 2.5 of ITU-T Recommendation X.25.

The LAPB frames supported by the *5ESS* switch must always consist of an integral number of octets.

The B-channel links come into existence at the *5ESS* switch in a disconnected phase. The switch initiates link setup only under one of the following conditions:

- when a new B-channel is provisioned
- upon restoring a B-channel
- if there is a network initialization

If the reset fails, the *5ESS* switch will enter the disconnected phase and wait for the user to initiate link reset. The switch responds to the receipt of a set asynchronous balanced mode (SABM) command from the user side as specified in Section 2.4.4.1 of ITU-T Recommendation X.25.

The switch supports only the basic mode (modulo 8) of LAPB, as specified in Section 2.4.1 of ITU-T Recommendation X.25.

11.10.1.2.1 LAPB System Parameters

Section 2.4.8 of ITU-T Recommendation X.25 defines several system parameters without specifying their values. The following values are required for the implementation of packet transport mode service.

- Timer T1 is set per-link, by service order, within a range of 2 through 20 seconds, in approximately 0.2-second increments.
- Timer T3 is set per-link, by service order, within a range of 3 through 30 seconds, in 2-seconds increments.
- Parameter N1 is 2136 bits, supporting a maximum I-field size of 260 octets; the information field is restricted to an integral number of octets.
- Parameter N2 is set per link, by service order, within a range of 2 through 16, in unitary increments.
- Parameter k is set per-link, by service order, within a range of 1 through 7, in unitary increments.

The X.25 specification states that the network side parameters T1, T2, T3, N1, and N2 “shall be made known” to the user side, and that the user side parameters T1, T2, N1, and N2 “shall be made known” to the network side. X.25 suggests no actual mechanism for making the information known. The *5ESS* switch requires external administrative procedures for this purpose. The network-side values are negotiated with the user-side administrator through the operating company service ordering process; similarly, any needed information concerning the user-side parameters is passed to the switch by the operating company through standard recent change procedures.

11.10.1.2.2 Link Setup Procedure Failure Handling

Section 2.4.4.1 of ITU-T Recommendation X.25 states that after N2 occurrences of the network sending an SABM frame to request link setup, followed by a failure of the user side to respond with a unnumbered acknowledgment (UA) or disconnected mode (DM) frame within T1 seconds, the network side initiates “appropriate higher level recovery action.” The appropriate action is unspecified. The *5ESS* switch responds to this failure by entering the disconnected phase defined in “Data Link Layer Specifications for the B-channel,” Section 11.10.1.2.

11.10.1.2.3 Expiration of Timer T3

Timer T3 detects an excessively long idle channel state condition on the link level. At the expiration of Timer T3, the *5ESS* switch will follow the link disconnection procedure as described in Section 2.4.4.3 of ITU-T Recommendation X.25.

11.10.1.2.4 Link Disconnection Procedure Failure Handling

Section 2.4.4.3 of ITU-T Recommendation X.25 states that after N2 occurrences of the network side sending a DISC frame to request link disconnection, followed by a failures of the user side to respond with a UA or DM frame within T1 seconds, the network side initiates “appropriate higher level recovery action.” Again, the appropriate action is unspecified within ITU-T Recommendation X.25. The *5ESS* switch responds to this failure by entering the disconnected phase defined in “Data Link Layer Specifications for the B-channel,” Section 11.10.1.2.

11.10.1.2.5 RNR and Timer Recovery Procedure Failures

Sections 2.4.5.7 and 2.4.5.9 of ITU-T Recommendation X.25 give the network side two options for responding to the occurrence of N2 timeouts in attempting to perform RNR and timer recovery procedures. The *5ESS* switch responds to these failures by entering the disconnected phase described in “Data Link Layer Specifications for the B-channel,” Section 11.10.1.2.

11.10.1.2.6 Link Reset Procedure Failure Handling

Section 2.4.7.2 of ITU-T Recommendation X.25 states that after N2 occurrences of the network side sending an SABM frame to request link reset, followed by a failure of the user side to respond with a UA or DM frame within T1 seconds, the network side initiates the “appropriate higher level recovery action.” The *5ESS* switch responds to this failure by entering the disconnected phase defined in “Data Link Layer Specifications for the B-channel,” Section 11.10.1.2.

11.10.1.2.7 Excessive Error Count

If the *5ESS* switch receives an excessive number of unexpected frames, which might indicate a malfunction at the CPE, the switch will deactivate the B-channel for a period of 5 minutes. At the end of the 5-minute period, the switch will reactivate the B-channel and attempt link setup.

11.10.1.3 X.25 Facilities

The network layer supports X.25 packet-mode transport facilities. The user accesses these facilities as though accessing an X.25 data network. All essential X.25 facilities (per X.2) are available to the user, plus the following additional facilities: 1-way logical channel incoming, intercom addressing, interexchange carrier preselect, registered private operating agency (RPOA) selection, reverse charging, and reverse charging acceptance. The *5ESS* switch also supports the use of the facility marker to identify CCITT-specified DTE facilities.

The X.25 facilities consist of two types, per-call and provisioned. Provisioned facilities are added, removed, or changed through a service order. These services include intercom addressing, incoming and outgoing calls barred, closed user groups, fast select acceptance, flow control parameter negotiation, IEC preselect, multiline hunt group, 1-way logical channel outgoing, 1-way logical channel incoming, permanent virtual circuit, reverse charging acceptance, and throughput class negotiation. These facilities are defined in ITU-T Recommendation X.25.

11.10.1.4 Summary of Support for X.25

11.10.1.4.1 Physical and Link Layer Attributes

- Information flow
  - — 64 kbps on B-channel
- LAPB single-link protocol

- Frame sequence numbering:	modulo 8
- Parameter k	1 to 7
- T1	2-20 seconds
- T3	3-30 seconds
- N1	2136 bits
- N2	2-16

11.10.1.4.2 Network Layer Attributes

- VC service on permanent B-channel connections
- PVC Service on permanent B-channel connections
- Packet sequence numbering: modulo 8
- Logical channels used for VCs and PVCs: 127 (not counting Logical Channel 0, which is reserved for DIAGNOSTIC and RESTART packets)

11.10.1.4.3 X.25 Essential Facilities

- Calls barred (incoming)
- Calls barred (outgoing)
- Closed user groups (maximum of 100 for B-channel)
- Closed user group selection
- Fast select
- Fast select acceptance
- Flow control negotiation
  - — support window sizes of 2 or 3
  - — support maximum packet sizes of 128- and 256-octet data fields
- One-way logical channel outgoing
- Throughput class negotiation
  - — X.25 standard values up to 19.2 kbps on the B-channel (75, 150, 300, 600, 1200, 2400, 4800, 9600, and 19,200 bps)
- Transit delay selection and indication

11.10.1.4.4 Additional X.25 Facilities

- Single address hunt group
- Single address hunt group with individual addressing

- Multiple address hunt group (up to 2,000 B-channels, up to 10,000 contiguous addresses)
- Multiple address hunt group with individual addressing (up to 2,000 B-channels, up to 10,000 contiguous addresses)
- RPOA selection
- Reverse charging
- Reverse charging acceptance
- Closed user group with outgoing access
- Closed user group with outgoing access selection
- Closed user group with incoming access
- Default throughput class assignment
- IEC preselect (non-X.25 facility)
- Intercom addressing (non-X.25 facility)
- One-way logical channel incoming

Some characteristics attributed to other X.25 facilities are available, although the full facilities themselves are not available. These include:

- Nonstandard default window sizes (3 only)
- Nonstandard default packet sizes (256 only)

11.10.1.5 Maintenance of B-channel for Packet

The maintenance for this capability is done manually and can be initiated either by the CPE or by the network. The B-channel must be taken out of service before the manual test can be applied. No D-channel messages are sent for any maintenance procedures for B-channels provisioned for permanent packet-mode service. The B-channels provisioned for packet-mode service operate independently from the PRI D-channel.

With the B-channel in service, the subscriber may generate a logical loop-back to test the channel by simply addressing a packet to the same port from which it is sent.

11.10.2 CIRCUIT-MODE DATA SPECIFICATION

The procedures for establishing circuit-mode connections used to transport packet and nonpacket data are the same as those for other circuit-mode calls described in “Call Control Procedures for Circuit-Switched Calls,” Section 5.1. In addition, the user must code the following fields in the bearer capability IE of the SETUP message as follows:

- ***Information Transfer Capability.***
  - — restricted digital information (see ITU-T Recommendation I.464)
  - — unrestricted digital information

- ***Transfer Mode.***
  - circuit mode

The following also applies:

- ***Call Establishment (Origination Exchange).*** The low layer compatibility IE is present in the SETUP message if the user wishes to specify the protocols to be used (for example, LAPB link layer with X.25 packet layer protocols) and the data rate. This IE is passed transparently by the *5ESS* switch; that is, the switch does not act on the information contained in this IE.
- ***Call Establishment (Terminating Exchange).*** If the originator provides the low layer compatibility IE, this IE is present in the SETUP message sent to the terminating user side. This IE specifies the required protocols and the data rate.

The call clearing procedures specified in “Call Control Procedures for Circuit-Switched Calls,” Section 5.1, are applicable for clearing the circuit-mode data connection.

11.10.3 INTERWORKING WITH SWITCHED 56-kbps DATA CUSTOMER

This section describes how ISDN customers can place and receive circuit transport mode calls from a switched 56-kbps data customer. The procedures are identical to those described in “Call Control Procedures for Circuit-Switched Calls,” Section 5.1, with the following exceptions:

- ***Call Origination.*** To place a circuit-mode data call to a switched 56-kbps data customer, the user must code the following fields in the bearer capability IE of the SETUP request as follows:
  - ***Information Transfer Capability*** – coded either (treated identically by the network in this case) restricted digital information (ITU-T Recommendation I.464) or unrestricted digital information
  - ***Transfer Mode*** – circuit mode
  - ***Layer Identification*** - user information Layer 1 protocol
  - ***Protocol Identification*** - rate adaptation
  - ***Rate*** – 56-kbps rate adaptation per ITU-T Recommendation V.110 (I.463).
- ***Call Completion.*** The network transmits a PROGRESS message to the user after the CALL PROCEEDING message to indicate that the call has left the ISDN. The progress indicator IE, in the PROGRESS message, will be coded as follows:
  - ***Location*** – transit network
  - ***Progress Description*** - call is not end-to-end ISDN

  When the user receives a CONNECT message, an end-to-end connection has been established.
- ***Incoming Call.*** An incoming call to an ISDN user from a switched 56-kbps data customer will have the bearer capability IE in the incoming SETUP message coded as follows:
  - ***Information Transfer Capability*** – unrestricted digital information
  - ***Transfer Mode*** – circuit mode

— ***Layer Identification*** **-** user information Layer 1 protocol

— ***Protocol Identification*** **-** rate adaptation

— ***Rate*** – 56-kbps rate adaptation per ITU-T Recommendation V.110 (I.463).

11.11 CALLING NAME FOR ISDN PRI (CNAM-P)

11.11.1 DEFINITION

The ISDN Calling Name Delivery (CND) for PRI (CNAM-P) feature consists of three components as follows:

- **Privacy of Calling Name,** which allows an originating CPE to signal on a per-call basis the presentation status (that is, public or private) for their CNAM. The Q.932 protocol for both the Custom and National ISDN PRI interfaces will be used to signal a facility IE in a SETUP message encoded for “presentation status restricted” or “presentation status allowed.” Remote operations notation is used to encode an Invoke component in the facility IE containing the requested presentation status through the callingName operation.
- **Calling Name Delivery,** which provides name information (name characters, a private indication, or an unavailable indication) to a subscribed terminating interface (PRI trunk group) at the time of call setup. Name characters are obtained from a name database (for example, Advanced Intelligent Network SCP) based on a terminating name query using the CgPN. If the CNAM is marked “presentation restricted” or if the CgPN is unavailable, the appropriate indication (private or unavailable) is delivered in the facility IE of the SETUP message to the called CPE. Remote operations notation is used to code the name information in the callingName operation of an Invoke component. When a database query is made (using SS7 Transaction Capabilities Application Protocol [TCAP] to an SCP database), the name information is delivered to the called CPE using the facility IE of a FACILITY message (call SETUP is not delayed awaiting the response to the name query).
- **Electronic Directory Service Calling Name Display (EDS CND),** which is used for intrabusiness group calls. A EDS group (EDS GRP) will be required to be assigned to PRIs subscribed to EDS CND to deliver calling and/or original called name information on intrabusiness group calls. EDS CND will query a local applications processor (AP) name database for calling and/or original called name information instead of an SCP. Name information is delivered as described for CNAM delivery in the facility IE of either a SETUP or a subsequent FACILITY message.

These services are considered part of the 1996 National ISDN-3 feature offering and are available on both the Custom and National ISDN PRIs. All three capabilities apply to circuit switched voice, circuit switched data, and switched fractional-DS1 calls, but are not applicable to packet switched data calls.

11.11.2 SERVICE PROVISIONING OPTIONS

The service provider must specify at service provisioning time on a per-PRI trunk group basis subscription to PCN, CNAM, or EDS CND, as well as a billing option for PCN or CNAM. Billing options of both “usage sensitive” and “flat rate” are supported for both PCN and CNAM. A billing DN must likewise be provided for any trunk groups to which a “usage sensitive” billing option is assigned.

11.11.3 SUBSCRIPTION SCREENING

The network will screen calls for which PCN is invoked by the calling CPE. If the calling CPE (that is the originating PRI trunk group) is not subscribed to the PCN service, the call will be rejected.

11.11.4 CODING OF THE FACILITY IE FOR PRIVACY OF CALLING NAME

In order to invoke the PCN capability to explicitly set the presentation status of the calling name, the CPE must be able to include the callingName operation in the ROSE Service Component (Invoke) of the facility IE. The facility IE shall be coded as follows:

- The service discriminator (also known as protocol profile) is set to “networking extensions.”
- The NFE (Octet 3.1) should be excluded. If the network receives an NFE octet in a facility IE, the NFE will be ignored and discarded by the switch.
- The NPP (Octet 3.2) must be excluded. If the network receives an NPP octet in a facility IE, the entire facility IE will be discarded by the switch.
- The interpretation component (Octet 3.3), if included, is set to one of the following:
  - Discard any Invoke component containing an unrecognized operation value.
  - Clear call if any Invoke component contains an unrecognized operation value.
  - Discard any Invoke component containing an unrecognized operation value and return a Reject component.
- The Service component type is invoke with the data elements of the Invoke component coded as follows:
  - The invoke ID is coded using the short form of length. The *5ESS* switch accepts an invoke ID of one or two octets in length.
  - The operation value is coded to callingName operation (integer tag with the value of “0”).
  - The name argument of the callingName operation is coded to either NamePresenationRestrictedNull or NamePresentationAllowed. If name characters are received in the name argument, they will be discarded by the *5ESS* switch.

11.11.5 CODING OF THE FACILITY IE FOR CALLING NAME DELIVERY (CND)

In order to deliver calling and/or original called name information to the CPE, the *5ESS* switch will include the callingName, DivertingLegInformation2, and informationFollowing operations in ROSE Service component(s) (Invoke) of a facility IE as described in the following sections.

11.11.5.1 Name Information Unavailable or Presentation Restricted

When the switch determines that name information cannot be obtained for the call (for example, the CgPN is unavailable or the CNAM is “presentation restricted”) and therefore does not launch a query to a name database, the switch sends name information in the facility IE of a SETUP message. In this case, the name information consists of an indication of either “presentation restricted name” or “unavailable name” and is coded as follows:

- The service discriminator (also known as the protocol profile) is set to “networking extensions.”
- The NFE (Octet 3.1) is not included.
- The NPP (Octet 3.2) is not included.
- The Interpretation component (Octet 3.3) is coded as discard any Invoke component containing an unrecognized operation value (do not return a Reject component).
- The only service component type is coded as invoke with the data elements of the Invoke component coded for CNAM as follows:
  - — The invoke ID is coded using the short form of length. The *5ESS* switch will send an invoke ID that is one or two octets in length.
  - — The operation value is coded to callingName operation (integer tag with a value of “0”).
  - — The name argument of the callingName operation is coded to either NamePresentationRestrictedNull or NameNotAvailable.
- If call forwarding or call redirection has occurred, the original called name information may also be included for PRI trunk groups subscribed to EDS CND. In this case, a second service component type coded as invoke with the data elements of the Invoke component coded for original called name is included as follows:
  - — The invoke ID is coded using the short form of length. The *5ESS* switch will send an invoke ID that is one or two octets in length.
  - — The operation value is coded to DivertingLegInformation2 operation (integer tag with the value of “21”).
  - — The diversionReason of the DivertingLegInformation2 operation is coded to: unknown, cfu (call forwarding all calls), cfb (call forwarding busy), or cfnr (call forwarding no answer), as appropriate.
  - — The redirectingName argument of the DivertingLegInformation2 operation is coded to either NamePresentationRestrictedNUll or NameNotAvailable.
  - — No other arguments of the DivertingLegInformation2 operation are included by the *5ESS* switch in this service component.

11.11.5.2 Name Information Available

When the switch determines that a query should be launched to retrieve name information from a name database, the switch sends an indication of “information following” to the CPE in the facility IE of a SETUP message. In this case, the actual name information is provided in a subsequent FACILITY message once the name query has been completed. The facility IE of the SETUP message is coded as follows to indicate “information following.”

- The service discriminator (also known as protocol profile) is set to “networking extensions.”
- The NFE (Octet 3.1) is not included.

- The NPP (Octet 3.2) is not included.
- The interpretation component (Octet 3.3) is coded as discard any Invoke component containing an unrecognized operation value (do not return a Reject component).
- The Service component type is coded as invoke with the data elements of the Invoke component coded for CNAM as follows:
  — The invoke ID is coded using the short form of length. The *5ESS* switch will send an invoke ID that is one or two octets in length.
  — The operation value is coded to informationFollowing operation (object ID tag with a value of 1 2 840 10005 0 4).
  — A single argument coded as includesNameInformation is present for the informationFollowing operation.

Once the name query has been completed, a FACILITY message is sent with the calling and/or original called name information coded in the facility IE as follows:

- The service discriminator (also known as the protocol profile) is set to “networking extensions.”
- The NFE (Octet 3.1) is not included.
- The NPP (Octet 3.2) is not included.
- The Interpretation component (Octet 3.3) is coded as discard any Invoke component containing an unrecognized operation value (do not return a Reject component).
- The only service component type is coded as invoke with the data elements of the Invoke component coded for CNAM as follows:
  — The invoke ID is coded using the short form of length. The *5ESS* switch will send an invoke ID that is one or two octets in length.
  — The operation value is coded to callingName operation (integer tag with a value of “0”).
  — The name argument of the callingName operation is coded to one of the following, as appropriate:
    - NamePresentationRestrictedNull, when the name information from the database results in the name being treated as “private.”
    - NameNotAvailable, when no response is received to the name information query.
    - NamePresentationAllowedSimple with up to 15 characters of name data encoded as iso8859 characters, when a name is returned from the name database and is not treated as “private” due to default name presentation status or originating caller actions.
- If call forwarding or call redirection has occurred, the original called name information may also be included for PRI trunk groups subscribed to EDS CND. In this case, a second service component type coded as invoke with the data

elements of the Invoke component coded for original called name is included as follows:

— The invoke ID is coded using the short form of length. The *5ESS* switch will send an invoke ID that is one or two octets in length.

— The operation value is coded to DivertingLegInformation2 operation (integer tag with the value of “21”).

— The diversionReason of the DivertingLegInformation2 operation is coded to: unknown, cfu (call forwarding all calls), cfb (call forwarding busy), or cfnr (call forwarding no answer), as appropriate.

— The redirectingName argument of the DivertingLegInformation2 operation is coded to one of the following, as appropriate:

- NamePresentationRestrictedNull, when the name information from the database results in the name being treated as “private.”
- NameNotAvailable, when no response is received to the name information query.
- NamePresentationAllowedSimple with up to 15 characters of name data encoded as iso8859 characters, when a name is returned from the name database and is not treated as “private” due to default name presentation status.

— No other arguments of the DivertingLegInformation2 operation is included by the *5ESS* switch in this Service component.

11.11.6 ASN.1 REPRESENTATION FOR CALLING NAME

All operations included in Exhibit 11-1 are Class 5 operations to be used in the Invoke component for CNAM and PCN.

Exhibit 11-1 — ASN.1 Definition for Calling Name Identification Presentation

```
DEFINITIONS ::=
BEGIN
IMPORTS        OPERATION FROM Remote-Operation-Notation
                  {joint-iso-ccitt (2) remote-operations (4) notation (0)}
               Extension FROM manufacturer-specific-service-extension-definition
                  {iso (1) standard (0) pss1 generic-procedures (11582)
                  msi-definition (0)}
               PresentedNumberUnscreened FROM Addressing-Data-Elements
                  {ccitt (0) recommendation (0) q (17) 932 (932)
                  addressing-data-elements (7)}

EXPORTS        Name, Nameset

callingName    OPERATION
               ARGUMENT CHOICE
                 Name, SEQUENCE {
                        Name, CHOICE {
                           [5] IMPLICIT Extension,
                           [6] IMPLICIT SEQUENCE OF Extension}
                               OPTIONAL }
                  }
::= {calling-name (0)}

DivertingLegInformation2 OPERATION
           ARGUMENT SEQUENCE  {
             diversionCounter        INTEGER  (1..15),
             diversionReason          DiversionReason,
             originalDiversionReason [0] DiversionReason OPTIONAL,
             divertingNr             [1] PresentedNumberUnscreened OPTIONAL,
             originalCalledNr        [2] PresentedNumberUnscreened OPTIONAL,
             redirectingName         [3] Name OPTIONAL,
```

```
            originalCalledName      [4] Name OPTIONAL,
            extension               CHOICE {
                                      [5] IMPLICIT Extension,
                                      [6] IMPLICIT SEQUENCE of Extension}
                                           OPTIONAL
                               }
    -- Some arguments (divertingNr, originalCalledNr, and extension) are not
    -- used by the U.S. public network calling name feature.
    -- Unless indicated as original, the redirecting name applies to the
    -- last instance of redirection (if only one instance of forwarding
    -- has occurred, it is considered the last instance).
::=21

DiversionReason   ::=ENUMERATED   {
                     unknown (0), cfu (1), cfb (2), cfnr (3),
                     cd (4),                      -- reserved for future use
                     cdImmediate (5)              -- reserved for future use
                                 }

Name   ::= CHOICE
            { NamePresenationAllowed,
              NamePresentationRestricted,
              NameNotAvailable }

NamePresentationAllowed   ::= CHOICE
                  { namePresentationAllowedSimple    [0] IMPLICIT NameData,
                    namePresentationAllowedExtended  [1] IMPLICIT NameSet }
          -- iso8859 character set is implied in namePresentationAllowedSimple


NamePresentationRestricted   ::= CHOICE
                  { namePresentationRestrictedSimple    [2] IMPLICIT NameData,
                    namePresentationRestrictedExtended  [3] IMPLICIT NameSet,
                    namePresentationRestrictedNull      [7] IMPLICIT NULL}
         -- iso8859 character set is implied in namePresentationRestrictedSimple
         -- namePresentationRestrictedNull is only used in the case where an
         -- indication that the name is restricted is being provided without
         -- providing name characters

NameNotAvailable   ::=[4] IMPLICIT NULL

NameData   ::=OCTET STRING (SIZE (1..50))
         -- The maximum allowed size of the name field is 50 octets.
         -- The minimum required size of the name field is 1 octet.

NameSet    ::=SEQUENCE
                {nameData     NameData,
                 characterSet CharacterSet OPTIONAL}
         -- If character set is not included, iso8859-1 is implied.

CharacterSet ::=INTEGER
                 { unknown (0),
                   iso8859-1 (1),
                   t-61 (2)}    (0..255)
          -- Character set iso8859-1 is specified in ISO 8859-1.
          -- Character set t-61 is specified in CCITT T.61.
          -- All other character sets are reserved for future use.

informationFollowing   OPERATION
          -- This operation is included in the network to user direction SETUP
          -- message to indicate that name information will be included in
          -- a subsequent FACILITY message.

    ARGUMENT ENUMERATED
       {includesNameInformation (0)
    -- Other values may be defined in the future}

    ::={1 2 840 10005 0 4}

END
```

11.11.7 CAUSE CODES INVOKED BY PCN AND CNAM

The following cause codes may be produced during call processing PCN invocations (note there are no cause codes produced by the CNAM delivery function).

- Cause code value of 31 “normal unspecified”

  This cause code value is used when the network receives a SETUP message with a facility IE with coding errors in the service components and rejects the call. A Reject component is also included as a facility IE of the call clearing message, to specify the type of service component coding problem encountered.

- Cause code value of 50 “requested facility not subscribed”

  If the calling CPE includes a facility IE in the SETUP message coded for PCN invocation when the originating PRI trunk group is not subscribed to PCN, the call will be rejected.

- Cause code value of 53 “(diagnostic: short term denial), service operation violated”

  If the calling CPE includes multiple service components (invoke) in the facility IE(s) of the SETUP message coded for PCN invocation, the call will be rejected.

- Cause code value of 100 “invalid information element contents”

  If the calling CPE includes a facility IE in the SETUP message containing protocol errors in the Layer 3 networking extension components (NPP, NFE, or Interpretation), the switch will respond with this cause code along with a Reject component indicating the problem value.

11.12 ORIGINATING SWITCH CALLING NAME

11.12.1 DEFINITION

Originating Switch Calling Name, introduced as a software update in the 5E13 release, allows the *5ESS* switch to receive a calling party name on an incoming PRI call and deliver this information to a Calling Name subscriber or send it on an outgoing interswitch SS7 call. This feature extends the base functionality introduced in the Calling Name for ISDN PRI feature, under which the *5ESS* switch delivered the calling party name from a Calling Name Transaction Capabilities Application Part (TCAP) query at the terminating switch only. Refer to Section 11.11 for details on Calling Name for ISDN PRI.

When Originating Switch Calling Name is active on the originating switch, two provisionable options exist for obtaining calling name information. The calling name is obtained either from switch-based data for line originations (not for PRI originations) or through a Calling Name TCAP query to the calling name database. The calling name can also be received in a Name Operation in a facility IE in the SETUP message from an originating PRI.

For an interswitch call, the calling name is routed to the terminating switch in the Generic Name Parameter of an Initial Address Message (IAM). For a PRI termination, the calling name is delivered to the called CPE in a facility IE in the terminating SETUP message. If Originating Switch Calling Name is not active at the terminating switch when a CNAM TCAP query is made to the Calling Name database, the calling name is delivered in a subsequent FACILITY message because it is not available when the SETUP message is sent.

This feature is consistent with Bellcore References TR-1188, TR-1326, GR-1367, and with ANSI specifications for Calling Name.

11.12.2 INTERACTION WITH ELECTRONIC DIRECTORY SERVICE (EDS)

An Electronic Directory Service (EDS) feature provides calling name information for calls between members of the same business group. Using the Lucent Attached Processor Interface message set, EDS causes a terminating query to be sent to an attached processor (AP) database.

If EDS Calling Name is assigned to a terminating PRI, then this EDS query for calls within a business group is unaffected by the Originating Switch Calling Name feature, unless a calling name is received from an incoming PRI or SS7 trunk. When a calling name is received from an incoming PRI in the same business group, or from an SS7 trunk where the calling number is in the same business group as the EDS calling name subscriber, the switch uses this name and delivers this name in the SETUP message.

If call forwarding takes place, however, and the original called number is in the same business group as the EDS subscriber, then the original called name is derived from the EDS AP. In this case, even if name information is available from an incoming PRI in the same business group or from an SS7 trunk where the calling number is in the same business group, the switch delivers name information to the PRI in a message subsequent to the initial SETUP message.

If the call is not from within the same business group, and the EDS subscriber is *not* also a Calling Name subscriber, an indication of “Unavailable name” is delivered to the EDS subscriber. If the incoming call has an indication of name presentation restricted, however, an indication of “Private name” is delivered.

If a call is terminating to an outgoing BRI or PRI with both the EDS Calling Name feature and the Calling Name Delivery feature assigned, and the original called DN (call forwarding) is in the same business group as the EDS subscriber but the calling DN is not, and the switch determines that a query to the EDS AP should be launched, then no calling name characters are delivered in the initial SETUP message. If calling name information is available (from switch data, a CNAM TCAP query, or an incoming PRI or SS7 trunk), it is delivered in a subsequent message (INFO for BRI, or FACILITY for PRI), along with the original called name information from the EDS AP.

If a call for which calling name is received in a SETUP message from the originating PRI (or for which calling name is received in an IAM message from the originating SS7 trunk) is terminating to an outgoing BRI or PRI with the EDS Calling Name feature assigned, and the original called DN (call forwarding) is in the same business group as the EDS subscriber and the calling DN, and the switch determines that a query to the EDS AP should be launched, then no calling name characters are delivered in the initial SETUP message. The calling name information from the incoming PRI or SS7 trunk is delivered in a subsequent message (INFO for BRI, or FACILITY for PRI), along with the original called name information from the EDS AP.

11.12.3 INTERACTION WITH PRIVACY OVERRIDE

Privacy override, a per-trunk group option, supports inter-office delivery of calling party number (CgPN) over PRI trunks within a private network. When privacy override is active, the switch delivers a CgPN marked “Presentation restricted” along with a presentation indicator of “Presentation restricted.” When Originating Switch

Calling Name is also active, the switch further delivers the calling name information (including name characters) with a “Presentation restricted.”

11.12.4 INTERACTION WITH ADVANCED SERVICES PLATFORM (ASP)

If an incoming call originating on a PRI encounters ASP trigger(s) that result in the CgPN being changed, and if the call is delivered intraswitch to a Calling Name subscriber or is sent out of the switch over an outgoing ISDN User Part (ISUP) trunk, then any calling name information (name characters and presentation information) received in a valid facility IE are discarded. If the CNAM SRC option is set to SCP, then the new CgPN (after the last ASP query) is sent in the CNAM TCAP query. If the calling number is not changed as a result of the ASP trigger(s), these triggers have no impact on the calling name information.

11.12.5 SERVICE PROVISIONING OPTIONS

The Originating Switch Calling Name feature is a secured feature provisioned on the switch, not on the PRI. When this feature is active, name characters from an incoming PRI trunk group with the PCN option enabled are processed whereas, when this feature is not active, the name characters are ignored. All Call Name Privacy (ACNAP) is either stored on the switch along with the calling name or stored in the external Service control Point (SCP) Calling Name database.

11.12.6 CODING OF THE FACILITY IE FOR ORIGINATING SWITCH CALLING NAME

The facility IE for Originating Switch Calling Name is coded as for Calling Name for ISDN PRI, as specified in “Calling Name for ISDN PRI (CNAM-P),” Section 11.11.

11.12.7 PRI CALL ORIGINATION WITH NO CALLING PARTY NAME/NUMBER

If a call with no valid name character is originated from a PRI trunk when the originating switch has Originating Switch Calling Name active, and no valid 10-digit calling party number is associated with the call, then:

- If the call is delivered intraswitch to a calling name subscriber, it is delivered with an indication of “Unavailable name.”
- If an outgoing IAM is sent, no Generic Name Parameter is included.

11.12.8 PRI CALL ORIGINATION WITH VALID CALLING NAME RECEIVED FROM PRI

If a call with at least one name character in a valid facility IE is originated from a PRI when the originating switch has Originating Switch Calling Name active, then:

- If the call is to be delivered intraswitch to a calling name subscriber, then:
  - — If the name character(s) are received in a namePresentationRestrictedSimple Name argument, an indication of “Private” is delivered, with no name characters.
  - — If the name character(s) are received in a namePresentationAllowedSimple Name argument (in a callingName operation in a valid facility IE of a SETUP message), up to 15 name characters are delivered. This calling name is used instead of any other calling name stored on the switch or obtained from a Calling Name TCAP query.
- If the call is to be routed out of the switch on an outgoing SS7 trunk, then a Generic Name parameter is included in the outgoing IAM with the following coding:
  - — Type of name field coded “Calling Name” (001)

— Availability field coded “Name available/unknown” (0)

— Presentation field coded:

- “Presentation Allowed” (00), if the name character(s) are received in a namePresentationAllowedSimple Name argument, and the name characters are included in the Generic Name parameter.
- “Presentation Restricted” (01), if the name character(s) are received in a namePresentationRestrictedSimple Name argument, and the name characters are included in the Generic Name parameter.

11.12.9 PRI CALL ORIGINATION WITH NO VALID CALLING NAME RECEIVED FROM PRI

If a call with a valid 10-digit calling party number and no valid name characters in a valid facility IE is originated from a PRI when the originating switch has Originating Switch Calling Name active with the *switch-based data option*, then:

- If the call is to be delivered to a calling name subscriber, then:

  — If an indication of “Presentation restricted” (namePresentationRestrictedNull Name or namePresentationRestrictedExtended Name argument) is received in a valid facility IE, the call is delivered with an indication of “Private.”

  — If *no* indication of “Presentation restricted” (no valid Name argument or an argument of nameNotAvailable or namePresentationAllowedExtended) is received in a valid facility IE, the call is delivered with an indication of “Unavailable name.”

- If the call is to be routed out of the switch on an outgoing SS7 trunk, then a Generic Name parameter is included in the outgoing IAM with:

  — Type of name field coded “Calling name” (001)

  — Availability field coded “Name available/unknown” (0)

  — No name characters included

  — Presentation field coded:

  - “Presentation restricted” (01), if an indication of “Presentation restricted” (namePresentationRestrictedNull Name or namePresentationRestrictedExtended Name argument) is received in a valid facility IE
  - “Presentation allowed” (00), if a Name argument of namePresentationAllowedExtended is received in a valid facility IE
  - “No indication” (11), if no valid Name argument is received or an argument of nameNotAvailable is received.

If a call with a valid 10-digit calling party number and no valid name characters in a valid facility IE is originated from a PRI when the originating switch has Originating Switch Calling Name active with the *SCP-based data option*, then:

- If the call is to be delivered intraswitch to a calling name subscriber, then:

  — If an indication of “Presentation restricted” (namePresentationRestrictedNull Name or namePresentationRestrictedExtended Name argument) is received in a valid facility IE, no query is made and an indication of “Private” is delivered to the calling name subscriber.

— If *no* indication of “Presentation restricted” (no valid Name argument or an argument of nameNotAvailable or namePresentationAllowedExtended) is received in a valid facility IE, then an attempt is made to launch a CNAM TCAP query.

— If a CNAM TCAP query is attempted, the outcome of this attempt is handled as follows:

- A Calling Name is delivered if at least one name character is received in response to the CNAM TCAP query and either of the following applies:

  — No presentation indication (no valid Name argument or an argument of nameNotAvailable) was received in a valid facility IE and the “Presentation” field in the TCAP response is “Presentation allowed”

  — An indication of “Presentation allowed” (a Name argument of namePresentationAllowedExtended) was received in a valid facility IE.

- An Indication of “Private” is delivered if no presentation indication was received in a valid facility IE and the “Presentation” field in the TCAP response is “Presentation restricted.”

- An Indication of “Unavailable name” is delivered if any of the following applies:

  — The switch was not provisioned to do a TCAP query.

  — An error response was received.

  — A timeout has occurred.

  — No name characters were received in response to the CNAM TCAP query and none of the conditions for delivering an indication of “Private” (as described in this section) apply.

  — A Presentation field of “Blocking toggle” or “No indication” was received in the TCAP response, and no presentation indication was received in a valid facility IE.

- If the call is to be routed out of the switch on an outgoing SS7 trunk, then:

— If an indication of “Presentation restricted” (namePresentationRestrictedNull Name or namePresentationRestrictedExtended Name argument) is received in a valid facility IE, no query is made, and a Generic Name parameter is included in the outgoing IAM with:

- Type of name field coded “Calling name” (001)
- Availability field coded “Name available/unknown” (0)
- Presentation field coded “Presentation restricted” (01)
- No name characters are included.

— If *no* indication of “Presentation restricted” (no valid Name argument or an argument of nameNotAvailable or namePresentationAllowedExtended) is received in a valid facility IE, then an attempt is made to launch a CNAM

TCAP query. The outcome of this attempt is handled as follows:

- A Generic Name parameter is included in the outgoing IAM with the Type of name field coded “Calling Name” (001).
- The Availability field is coded “Name available/unknown” (0) if any of the following applies:
  - — At least one name character is received in response to the CNAM TCAP query, unless no presentation indication was received and the TCAP response contains a Presentation field coded “Blocking toggle” or “No indication.”
  - — The switch was not provisioned to do a TCAP query.
  - — An error response was received.
  - — A timeout has occurred.
- The Availability field is coded “Name not available” (1) if any of the following applies:
  - — The CNAM TCAP response contains no name characters.
  - — No presentation indication was received and the TCAP response contains “Blocking toggle” or “No indication.”
- The name Presentation field is coded “Presentation Allowed” (00) if any of the following applies:
  - — No presentation indication (no valid Name argument or an argument of nameNotAvailable) was received in a valid facility IE, and the TCAP Presentation field is “Presentation allowed.”
  - — An indication of “Presentation allowed” (namePresentationAllowedExtended) was received in a valid facility IE.
- The name Presentation field is coded “Presentation Restricted” (01) if no presentation indication was received in a valid facility IE, and the TCAP Presentation field is coded “Presentation restricted.”
- The name Presentation field is coded “No indication” (11) if no presentation indication was received in a valid facility IE and any of the following applies:
  - — The switch was not provisioned to do a TCAP query.
  - — An error response was received.
  - — A timeout has occurred.
  - — A TCAP response containing “Blocking toggle” or “No indication” is received.
- Up to a 15-character name is included if both of the following apply:
  - — At least one name character is received in the TCAP response
  - — The Presentation is “Presentation allowed” (00).

11.13 PRI TWO B-CHANNEL TRANSFER

11.13.1 DEFINITION

PRI Two B-channel Transfer (TBCT), introduced in the 5E13 software release, is defined by Bellcore in GR-2865-CORE, and by ANSI as Enhanced Explicit Call Transfer supplementary service in ANSI T1S1.1/96-346. The Notification to Controller (NTC) subscription option to the TBCT feature is available beginning with a software update to the 5E13 software release. A “controller,” which is an intelligent peripheral interfaced to the *5ESS* switch over an ISDN PRI, can request that two independent calls, each on an ISDN PRI B-channel, be transferred away from the PRI and connected to each other. This frees up the PRI B-channels while the transferred calls are active on the switch. The NTC feature option notifies the controller when the call previously transferred by Two B-channel Transfer has cleared.

These two calls may be on B-channels on different PRIs but, if they are, the two PRIs must be members of the same PRI serving group. At least one of the two calls must be answered; the other call may be answered, or alerting if it is incoming from the controller to the switch.

TBCT is invoked by the controller sending the *5ESS* switch a FACILITY message containing a facility IE coded to request invocation of the feature. This request is associated with the call reference value of the call on one of the B-channels, and identifies the call reference value of the call on the other B-channel. If the two B-channels are on different PRIs, the controller must include a D-channel identifier in its feature invocation request. The controller may request the identity of a D-channel by sending a FACILITY message containing a facility IE coded for a D-channel identifier request.

If the transfer can be carried out, the *5ESS* switch sends the controller a DISCONNECT message for each of the two B-channels. The DISCONNECT message for the B-channel associated with the TBCT request contains a facility IE with:

- a Return Result component
- an invocation of a Transfers operation that includes:
  — the current number of active transfers
  — the number of available transfers, based on the provisioning of the maximum number of active transfers as described in “Reject Responses for TBCT Feature Invocation,” Section 11.13.9.
- an invocation of the SetCallTag operation if the PRI Group has been provisioned for Notification to Controller.

The DISCONNECT message for the other B-channel does not contain a facility IE.

If the transfer cannot be carried out, the *5ESS* switch responds according to whether a failure has occurred that requires the calls on the PRI be torn down:

- If such a failure has occurred, the switch sends the controller a DISCONNECT message containing a Reject component.
- If such a failure has not occurred, the switch sends the controller a FACILITY message containing a facility IE with either a Return Error component or a Reject component.

11.13.2 SERVICE PROVISIONING OPTIONS

The TBCT feature is provisioned on a PRI Group basis. Two maxima, which may be optionally deactivated, may be specified:

- One to limit the number of TBCT requests within a 10-second interval
- One to limit the number of active transfers.

  Note: The number of active transfers is defined as the number of pairs of calls connected together after transfer from the PRI.

The optional NTC feature may be provisioned for the PRI Group when the TBCT feature is provisioned.

The Notification to Transferred Users option defined for TBCT by Bellcore in GR-2865-CORE is *not* supported in the *5ESS* switch version of TBCT.

11.13.3 INVOKE COMPONENT OPERATIONS USED BY TBCT

The following invoke operations are used by the TBCT feature:

- The controller requests a TBCT by invoking the EnhancedExplicitECTExecute operation in a facility IE in a FACILITY message.
- After a successful transfer, the switch invokes a Transfers operation in the facility IE of a DISCONNECT message to the controller.
- After a successful transfer, the switch invokes a SetCallTag operation if the PRI Group is provisioned for Notification to Controller. This operation sends to the controller a switch-assigned unique identifier of the call transferred by Two B-channel Transfer.
- The controller may request a D-channel identifier by invoking a DChannelIdentifierRequest operation in the facility IE of a FACILITY message.

11.13.4 OTHER COMPONENTS USED BY TBCT

The following other components are used.

- When a Class 2 operation has been performed successfully, the Return Result component is included.
- When a Class 2 operation has been performed unsuccessfully, the Return Error component is included.
- When an operation has been rejected, the Reject component is included.

11.13.5 CODING OF THE FACILITY IE FOR TBCT INVOKE SERVICE COMPONENTS

The coding of the facility IE for TBCT follows generally the format described under “Facility,” Section 4.3.3.11. For these operations the facility IE is coded as follows:

- The service discriminator (protocol profile) in Octet 3 is coded *10001* to indicate ROSE for ISDN supplementary services.
- The service component beginning in Octet 4 is coded *10100001* to indicate an invoke component type, whose data elements are defined in “Data Elements,” Section 4.4.
- The invoke identifier consists of the invoke identifier tag, a length, and the invoke identifier body. The invoke identifier body is coded according to the ASN.1 rules and representations specific to the invoke operation.

11.13.6 ASN.1 REPRESENTATION OF THE ENHANCED EXPLICIT CALL TRANSFER OPERATIONS

The ASN.1 representation for TBCT invocations is provided in Exhibit 11-2. EnhancedExplicitECTExecute and DChannelIdentifierRequest are Class 2 operations; Transfers and SetCallTag are Class 5 operations.

Exhibit 11-2 — ASN.1 Description of Enhanced Explicit Call Transfer Operations

```
-- begin  Enhanced Explicit Call Transfer, D-Channel Identifier Request, Transfers and
-- Set Call Tag ASN.1 definitions

Enhanced-Explicit-Call-Transfer-Operations

DEFINITIONS ::=

BEGIN

EXPORTS        linkID, dChannelIdentifier, dChannelIdRequest;


IMPORTS        OPERATION, ERROR FROM Remote-Operation-Notation
                  {joint-iso-ccitt remote-operations (4) notation (0)}

       notAvailable, notSubscribed, invalidCallState,
       supplementaryServiceInteractionNotAllowed, notAllowed,
       FROM General-Error-List
       { ccitt recommendation q 950 general-error-list(1) }

       linkIdNotAssignedByNetwork, enhancedExplicitECTExecute,
       dChannelIdNotAssignedByNetwork
-- dChannelIdNotAssignedByNetwork same as ANSI T1.643 dCINotAssignedByNetwork
       FROM {ANSI T1.643-1998};

EnhancedExplicitECTExecute ::= OPERATION
       ARGUMENT SEQUENCE{
                   linkId,
       dChannelIdentifier OPTIONAL}

-- linkID contains the call reference value and the call reference flag
-- of the other call to be transferred.

-- dChannelIdentifier contains the PRI group number of the other channel
-- to be transferred, obtained from a previous dChannelIdentifierRequest
-- operation invocation.
-- dChannelIdentifier is an optional argument. If it is not included,
-- the interface on which the message is received is assumed to apply to the
-- other call.

       RESULT

-- The return of a Return Result component acknowledges success.

       ERRORS  {notSubscribed,
supplementaryServiceInteractionNotAllowed,
notAvailable, invalidCallState,
linkIdNotAssignedByNetwork, notAllowed
dChannelIdNotAssignedByNetwork}


DChannelIdentifierRequest ::= OPERATION

RESULT dChannelIdentifier
ERRORS {notAvailable}

-- DChannelIdentifierRequest same as ANSI T1.643 DCIRequest
-- The result returned from the dChannelIdentifierRequest is a
-- 2-octet interface identifier, which is the PRI group on the 5ESS switch.

notSubscribed ::= 0
supplementaryServiceInteractionNotAllowed ::=10
notAvailable ::= 3
notAllowed ::= 32
invalidCallState ::= 7

LinkIdNotAssignedByNetwork ::= ERROR
```

```
DChannelIdNotAssignedByNetwork ::= ERROR

dChannelIdentifier ::= OCTET STRING (SIZE(1..4))
linkID ::= INTEGER (-32768 .. 32767)

Transfers ::= OPERATION
       ARGUMENT SEQUENCE{
   activeTransfers [0] IMPLICIT INTEGER (0-60,000),
   availableTransfers [1] IMPLICIT INTEGER (0-60,000) OPTIONAL}

-- Transfers is a class 5 operation that provides counts of the number of active transfers
-- and optionally the number of transfers still available.
-- If the maximum active transfers parameter is NULL (unlimited), the available transfers
-- is not returned.

SetCallTag ::= OPERATION
      ARGUMENT CallTag [1] IMPLICIT INTEGER (1-120,000)

-- The call tag is a unique value which identifies the transferred call.

enhancedExplicitECTExecute EnhancedExplicitECTExecute ::= {1 2 840 10005 0 8}

-- operation value is an object identifier in number form which represents: ISO (1),
-- member-body (2), USA country code (840), ANSI T1 (10005),
-- operations (0), enhancedExplicitECTExecute (8)

transfers Transfers ::= {1 3 17 102 3 2}

-- operation value is an object identifier in number form which represents: ISO (1),
-- member-body (3), Bellcore (17), ISDN-supplementary-services (102),
-- tbct (3), transfers (2)

setCallTag SetCallTag ::= {1 2 840 10005 0 10}

-- operation value is an object identifier in number form which represents: ISO (1),
-- member-body (2), USA country code (840), ANSI T1 (10005),
-- operations (0), setCallTag (10)

dChannelIdentifierRequest DChannelIdentifierRequest ::= {1 2 840 10005 0 9}

dChannelIdNotAssignedByNetwork DChannelIdNotAssignedByNetwork ::= {1 2 840 10005 1 1}

linkIdNotAssignedByNetwork LinkIdNotAssignedByNetwork ::= 61

END
```

11.13.7 CODING OF THE FACILITY IE FOR RETURN RESULT, REJECT, AND RETURN ERROR SERVICE COMPONENTS

Component types for these service components are as follows:

- The Return Result component type is *10100010*. If any results are to be included, additional invoke service components may be included in the facility IE.
- The Return Error component type is *10100011*.
- The Reject component type is *10100100*.

11.13.8 ERRORS RETURNED FOR TBCT FEATURE INVOCATION

When the *5ESS* switch detects errors in the TBCT feature invocation, it sends the controller one or more of the following error values in the Return Error component of the facility IE.

- Error Value 0, “Not Subscribed”

  Error value 0 indicates one of the following conditions:

  — The secured feature identifier (SFID) is not activated for the TBCT feature.

— The TBCT feature is not assigned as active for the PRI group for either or both of the PRI B-channels in the TBCT request.

— The bearer capabilities associated with the calls identified in the TBCT request are not valid.

- Error Value 3, “Not available”

  Error value 3 indicates that the bearer capabilities associated with the calls identified in the TBCT request are not compatible.

- Error Value 7, “Invalid call state”

  Error value 7 indicates that the call states of the calls to be transferred are not properly in the answered or alerting states.

- Error Value 10, “Supplementary Service Interaction Not Allowed”

  Error value 10 indicates either of the following conditions:

  — TBCT cannot be allowed due to an interaction with another feature.

  — A condition incompatible with TBCT exists. For example, a TBCT request is received for a call on a B-channel that currently has a TBCT request in progress.

- Error Value 32, “Not Allowed”

  Error value 32 may indicate that:

  — Both of the PRI B-channels to be transferred are on a single call; for example, the call reference values of the two calls to be transferred are on the same PRI and are identical.

  — The two PRIs are members of different PRI serving groups.

- Error Value 61, “Link ID Not Assigned By The Network”

  Error value 61 indicates that the call reference value in the link ID passed in the invocation request is either missing or not valid.

- Error Value “D-channel ID Not Assigned By Network”

  This error value indicates that the dChannelIdentifier received in the FACILITY message is untranslatable, incomplete, or does not correspond to a meaningful PRI group. This error value has no standard error value number, but is identified by {1, 2, 840, 10005, 1, 1} as shown in Exhibit 11-2.

11.13.9 REJECT RESPONSES FOR TBCT FEATURE INVOCATION

The *5ESS* switch returns a Reject component when certain types of invoke errors are detected, and when the request is valid but the transfer operation cannot be carried out.

- If the *5ESS* switch receives a facility IE that includes an Invoke component with an unrecognized operation, the switch responds by sending a FACILITY message that includes a Reject component containing Problem Tag 129, “Invoke-problem,” and Problem Value 1, “unrecognized-operation.” The switch responds identically if a recognized TBCT request is improperly included in an expected message; for example, if the switch receives in the idle state a TBCT request in a facility IE of a SETUP message.

- If the switch receives more than one Invoke component in a facility IE, and the same invoke identifier is included in multiple Invoke components, the switch generates for each duplicate invocation a Reject component containing a Problem Tag 129, “Invoke-problem,” and Problem Value 0, “duplicate-invocation.”

If the TBCT request is valid but the transfer operation cannot be carried out, the *5ESS* switch sends the controller a Reject component in the facility IE. The switch sends this reject response in the following examples.

- Either of the following conditions exists:
  - — The number of transfer requests per 10 seconds exceeds the provisioned maximum.
  - — The number of active transfers exceeds the provisioned maximum.

  In either of these cases, the switch sends the controller a *FACILITY* message containing a facility IE that includes a Reject component with Problem Tag 129, “Invoke-problem,” and Problem Value 3, “resource-limitation.”

- The transfer operation fails.

  In this case, the switch sends the controller a *DISCONNECT* message containing a facility IE that includes a Reject component with Problem Tag 129, “Invoke-problem,” and Problem Value 3, “resource-limitation.”

11.13.10 ERROR TREATMENT FOR MULTIPLE INVOCATIONS

If the *5ESS* switch receives multiple invocations in a facility IE, it parses all of the Invoke components in the facility IE and responds as follows:

- For any Invoke components containing an unrecognized operation, the switch generates a Reject component with Problem Tag 129, “Invoke-problem,” and Problem Value 1, “unrecognized-operation.”
- If one of the Invoke components contains a recognized TBCT operation, the switch carries out the operation.
- If more than one of the Invoke components contain recognized TBCT operations:
  - — The switch acts on only the first Invoke component with a recognized operation (not on the subsequent Invoke components).
  - — If the switch receives the facility IE in a FACILITY message or in a SETUP message:
    - For each subsequent Invoke component with an invoke identifier identical to that of the first recognized operation, the switch generates a Reject component with Problem Tag 129, “Invoke-problem,” and Problem Value 0, “duplicate-invocation.”
    - For each subsequent Invoke component with an invoke identifier different from that of the first recognized invoke operation, the switch generates a Return Error component with Error Value 10, “Supplementary service interaction not allowed.”
- Before the *5ESS* switch processes the first valid Invoke component, it sends a single FACILITY message that includes all of the generated Reject components and Return Error components.

11.13.11 NOTIFICATIONS USED BY TBCT NTC

If the PRI Group is provisioned for Notification to Controller, the following notifications are sent to the controller when the call transferred by Two B-channel Transfer clears:

- a Transfers notification that includes the current number of active transfers and, when a limit has been provisioned for the number of active transfers, the number of available transfers.
- a TransferredCallClearing notification that includes the call tag previously assigned by the switch to the call transferred by Two B-channel Transfer.

11.13.12 CODING OF THE NOTIFY MESSAGE

In a non-call-associated NOTIFY message encoded as follows, the switch notifies the controller that the call previously transferred by Two B-channel Transfer has cleared:

- The NULL call reference is used as described in “Call Reference,” Section 4.3.1.2.
- To signal the Transfers and TransferredCallClearing notifications, two notification indicator IEs are included and follow the format described in “Notification Indicator,” Section 4.3.3.16.

11.13.13 ASN.1 REPRESENTATION OF THE EXPLICIT CALL TRANSFERS NOTIFICATION

The ASN.1 representation for the TBCT NTC notifications is provided in Exhibit 11-3, “ASN.1 Description of Explicit Call Transfers Notification.”

Exhibit 11-3 — ASN.1 Description of Explicit Call Transfers Notification

```
-- begin Explicit Call Transfer Notifications ASN.1 definition

Explicit-Call-Transfer-Notifications

DEFINITIONS ::=

BEGIN

EXPORTS         transferredCallClearing;

IMPORTS         NOTIFICATION, FROM Notification-Indicator-IE-Data-Structure
                { ccitt recommendation q 932 notification-data-structure (6) }

TransferredCallClearing::= NOTIFICATION
                ARGUMENT callTag

callTag CallTag ::= [1] IMPLICIT INTEGER (1-120,000)

-- the call tag is a unique value which identifies the transferred call that has cleared.
-- ANSI T1.643 supports a CHOICE of two structures for the call tag;
-- only the above structure is required by Bellcore.

transferredcallClearing TransferredCallClearing ::= {1 2 840 10005 2 1}

-- notification value is an object identifier in number form which represents: ISO (1),
-- member-body 920, USA country code (840), t1-610 (10005), notifications (2),
-- transferred call clearing (1).

Transfers ::= NOTIFICATION
ARGUMENT SEQUENCE {
   activeTransfers [0] IMPLICIT INTEGER (0-60,000),
   availableTransfers [1] IMPLICIT INTEGER (0-60,000)}

-- The content structure of the Transfers notification is the same as the class 5 Transfers
-- operation that provides counts of the number of active transfers
-- and optionally, the number of transfers still available.
-- If the maximum active transfers parameter is NULL (unlimited) the available transfers
-- is not returned.
```

```
transfers Transfers ::= {1 3 17 102 3 3}

-- operation value is an object identifier in number form which represents ISO(1),
-- identified organization (3), Bellcore (17). ISDN-Supplementary-services (102),
tbct (3), transfers (3)

END
```

11.14 PRI B-CHANNEL NEGOTIATION

When the *5ESS* switch offers a call to the user over a PRI, the switch selects the B-channel to be used. With PRI B-channel Negotiation, which was introduced in the 5E14 software release, the ISDN PRI customer premises equipment (CPE) user response to the call offering can include a request that the call be connected on a different B-channel from the one that was offered by the switch. PRI B-channel Negotiation is limited, however, to members of the same PRI trunk group and PRI group. This feature is available on both Custom and National ISDN PRI interfaces.

If PRI B-channel Negotiation is active on the PRI B-channel trunk group, the switch sends to the CPE a SETUP message with a channel identification IE coded to "preferred," indicating that Channel Negotiation is allowed. If the Class II equipment elects to change the B-channel to a different channel, the equipment should in the first response to the SETUP message code the channel identification IE with the desired channel number. The first response on a Custom PRI must be a CALL PROCEEDING message; the first response on the National ISDN PRI can be a CALL PROCEEDING, ALERTING, or CONNECT message. After receiving the appropriate message, the switch completes the setup of the call using the B-channel that the user specified.

PRI B-channel Negotiation conforms to a subset of the specifications published in Bellcore Reference TR-NWT-001268. It *does not* conform to these Bellcore specifications as follows:

- Subscription to PRI B-channel Negotiation procedures is not automatic; subscription is through a recent change parameter assigned per PRI trunk group.
- The *5ESS* switch marks the preferred/exclusive bit in Octet 3 of the channel identification IE as "preferred" only if the PRI B-channel Negotiation procedure is active on the PRI trunk group. Otherwise, the switch marks the bit to its default value "exclusive."
- The *5ESS* switch *does not* distinguish whether the channel is preferred or exclusive in the channel identification IE of the first response message.
- PRI B-channel Negotiation procedures are supported for only circuit-switched voice calls. These procedures are not supported for packet calls.
- PRI B-channel Negotiation procedures are not supported for multi-rate (wideband) calls.

11.14.1 SERVICE PROVISIONING OPTIONS

PRI B-channel Negotiation is provisioned on a PRI trunk group basis.

11.14.2 CODING OF THE SETUP MESSAGE FOR PRI B-CHANNEL NEGOTIATION

If PRI B-channel Negotiation is active for the B-channel trunk group, the preferred/exclusive bit (Bit 4 in Octet 3) of the channel identification IE is coded to 0 for "preferred" in the terminating SETUP message.

11.14.3 ERRORS INVOKED BY PRI B-CHANNEL NEGOTIATION

11.14.3.1 Cause Codes Invoked by PRI B-channel Negotiation for Custom PRI

The following cause codes may be produced during call processing under PRI B-channel Negotiation on a Custom PRI.

- Cause code value 6 “channel unacceptable”

  If the first response to the outgoing SETUP message is a CALL PROCEEDING message containing a channel identification IE whose channel number differs from the offered channel ID, and if PRI B-channel Negotiation is not active for the B-channel trunk group, then the switch initiates call clearing to the called user by sending a RELEASE message with a cause code value of 6 “channel unacceptable” (location: public network serving the local user).

  If the first response to the outgoing SETUP message is a CALL PROCEEDING message in which the B-channel trunk group associated with the channel number in the channel identification IE differs from that of the offered B-channel, and if PRI B-channel Negotiation is active for the offered B-channel trunk group, then the switch releases the offered channel, sends to the user a RELEASE message containing a cause code value of 6, “channel unacceptable” (location: public network serving local user), and clears the call.

  If the first response to the outgoing SETUP message is a CONNECT message containing a channel identification IE whose channel number differs from the offered channel ID, and if PRI B-channel Negotiation is active for the B-channel trunk group, the switch sends to the user a DISCONNECT message containing a cause code value of 6, “channel unacceptable,” and proceeds with call teardown.

  If the first response to the outgoing SETUP message is an ALERTING message containing a channel identification IE whose channel number differs from the offered channel ID, and if PRI B-channel Negotiation is active for the B-channel trunk group, the switch sends to the user a RELEASE COMPLETE message containing a cause code value of 6, “channel unacceptable,” without diagnostic, and the switch proceeds with call teardown.

- Cause code value 34 “no circuit/channel available”

  If the first response to the outgoing SETUP message is a CALL PROCEEDING message containing a channel identification IE whose channel number differs from the offered channel ID, if the received B-channel trunk group member is not available for a call, and if PRI B-channel Negotiation is active for the B-channel trunk group, then the switch releases the offered channel, sends to the user a RELEASE COMPLETE message containing a cause code value of 34, “no circuit/channel available” (location: public network serving local user), and clears the call.

- Cause code value 82 “identified channel does not exist”

  If the first response to the outgoing SETUP message is a CALL PROCEEDING message containing a channel identification IE whose channel number differs from the offered channel ID, if PRI B-channel Negotiation is active for the B-channel trunk group, and if the received B-channel does not exist or is not valid for the offered PRI Group (for example, the received and offered B-channels are not in the same PRI Group), then the switch releases the offered B-channel and sends to the user a RELEASE COMPLETE message containing a cause code value of 82, “identified channel does not exist” (location: public network serving local user) and clears the call.

- Cause code value 100 “invalid information element contents”

  If the first response to the outgoing SETUP message is an ALERTING or CONNECT message containing a channel identification IE whose channel number differs from the offered channel ID, and if PRI B-channel Negotiation is not active for the B-channel trunk group, the switch sends to the user a DISCONNECT message containing a cause code value of 100, “invalid information element contents,” without diagnostic, and proceeds with call teardown.

11.14.3.2 Cause Codes Invoked by PRI B-channel Negotiation for National ISDN PRI

The following cause codes may be produced during call processing under PRI B-channel Negotiation on a National ISDN PRI.

- Cause code value 6 “channel unacceptable”

  If the first response to the outgoing SETUP message is a CALL PROCEEDING, ALERTING, or CONNECT message containing a channel identification IE whose channel number differs from the offered channel ID, and if PRI B-channel Negotiation is not active for the B-channel trunk group, then the switch initiates call clearing by sending to the user a RELEASE message containing a cause code value of 6, “channel unacceptable” (location: public network serving the local user).

  If the first response to the outgoing SETUP message is a CALL PROCEEDING, ALERTING, or CONNECT message in which the B-channel trunk group associated with the received B-channel differs from that of the offered B-channel, and if PRI B-channel Negotiation is active for the offered B-channel trunk group, then the switch sends to the user a RELEASE message containing a cause code value of 6, “channel unacceptable” (location public network serving local user).

  If the first response to the outgoing SETUP message is a CALL PROCEEDING, ALERTING, or CONNECT message containing a channel identification IE whose channel number differs from the offered channel ID and does not exist or is not valid for the offered PRI Group (for example, the received and offered B-channels are not in the same PRI Group), and if PRI B-channel Negotiation is active for the B-channel trunk group, then the switch initiates call clearing by sending to the user a RELEASE message with cause code value of 6, “channel unacceptable” (location: public network serving the local user).

  If the first response to the outgoing SETUP message is a CALL PROCEEDING, ALERTING, or CONNECT message containing a channel identification IE whose channel number differs from the offered channel ID, if the received B-channel trunk group member is not available for a call, and if PRI B-channel Negotiation is active for the B-channel trunk group, then the switch initiates call clearing by sending to the user a RELEASE message containing a cause code value of 6, “channel unacceptable” (location: public network serving the local user).

ISDN Primary Rate Interface Specification

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12. CROSS-REFERENCES TO SECTIONS OF BELLCORE SR-4287

Table 12-1 relates sections of this *5ESS*® switch PRI specification to corresponding sections of Bellcore's *National ISDN Primary Rate Interface Customer Premises Equipment Generic Guidelines* (SR-4287).

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ABBREVIATIONS AND ACRONYMS

ACK	Acknowledgment
AIN	Advanced Intelligent Network
AMI	Alternate Mark Inversion
ANI	Automatic Number Identification
AOOS	Automatic Out of Service
ARS	Automatic Route Selection
ASP	Advanced Services Platform
ASP	Assignment Source Point
Ai	Action Indicator
B8ZS	Bipolar 8-bit Zero Suppression
BCAS	B-channel Availability Signaling Procedures
BCD	Binary Code Decimal
BGUCD	Backward Circular Sequential
BN	Billing Number
BRI	Basic Rate Interface
C/R	Command/Response Field Bit
CBC	Call-by-call
CCITT	International Telegraph and Telephone Consultative Committee
CCS	Common Channel Signaling
CdPN	Called Party Number
CEI	Connection Endpoint Identifier
CgPN	Calling Party Number
CIC	Carrier Interconnection Code
CDMA	Code Division Multiple Access
CNAM	Calling Name
CND	Calling Name Delivery
CND	Calling Name Display
CNIS	Calling Number Identification System
CO	Central Office
CPE	Customer Premises Equipment
CRV	Call Reference Value
CSD	Circuit-Switched Data
CUG	Closed User Group
DA	Discontinued Availability
DCBU	D-channel Backup

DCE	Data Communications Equipment
DFI	Digital Facility Interface
DISC	Disconnect
DLCI	Data Link Connection Identifier
DM	Disconnected Mode
DN	Directory Number
DNU-S	Digital Networking Unit – Synchronous Optical Network (SONET)
DP	Dial Pulse
DPBX	Digital Private Branch Exchange
DS0	Digital facility having 64-kbps capacity
DS1	Digital facility having 1544-kbps capacity
DTE	Data Terminal Equipment
EA	Extended Address field bit
EDS	Electronic Directory Service
EDSL	Extended Digital Subscriber Line
EDSLHM	Extended Digital Subscriber Line – Hotel/Motel
EEICI	End-to-End ISDN Connectivity Indicator
ESF	Extended Superframe Format
ESSX	Electronic Switch Services
ETN	Electronic Tandem Network
ETS	Electronic Tandem System
FCS	Frame Check Sequence
FE	Far End
FRL	Facility Restriction Level
FRMR	Frame Reject
FX	Foreign Exchange
GRP	Group
GUCD	Forward Circular Sequential
HM	Hotel/Motel
I	Information
IA5	International ASCII code
IAM	Initial Address Message
IC	Interexchange Carrier
ICLID	Individual Calling Line Identification
ID	Identification
ID	Identity

IE	Information Element
IEC	Interexchange Carrier
II	Interchange Identification Digit
INWATS	Inward Wide Area Telephone Service
IS	In Service
ISDN	Integrated Services Digital Network
ISDS	International Switched Digital Service
ISUP	ISDN User Part
ITC	Information Transfer Capability
ITR	Information Transfer Rate
ITU-TS	International Telecommunication Union – Telecommunication Standardization Sector
Inter-LATA	Crossing LATA boundary
kb	kilobit
kHz	kilo-Hertz
kbps	kilobits per second
L1	Layer 1
L2	Layer 2
L3	Layer 3
LAPB	Link Access Protocol – Balanced
LAPD	Link Access Protocol – D-channel
LATA	Local Access Transport Area
LDS	Long Distance Service
LEC	Local Exchange Carrier
LFB	Look for Busy
LIGI	Limited Intra-Group Individual Calling Line Identification
M	Modifier Function Bit
MAUUI	Message-associated User-to-User Information
MAXOWATS	Maximal OUTWATS Service
MB	Maintenance Busy
METROHUB	AT&T Network Service
MF	Multifrequency
MLPP	Multilevel Precedence and Preemption
MOOS	Manual Out of Service
MTCE	Maintenance
N(R)	Receive Sequence Variable
N(S)	Send Sequence Variable

NARTAC	North American Regional Technical Assistance Center
NE	Near End
NFAS	Nonfacility Associated Signaling
NFE	Network Facilities Extension
NIP	Network Identification Plan
NPA	Numbering Plan Area
NPI	Numbering Plan Identifier
NPP	Network Protocol Profile
NSF	Network Specific Facilities
NTC	Notification to Controller
NTWK	Network
NXDS0	N-times-DS0 or Switched/Fractional-DS1
OLI	Originating Line Information
OOS	Out of Service
OPOTS	Originating Plain Old Telephone Service
OSA	Operator System Access
OSS	Operator Service System
OUTWATS	Outward Wide Area Telecommunications Service
P(S)	Packet Send Sequence Number
P/F	Poll/Final Bit
PBX	Private Branch Exchange
PCN	Privacy of Calling Name
PFA	Private Facilities Access
PIDB	Peripheral Interface Data Bus
POTS	Plain Old Telephone Service
PRI	Primary Rate Interface
PVC	Permanent Virtual Circuit
RC	Retransmission counter
REJ	Reject
Ri	Reference number
RNR	Receive Not Ready
ROP	Receive-Only Printer
RPOA	Registered Private Operating Agency
RR	Receive Ready
S	Supervisory
S	Supervisory function bit

SABM	Set Asynchronous Balanced Mode
SABME	Set Asynchronous Balanced Mode Extended
SAP	Service access point
SAPI	Service Access Point Identifier
SCOCS	Selective Class of Call Screening
SDL	Specification Description Language
SDN	Software Defined Network
SDS	Switched Digital Service
SFG	Simulated Facility Group
SHC	Satellite Hop Counter
SID	Station Identification
SM	Switching Module
SONET	Synchronous Optical Network
STBY	Standby
SWF-DS1	Switched/Fractional DS1
TBCT	Two B-channel Transfer
TCM	Traveling Class Mark
TE	Terminal equipment
TEI	Terminal Endpoint Identifier
TGID	Trunk Group Identifier
TN	Telephone Number
TNS	Transit Network Selection
TPOTS	Terminating Plain Old Telephone Service
TR	Technical Reference
TSA	Time Slot Assignment
U	Unnumbered
UA	Unnumbered Acknowledgment
UCD	Uniform Call Distribution
UI	Unnumbered information
UUI	User-to-User Information
V(A)	Acknowledge state variable
V(R)	Receive state variable
V(S)	Send state variable
VC	Virtual Calls
VPN	Virtual Private Network
XID	Exchange Identification

ZCS	Zero Code Suppression

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