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ATIS-0300217.2013 (R2018)

INTEGRATED SERVICE DIGITAL NETWORK (ISDN) MANAGEMENT – PRIMARY RATE PHYSICAL LAYER

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ATIS-0300217.2013 (R2018), *Integrated Service Digital Network (ISDN) Management – Primary Rate Physical Layer*

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American National Standard for Telecommunications

Integrated Service Digital Network (ISDN) Management – Primary Rate Physical Layer

Alliance for Telecommunications Industry Solutions

Approved April 8, 2013

American National Standards Institute, Inc.

Abstract

This standard provides the maintenance operations requirements for primary rate physical layer ISDN access. It provides functional requirements to support maintenance and is not meant to be an equipment specification.

Foreword

The information contained in this Foreword is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI's requirements for an ANS. As such, this Foreword may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to the Standard.

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Suggestions for improvement of this document are welcome. They should be sent to the Alliance for Telecommunications Industry Solutions, TMOC, 1200 G Street NW, Suite 500, Washington, DC 20005.

At the time of consensus on this document, TMOC, which was responsible for its development, had the following leadership:

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S. Kiewel, TMOC Vice Chair (Ericsson)
L. Garbanati, TMOC Technical Editor (AT&T)
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Table of Contents

Table of Figures

Table of Tables

American National Standard for Telecommunications on –

Integrated Service Digital Network (ISDN) Management – Primary Rate Physical Layer

1 Purpose, Scope, & Structure

1.1 Purpose

The purpose of this standard is to establish required capabilities for the maintenance and operations needed for the primary rate physical layer associated with access to Integrated Services Digital Networks (ISDNs).This standard establishes needed maintenance functionality in customer and network equipment, particularly from the perspective of maintenance functionality available at the network boundary and from Operations Systems.

1.2 Scope

This document covers maintenance of the Primary Rate Access (PRA) physical layer, which consists of equipment and facilities that exist as part of the customer access and the customer installation (see Figure 1).

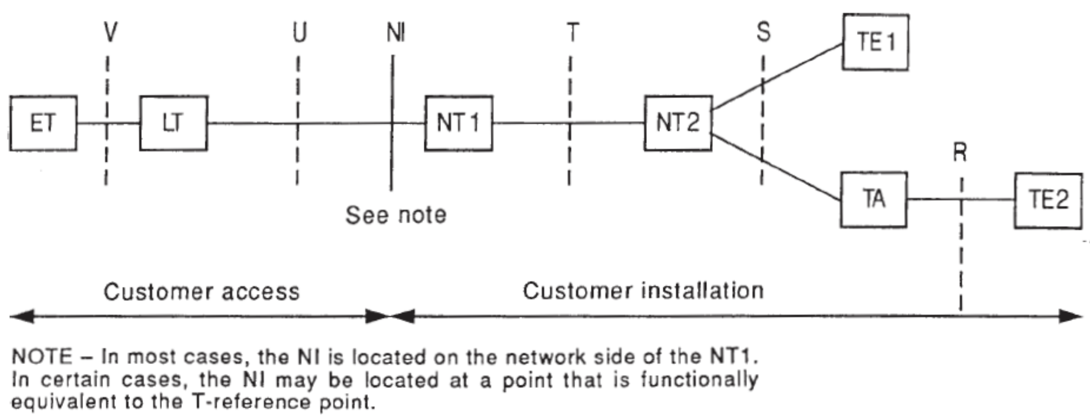

Figure 1 - ISDN Primary Access Reference Configuration

Maintenance of the data-link and network layers associated with the primary rate interface is covered in another ISDN management standard.

1.3 Structure

Clause 1 describes the purpose, scope, and structure of this document. Section 2 lists referenced documents. Clause 3 provides definitions of new terms introduced by this standard. Clause 4 describes PRA models that are used in Clause 5 to help describe the required maintenance capabilities. PRA maintenance topics for further study are discussed in Annex A. Details of the relationships at the customer installation between the maintenance capabilities at the various interfaces and reference points in the ISDN reference model and the physical interfaces to the primary rate customer equipment are provided in Annex B. PRA equipment interface operations under fault conditions are described in Annex C. A list of acronyms used in this document is provided in Annex E. A bibliography of related standards appears in Annex F.

2 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this American National Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

ATIS-0600403.1999 (R2012), *Carrier to Customer Installation – DS1 metallic interface specification*.[1]

ATIS-0600403.a.2001 (R2010), *Supplement to Carrier to Customer Installation – DS1 metallic interface specification.*[2]

ATIS-0600403.b.2002 (R2010), *Supplement to Carrier to Customer Installation – DS1 metallic interface specification.*[3]

3 Definitions

3.1 Administration Management Complex (AMC): A complex controlled by a network provider, which has the responsibility and capability for (among other management functions) the maintenance functions and the maintenance actions for a network.

3.2 Customer Access (CA): The portion of the ISDN access that a network provider supplies to connect the Customer Installation (CI) with the network. CA includes those network elements or portions of elements that extend from the access switch to the Network Interface (NI).

3.3 Customer Installation (CI): Consists of the equipment and facilities at the customer's location on the customer's side of the NI.

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[1] This document is available from the Alliance for Telecommunications Industry Solutions (ATIS), 1200 G Street N.W., Suite 500, Washington, DC 20005 < https://www.atis.org/docstore/product.aspx?id=26087 >

[2] This document is available from the Alliance for Telecommunications Industry Solutions (ATIS), 1200 G Street N.W., Suite 500, Washington, DC 20005 < https://www.atis.org/docstore/product.aspx?id=25246 >

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3.4 Customer Management Complex (CMC): A complex controlled by a customer, which has the responsibility and capability for (among other management functions) the maintenance functions and the maintenance actions within a customer's installation.

3.5 Digital Crossconnect System (DCS): A network element that may be used to arrange DS0 channels among DS1 facilities.

3.6 Embedded Operations Channel (EOC): A generic term used to describe the Extended Superframe Format (ESF) data link (DL) defined in ATIS-0600403.

3.7 Functional Group: Sets of capabilities in ISDN (e.g., Network Termination 1 (NT1), Network Termination 2 (NT2), Terminal Equipment (TE), and Terminal Adaptor (TA) per ITU-T Rec. I.411) that may be combined or distributed among ISDN equipment. These sets of capabilities generally are defined at a high level. For example, the NT1 functional group has only Layer 1 capability while the NT2 may have both Layer 1 and higher-layer capabilities.

3.8 H-channels: 384-kbps (H0-), 1472-kbps (H10-), or 1536-kbps (H11-) channels, intended to carry a wide variety of user information streams, such as fast facsimile, video, high-speed data, or high-quality audio.

3.9 I_a: The 4-wire (2-pair) bidirectional primary rate interface point on the network side of the termination equipment, including the equipment connecting cord or equivalent, on the user side of the interface cable.

3.10 I_b: The 4-wire (2-pair) bidirectional primary rate interface point on the user side of the termination equipment, including the equipment connecting cord or equivalent, on the network side of the interface cable.

3.11 loopback: A state of a transmission facility in which the received signal is returned towards the sender.

3.12 loopback point: The location of the loopback.

3.13 Network Element (NE): Telecommunication equipment (groups or parts) within ISDN that provides support and/or service to the customer.

3.14 Network Interface (NI): The point of demarcation between the network and the Customer Installation (see Figure 1).

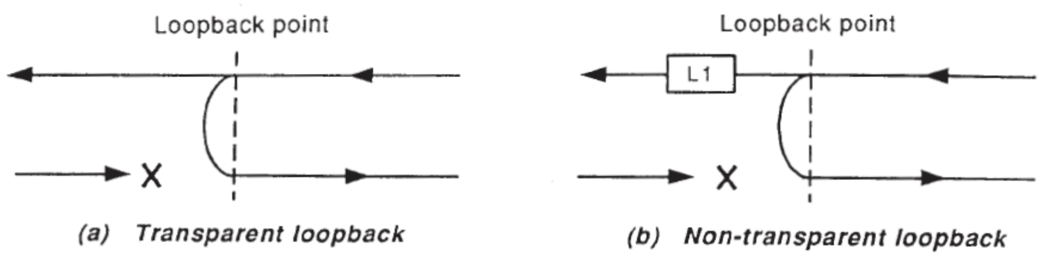
3.15 non-transparent loopback: A loopback in which the signal transmitted beyond the loopback point (the forward signal) when the loopback is activated, is not the same as the received signal at the loopback point (see Figure 2). The forward signal may be a defined signal or unspecified.

3.16 Operations System (OS): A system that processes information related to telecommunication management to support and/or control the realization of various telecommunication management functions. To support CA maintenance, OSs must perform surveillance and testing functions.

3.17 Primary Rate Access (PRA) path: Logical connection between ESF termination points (i.e., path terminations) on the CA and the CI.

3.18 Severely-Errored Framing Event (SEFE): The occurrence of two or more framing-bit errors within a 3-ms period[4]. Contiguous 3 ms intervals are examined. The 3 ms period may coincide with the Extended Superframe (ESF).

3.19 transparent loopback: A loopback in which the signal transmitted beyond the loopback point (the forward signal) when the loopback is activated, is the same as the received signal at the loopback point (see Figure 2).



L1 - Device that changes or inhibits the transferred signal

X - Signal inhibited in order to avoid interference with looped signal

NOTE – Transparent and non-transparent loopbacks should not be affected by facilities connected beyond the point at which the loop is provided; e.g., by the presence of short circuits, open circuits or foreign voltages.

Figure 2 - Loopback Types

4 Primary Rate Access Models

This section provides PRA models for:

- Customer Access (4.1); and
- Customer Installation (4.2).

The relationship between PRA lines and paths is shown on Figure 3. The Exchange Termination (ET), NT2, and TE/TA functional groupings terminate DS1 paths, while the Line Termination (LT) and NT1 functional groupings do not. When higher-rate multiplexers are not used on the PRA (See Figure 3, Item a), then the line and path are coincident. When higher-rate multiplexers are used on the PRA (See Figure 3, Item b), then line and path may not be coincident. In these cases, DS1-rate lines exist between the ET and its nearest multiplexer, and between the NT2 or TE/TA and its nearest multiplexer. However, the DS1-rate path still exists between the ET and the NT2 or TE/TA.

[4] On an interim basis, to facilitate early implementation of this standard, use of existing 2 of 4, 2 of 5, 3 of 5, etc., framing-error detection criteria may be substituted for this criteria.

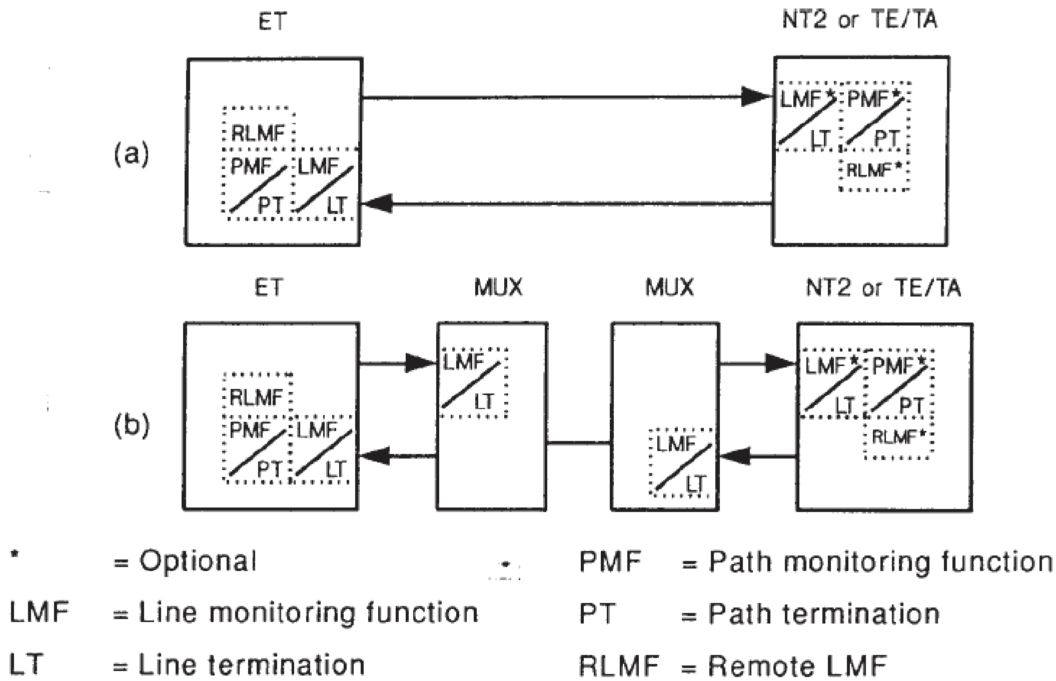
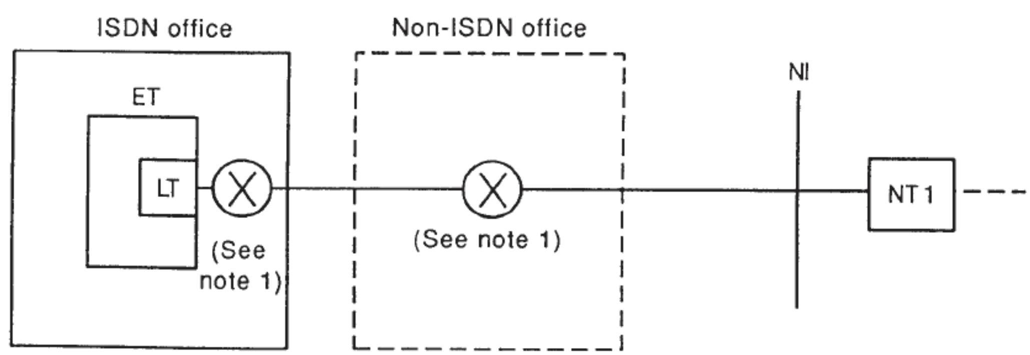


Figure 3 - Line and Path Monitoring

4.1 Customer Access

Figure 4 shows a simple ISDN maintenance model for PRA transport. Figure 5 shows a multiple-facility PRA model. Maintenance aspects of these PRA models are described below. Maintenance for PRAs that use DCSs is discussed in Annex A.



NOTES

1 Digital Signal Crossconnect (DSX) may provide Exchange Carrier/Interexchange Carrier Boundary.

2 DS1 Path may include multiplexing to higher-rate facilities.

3 PRA may consist of multiple DS1 facilities.

Figure 4 - ISDN Model for Primary Rate Customer Access

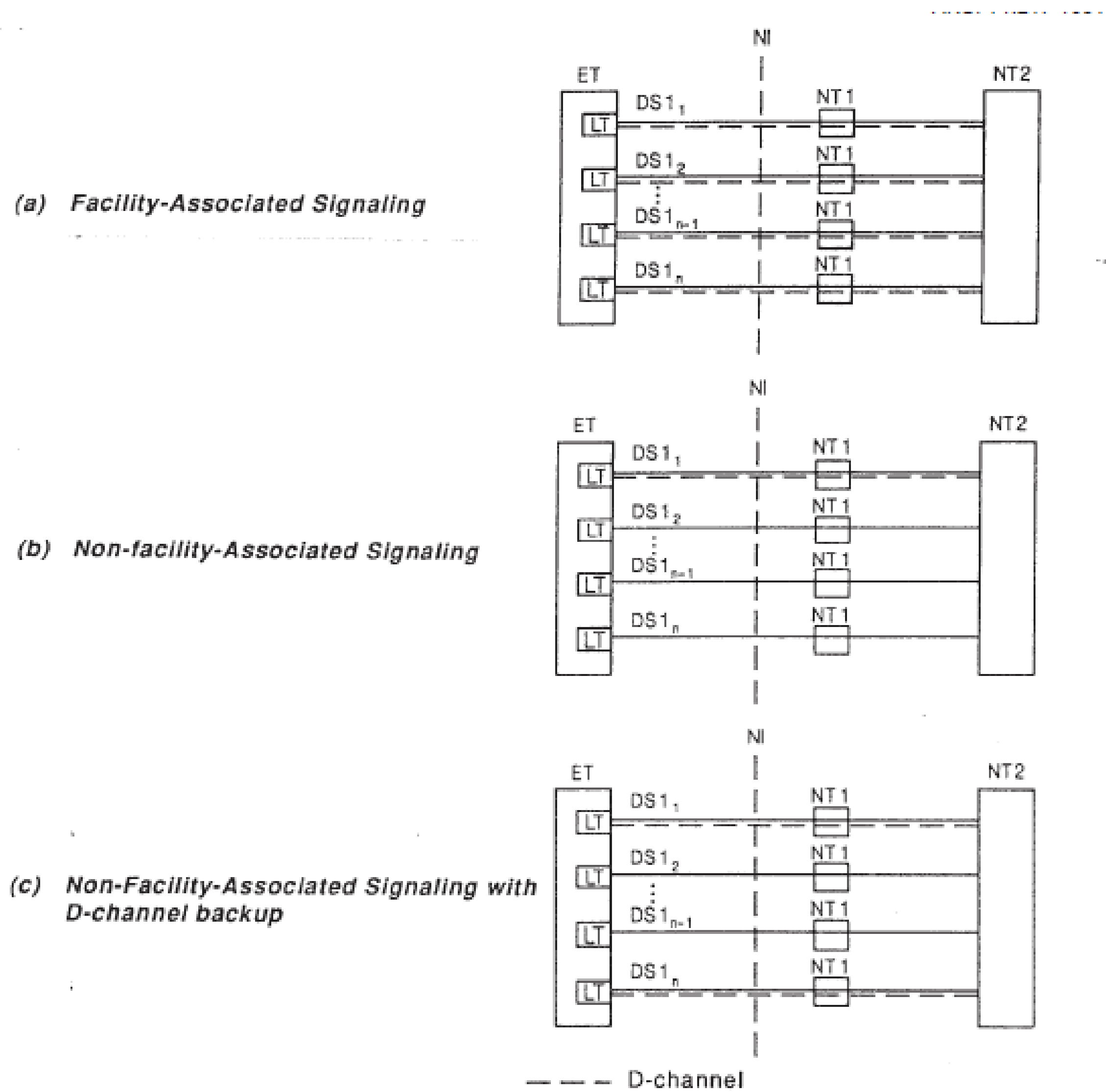


Figure 5 - PRA Multiple Facility Model

4.1.1 Simple PRA

Figure 4 shows a simple PRA architecture. A DS1 access is shown from an ET to the 1 NT1. Functionally, an ET performs D-channel processing, switching/routing, and related tasks. The ET also constructs the DS1 signal that is sent towards the NT1. The DS1 access may optionally traverse non-ISDN intermediate offices and/or be multiplexed onto higher-rate facilities. Also, exchange carrier/interexchange carrier interfaces are possible on the PRA.

4.1.2 Multiple DS1 Facilities

The simple PRA model shown in Figure 4 is extended to show three multiple DS1 facility cases in Figure 5. Each of these three cases is described as follows.

4.1.2.1 PRAs with Facility Associated Signaling

A model architecture showing multiple PRAs with facility-associated signaling is given in Figure 5a. The term “facility-associated” indicates that the D-channel within the PRA provides the signaling for its own bearer-channels[5] (e.g., up to 23 B-channels) and no others. In Figure 5a, multiple individual DS1-PRA paths are shown connecting an ET via an LT and an NT1 to an NT2. Each DS1-PRA provides its own facility-associated signaling D-channel yielding “n” separate PRA channel configurations of 23B + 1D.

4.1.2.2 PRA with Non-Facility-Associated Signaling

When a D-channel can assign calls to bearer-channels[6] on more than one DS1, including the one carrying the D-channel, this is called non-facility-associated D-channel signaling. Figure 5b shows the same multiple interface with “n” DS1s as in Figure 5a, this time with non-facility-associated signaling in which a single D-channel may control all B- channels carried by the “n” DS1s – e.g., a channel configuration of 95B + 1D when “n” equals 4.

4.1.2.3 Non-Facility Associated Signaling PRA with Backup D-channels

A multiple interface with non-facility-associated signaling may also be equipped with D-channel back-up using an active and standby D-channel[7]. This back-up arrangement provides signaling redundancy when large numbers of bearer-channels are controlled. In this arrangement, the numbering of the B- and D-channels is static, regardless of any back-up switching. After back-up switching has occurred, the former standby D-channel becomes (and remains) the active D-channel until the next back-up event.

In the D-channel back-up example in Figure 5c, two D- channels are used (only one active at a time), each located in a different DS1. 94B + 2D, when “n” equals 4, would be an example of such a channel configuration.

In general, during the back-up process, stable calls on non-failed bearer channels remain up, but some transient calls and temporary signaling connections may be impacted. Details of the failure conditions and the management states used for non-facility-associated signaling with and without backup will be covered in another standard. The protocol used to control the D-channel backup is covered in ATIS-1000607 (also see Annex F of ITU-T Rec. Q.931).

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[5] In this case, the bearer channels may be any combination of B- and H0-channels that use up to twenty-three 64-kb/sec timeslots or an H10 channel.

[6] In this case, the bearer channels may be any combination of B-, H0-, H10-, or H11- channels that use up to the capacity of the twenty-three 64- kb/s timeslots on the DS1 carrying the D-channel and the twenty-four 64-kb/s timeslots on the other DS1s, with the constraint that H-channels are not split across DS1s.

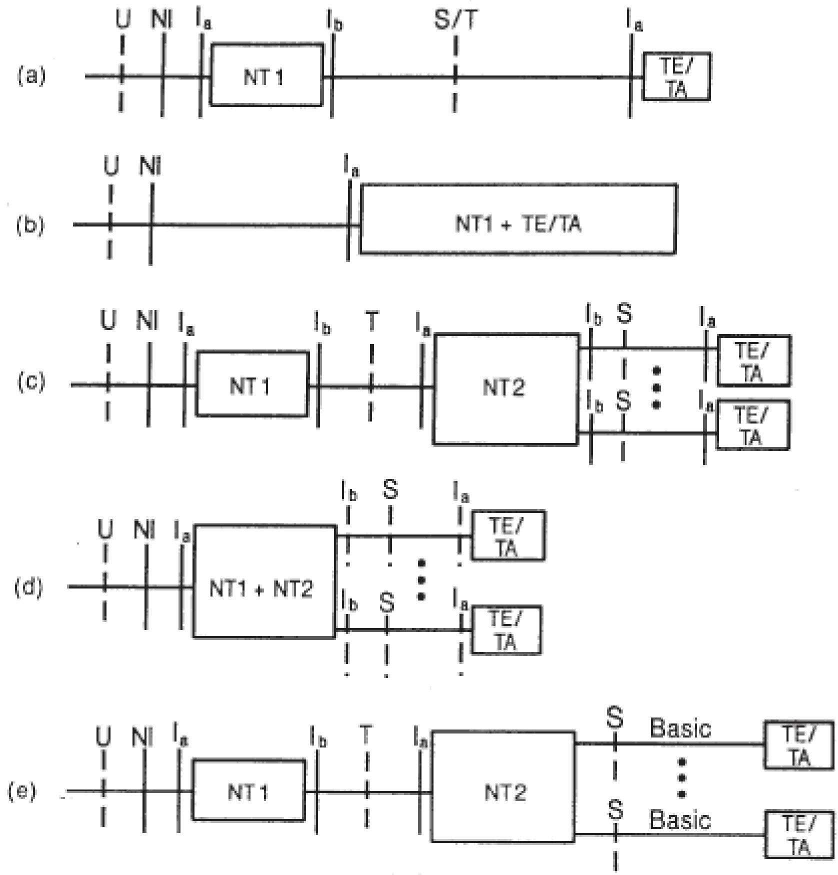
[7] D-channel back-up is not associated with any protection switching provided on the DS1 or higher-order facilities.

4.2 Customer Installation

Figure 6 provides examples of primary rate customer configuration models. These show the relationships between the NT/TE/TA functional groups, reference points, interfaces and equipment realizations. Case A shows the S/T interface that applies when no NT2 functions are required, and the NT1 and TE/TA functions are in separate pieces of equipment. Case B has the NT1 and TA/TE functional groups combined into the same piece of equipment. Case C shows the NT1, NT2 and primary-rate TE/TAs all in separate pieces of equipment. Case D has the NT1 and NT2 combined into one piece of equipment. Case E shows the same configuration as case C, except that the TE/TAs are at basic rate.

Note that when a stand-alone NT1 is provided (e.g., cases A, C and E), then an NT1 power failure could appear to the TE/TA or NT2 as a failed PRA.

For more details on how the various maintenance capabilities described in this standard are combined in typical pieces of customer installation equipment see Annex B. Annex B also describes the relationships in the customer installation between the features at the NI, the U, T, and S reference points shown in Figure 6 and the I_a and I_b physical interfaces to the primary rate customer equipment.



NOTES

1 All equipment interfaces are at primary rate unless otherwise indicated

2 This figure shows how the ISDN functional groups (NT1, NT2, TE/TA) may be combined into different equipment realizations.

Figure 6 - ISDN Equipment Realizations for Primary Rate Customer Installation

5 Required Capabilities

This clause describes required capabilities in the following areas:

- Transmission format maintenance features (5.1);
- Performance monitoring capabilities (5.2); and
- Testing capabilities (5.3).

5.1 Transmission Format Maintenance Features

Only primary access provided over transport systems that use the ESF[8] will be treated in this standard.

Continuous automatic surveillance requires the following operations features (see ATIS-0600403) to be included in the transmission format (ESF) for DS1 paths that carry primary access:

- CRC code;
- Performance report messages;
- EOC; and
- Alarms for service-affecting troubles.

The functional capabilities provided by these features are briefly described as follows.

5.1.1 Cyclic Redundancy Check

The CRC code is an error-detection code that is generated from the information bits in the superframe and inserted into the bit stream by the transmitter. At a downstream location, a CRC calculated from the received information bits in the superframe is compared with the CRC received in the bit stream. If the two CRCs differ, there has been at least one error in the superframe.

5.1.2 Performance Report Messages

Single-ended performance monitoring is accomplished by the use of the performance report message. Each path termination measures the errors in the incoming signal and periodically sends information on these to the far end path termination using the performance report message.

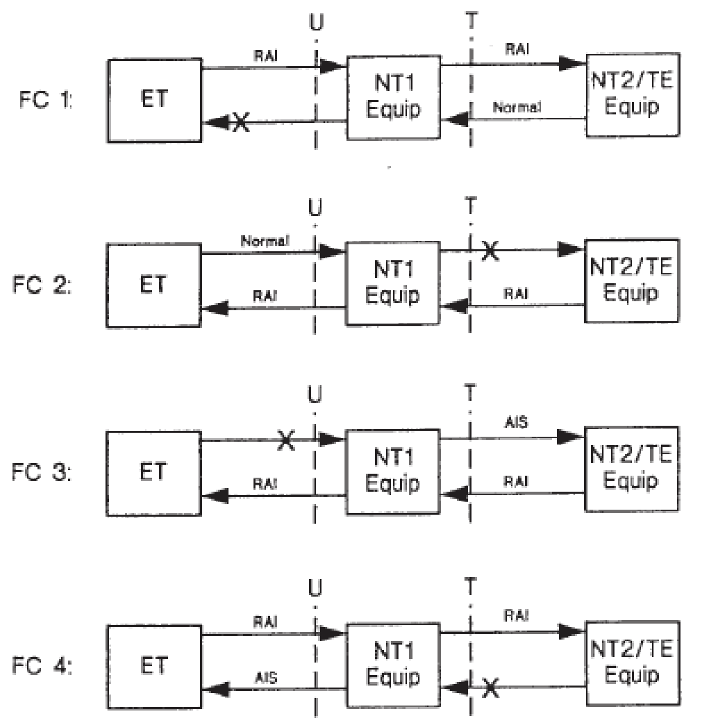
5.1.3 Embedded Operations Channel

The EOC carries performance report messages, Remote Alarm Indication (RAI) signals (described in 5.1.4), and loopback commands. Other EOC functions needed to support ISDN PRA are a subject for further study. The PRA architecture may be such that the EOC may be discontinuous (e.g., see Annex A). Other potential EOC functions are also discussed in Annex A.

[8] ESF is needed to overcome operational limitations of the Superframe Format (SF). Some SF limitations that become apparent when transmitting digital data are the occurrence of false framing in the presence of marginal error performance, the occurrence of false yellow alarms, and limitations on in-service performance monitoring capabilities (including the absence of any visibility on the performance of the signal received by the user).

5.1.4 Alarms for Service-Affecting Troubles

Service-affecting troubles prevent user channels from carrying user information, and put the PRA in the unavailable state. Figure 7 shows a realization of the PRA with the NT1 and NT2/TE functional groups in separate pieces of equipment for four possible failure conditions. It also shows how the equipment responds to these failures. Figure 8 shows a realization of the PRA with the NT1 and NT2/TE functional groups in a single piece of equipment, and how this equipment responds to incoming and outgoing failures. Note that the behavior of the NT2/TE equipment in Figure 7 is identical to the behavior of the combined equipment in Figure 8. (The ET response is also the same in the two figures.) Annex C provides additional details about the operational states associated with these failures.



AIS = Blue

FC n = Fault condition n (see annex C)

RAI = Yellow

X = Fault condition

Figure 7 - Possible Fault Locations and Resulting Alarm Transmissions

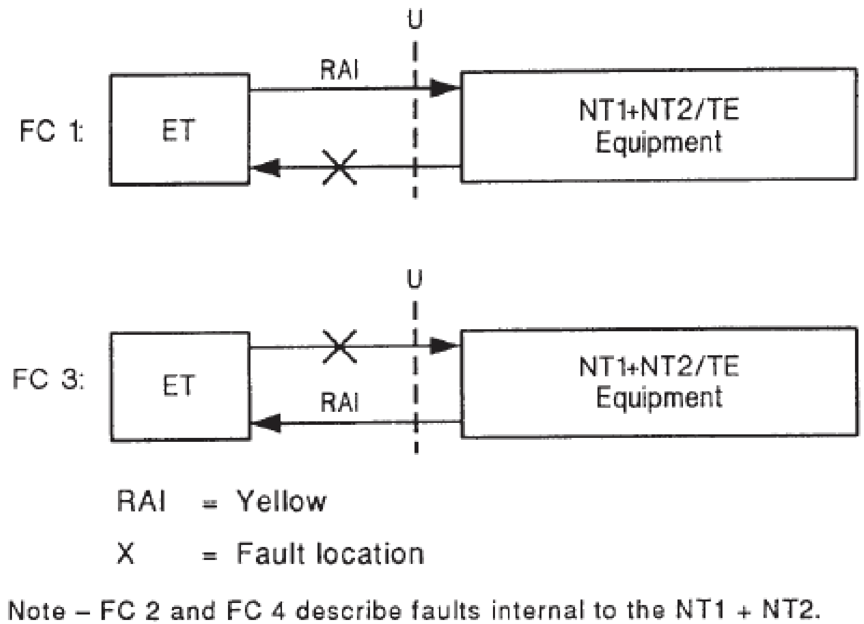


Figure 8 - Possible Fault Locations & Resulting Alarm Transmissions for Combined NT1 + NT2

In the configuration shown in Figure 7, it would be desirable for the NT2/TE equipment to be able to distinguish between failure conditions 4 and 1, and for the ET to be able to distinguish between failure conditions 2 and 3. Such alarm sectionalization may be achieved by operating the line loopback capabilities in the NT1 equipment (see Table 1). Another mechanism that could provide similar alarm sectionalization using EOC queries to the NT1 equipment is described in Annex A.

The Alarm Indication Signal (AIS) (also referred to as Blue) and the RAI (also referred to as Yellow), used in Figures 7 and 8, are defined in ATIS-0600403. These autonomous alarms are transmitted until the failed signal is restored (unless interrupted by an EOC message). In order to perform sectionalization procedures, RAI may be interrupted for a maximum of 100 ms per interruption with a minimum interval of one second between interruptions.

The network should be aware that loss of NT power may appear to the network as a failed PRA.

5.2 Performance Monitoring

The objective of the performance monitoring system is to help ensure the high-quality, availability, and maintainability levels of the ISDN PRA. When the PRA is comprised of more than one line, the performance monitoring objectives are met by ensuring the quality, availability and maintainability levels of each portion of the PRA configuration.

Quality is the performance level – e.g., measured in percent of error-free intervals.

Availability is the fraction of time that the line is ready and able to perform all supported functions.

Maintainability is the ability to identify, repair and restore the line after a failure.

The necessary functions include:

- Continuous transmission quality assessment;
- Fault detection and sectionalization to the responsible repair organization;
- Storage of performance data;
- Remote access to current and stored performance data; and
- Remotely-settable alert thresholds;

Continuous monitoring of the transmission system, made possible by in-service performance measurements, allows for trouble-detection and possibly repair of the ISDN access lines before the customer reports a trouble. When customers do report troubles, recent in-service data can be used to verify the trouble and, in some cases, sectionalize the problem to the responsible repair organization, leading to efficient trouble clearance. This serves to keep the quality and availability of the ISDN PRAs high.

When responding to trouble reports, performance history data is needed to quickly assess the recent performance of the lines. Limited performance data shall be stored in network elements to allow performance assessment against long-term performance objectives.

5.2.1 Performance Monitoring from Network Point of View

The Layer 1-monitored entities from the network point of view are:

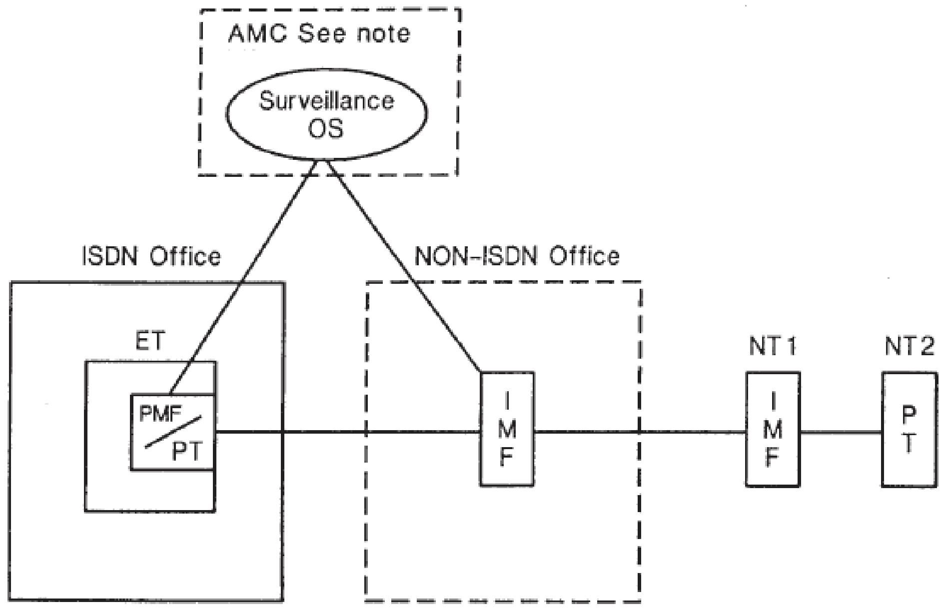
- DS1 lines;
- DS1 paths;
- Intermediate DS1 paths[9];
- DS3 or higher-rate facilities.

For all layer 1-monitored entities, each direction of transmission is monitored separately.

Figure 3 shows that DS1 lines (between two LTs) are monitored by Line Monitoring Functions (LMF). It also shows that DS1 paths (between two Path Terminations [PTs]) are monitored by Path Monitoring Functions (PMFs). The PMF uses CRC and performance report message information to monitor bi-directional path performance. Note that performance report messages also contain far-end line monitoring information. The Remote Line Monitoring Function (RLMF) uses this information to monitor far end line performance. DS3 or higher-rate facilities (between two multiplexers) are also monitored.

Figure 9 shows an optional configuration in which intermediate DS1 paths (between a PT and an intermediate point) are monitored by Intermediate Monitoring Functions (IMFs). The network provider may optionally locate IMFs at non-ISDN central offices in order to sectionalize loop and inter-office troubles. Similarly, customers may optionally locate IMFs within NT1s to sectionalize troubles between customer and network plant.

[9] Points intermediate to DS1 paths may also be intermediate to DS1 lines.



Note – AMC functions may be distributed among OSs and network elements.

Figure 9 - Possible Locations for IMF

In the remainder of 5.2, requirements are given for monitoring DS1 paths. These requirements apply to the PMF and, optionally, to the IMF.

5.2.2 Performance Monitoring from User Point of View

The monitored entities for primary rate, from the user point of view, depend on how the attachment to ISDN PRA is made. Figure 6 shows some examples of possible attachment scenarios. The ability to monitor Layer 1 will depend on the capability of the equipment at the end-point of the access.

In addition to generating the required performance report message, the user equipment may optionally derive and store performance parameters based on both the incoming block errors and performance report messages from the EOC.

5.2.3 Path Parameters

The required Layer 1 performance monitoring parameters for DS1 paths are:

- *Errored Second (ES):* A second in which any one or more of the following have been detected (applies to each direction of transmission):
  - One or more CRC-6 violations.
  - One or more SEFEs.
  - One or more controlled slips.
- *Severely-Errored Second (SES_{crc}):* A second in which any one or more of the following have been detected (applies to each direction of transmission):
  - 320 or more CRC-6 violations.
  - One or more SEFE.
- *CRC Coding Violations (CV_{crc}):* Individual CRC violations measured in a single direction of transmission.
- *Slip-Second (SLIP-SEC):* A second in which one or more controlled slips occur. (Controlled slips are defined in ATIS-0600403).
- *Severely-Errored Framing Event Second (SEFES):* A second in which one or more SEFE occur. Functionally, SEFE is an event that causes a frame search to start; such a frame search may lead to an Out-of-Frame (OOF) declaration or a Change of Frame Alignment (COFA).

Under normal conditions, each of the above parameters shall be computed by the network (i.e., parameters derived from CRC and performance report messages). When in an unavailable state, performance monitoring counters will not be incremented. Measurements made during the unavailable state are a subject for further study. The details of how to transition in and out of the unavailable state are also a subject for further study.

5.2.4 Path Monitoring History (Network)

Performance monitoring history shall be kept by network elements. A PMF or IMF shall report performance monitoring histories to the OS based on 15-minute and daily intervals.

For DS1 paths, the network element shall count ES, SES_{crc}, CV_{crc}, SLIP-SEC and SEFES for two directions of transmission (total of 10 counts/path). The minimum size for performance monitoring registers (counters) shall be 12 bits for 15-minute registers (except for CV_{crc}, which shall be 16 bits) and 16 bits for daily registers (except for CV_{crc}, which shall be 20 bits). When the maximum value of a register is reached, the register shall remain at that maximum value. For each parameter, the following performance registers shall be kept:

- *Current 15-minute register:* Contains the impairment count for the parameter during a 15-minute period. The current register shall be reset to zero at the end of each 15-minute period after the data is transferred to the previous 15-minute register.

- *Current day register:* Contains the impairment count for the parameter during a 24-hour period. The current day register shall be reset to zero on each day after the data is transferred to the previous day register.

- *Previous 15-minute register:* Contains a 15-minute count for the parameter. At the end of each 15-minute period (including during DS1 alarm conditions), the impairment counts from the current 15-minute register are stored in the previous 15-minute register, and the old data from the previous 15-minute register is discarded (except for data that is transferred to the first recent register).

- *Previous day register:* Contains a 24-hour count for the parameter. At the end of each day (including during DS1 alarm conditions), the impairment counts from the current day register are stored in the previous day register and the old data from the previous day register is discarded.

- *Recent 15-minutes registers (for ES, SES_{crc} and SLIP-SEC data only):* A group of thirty-one 15-minute registers, each of which contains a 15-minute count for the parameter, so that performance data for the 31 most recent 15-minute periods (plus the previous 15 minutes) is stored. This is intended to provide detailed coverage of the most recent 8-hour period. At the end of each 15-minute period (including when path framing has been lost), the impairment count from the previous 15-minute register is stored in the first recent register. The values in each successive register are pushed down one register in the stack. The oldest 15-minute period value at the bottom of the stack is discarded.

All of the above registers shall be readable upon demand.

Fifteen-minute and daily intervals shall be accurate to within plus or minus 10 seconds with respect to the duration of 15 minutes or a day (e.g., a 15-minute register may be accumulated over a period between 890 seconds and 910 seconds). The start of 15-minute and daily intervals shall be accurate to within plus or minus 30 seconds with respect to the start of the 15-minute period as determined by the network element clock (e.g., a 15-minute register may begin its 2:00 count between 1:59:30 and 2:00:30).

Any or all registers may be reset on demand. The registers shall not be reset automatically upon service restoral for outages that result in service-affecting alarms.

5.2.5 Path Monitoring Thresholds (Network)

Threshold crossing alert messages are an integral part of the performance monitoring approach to maintenance. The current 15-minute registers and the current day registers shall be thresholded for ES, SES_{crc}, and SLIP-SEC. Thresholding for CV_{crc} is optional. When a threshold is reached or exceeded, a threshold-crossing alert message shall be generated within 3 minutes (maximum) of the actual occurrence of the threshold crossing. The NE must check for daily threshold crossings at least once every 15 minutes. When the NE recognizes a daily threshold crossing, a threshold-crossing alert message shall be generated. For each of the parameters thresholded, a single threshold value will apply to both directions of transmission.

The 15-minute and daily thresholds for the parameters shall be settable on a per-line basis by requesting a specific value or by requesting “default”. A request to change all lines within the NE to “default” shall also be supported. The “default” values themselves shall also be settable on a per NE basis.

5.2.6 Scheduled Reporting

NEs shall also support the ability to report the values of the current 15-minute registers for all parameters at the end of the current 15- minute interval. Only non-zero values shall be reported. This ability can be turned on and off or scheduled to start and end at specific times on a per-line basis.

5.3 Testing

Digital testing is used in conjunction with in-service performance monitoring to verify, sectionalize, and isolate troubles. Digital testing is performed under the direction of a testing OS. The test may be initiated by a user report of trouble or receipt of an autonomous service-affecting trouble alarm. No routine testing is performed since this function is obviated by continuous performance monitoring.

5.3.1 Loopbacks

Loopbacks are used by network providers and users as maintenance tools to aid in problem resolution. Loopback types and locations are described in Table 1. All loopbacks are considered optional, except for the I_a line loopback, which is required. Unique EOC codewords have been specified to control:

- Line loopbacks at I_a and I_b;
- A payload loopback within the CI;
- A line loopback for use by a network provider; and
- A line loopback for use by the user within the CI.

Channel loopbacks are also used in problem resolution and are controlled by means higher than layer 1. The loopback types are further described as follows.

Table 1 - Description of Loopbacks for Primary Rate Access

Loopback	Looped Signal	Control Process	Forward Signal	Loopback Direction	Applicable Functional Group (Note 1)
Line loopback I_a	1.544 Mb/s	EOC	Non-transparent with AIS (Note 2)	Toward 1_a interface	NT1, NT2, TE/TA
Line loopback I_b	1.544 Mb/s	EOC	Non-transparent with AIS (Note 2)	Toward I_b interface	NT1, NT2
Payload loopback	1.536 Mb/s	EOC	No forward signal	Note 5	NT2, TE/TA
Channel loopback	B, H0, H10, H11	*Note 3*	Further study (Note 4)	Note 5	NT2, TE/TA, ET

[1] The applicability of these loopbacks to the various functional groups may depend on the way in which the functional groups are combined in equipment realizations (see Annex B).

[2] The definition of forward signals is only relevant when the line loopback is in equipment that is not at a path termination point.

[3] The control process for these loopbacks is by means higher than layer 1. These means are a subject for further study.

[4] The need for and type of forward signal is a subject for further study.

[5] Since these loopbacks are associated with path terminations, they return the looped signal back along the path.

5.3.1.1 Line Loopbacks

Line loopbacks have been defined at I_a and I_b. These line loopbacks are controlled by unique EOC messages.

Line loopbacks shall result in a full 1.544 Mb/s loopback (toward the interface) of the received bit stream. Bit-sequence integrity shall be maintained.

5.3.1.2 Payload Loopbacks

The payload loopback is a characteristic of the primary rate path termination. These loopbacks may face either the user or network, depending on the path that is terminated (see Annex B). When a 1.536-Mb/s payload loopback is activated, the received information bits (192 information bits per frame) are transmitted in the outgoing direction. The framing bits (frame synchronization, CRC-6, and EOC) are originated at the point of the payload loopback. The payload loopback shall maintain bit sequence integrity for the information bits; however, the payload loopback need not maintain the integrity of 8-bit time slots, frames, or superframes. The payload loopback is controlled by an EOC message.

5.3.1.3 Channel Loopbacks

Channel loopbacks are loopbacks of the B-, H0-, H10-, or H11- channels. These loopbacks preserve 8-kHz integrity within the channels. They are controlled by the functional group in which they occur. Requests for these loopbacks are made by means higher than Layer 1 that are a subject for further study.

5.3.1.4 Loopback Considerations

When out-of-service tests are to be made, the interface and the associated channels shall be placed into the proper management states.

When a 1.544-Mb/s non-transparent loopback is activated, AIS should be sent downstream from the loopback point unless it is a path-termination point. The receipt of AIS at a loopback point, when the loopback is activated, should cause the loopback to be released. This applies to both 1.544- and 1.536- Mb/s loopbacks.

A “return to normal” signal is used to release inadvertent loopbacks (see ATIS-0600403).

Further fault sectionalization of a PRA may be accomplished by either the network provider or the customer by using the line loopbacks specified for network and customer use (see Annex D).

5.3.1.5 Loopback-Requesting and Control

The loopback-requesting point is the point that requests the loopback control point to operate loopbacks. Loopback requests should be subject to identification and authorization. (The loopback-requesting point need not be at the source of the test pattern generation.)

The loopback-control point is the location from which activation/deactivation of the loopback is controlled – e.g., local exchange, NT2, etc. If the loopback point and the loopback control point are co-located, then the loopback is said to be under the control of an internal process within the control point. If the loopback point and the loopback control point are not co-located, then some control mechanism is used between the loopback-control point and the loopback point to activate or deactivate the loopback. (The loopback point is under the control of the loopback-control point; that is to say, the loopback point is within the management domain of the loopback-control point.)

5.3.2 Test Lines

A 64-kbp/s dialable test line loopback, to be located in the ET, is defined in ATIS-0300206. A similar test line may be optionally provided in the NT2.

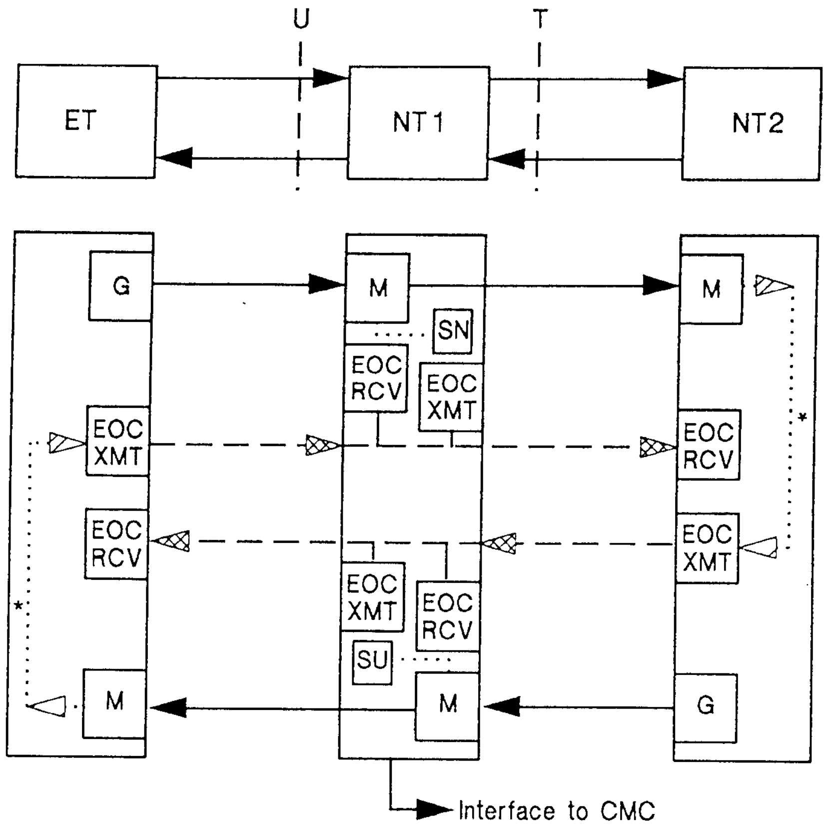
Annex A
(informative)

A Primary Rate Access Topics for Further Study

A.1 Additional PRA EOC Functions

Additional functions are under discussion for the EOC of the PRA. These additional functions would support non-service-disrupting sectionalization of performance problems, and provide for sectionalization of service affecting problems without the use of test equipment and loopbacks.

A potential mechanism under consideration is to allow the NT1 to be queried from either side over the EOC for information on the incoming performance seen on both sides. (Another potential mechanism is to query the NT1 over a separate physical interface that connects the NT1 to the CMC via a Telecommunications Management Network-like network.) Figure A.1 shows an NT1 connected between an ET and NT2. The ET and NT2 are DS1-framing source/sinks. The NT1 does not normally interrupt the DS1 signal; it only monitors the performance of the DS1 incoming from either side. Performance parameters and history similar to the ones discussed in clause 5 can then be stored in the NT1 (SU and SN in the figure). In addition to monitoring the performance, the NT1 also monitors the EOC for a query message addressed to it. (This addressing mechanism is a subject for further study.) This query can be sent from either the ET or NT2. When queried, the NT1 responds over the EOC with the required data. (The exact nature of the number and types of queries and responses, as well as the details of the protocol used, are subjects for further study.)



M - Monitor incoming CRC

G - Generate outgoing CRC and Far End Performance Report Message (FEPRM)

SN - Storage for network side monitor

SU - Storage for user side monitor

EOC - Embedded Operations Channel – Carries FEPRM and SN, SU information

XMT - Transmit

RCV - Receive

* Information for Far End Performance Report Message

Figure A.1 - Performance- monitoring Monitoring Capability in the NT1

As a simple example of the use of this type of arrangement, consider the problem of sectionalization shown in Figure 7. In the configuration shown in Figure 7, it would be desirable for the NT2 to be able to distinguish between Fault Condition (FC) 4 and FC1, and for the ET to be able to distinguish between FC2 and FC3. By allowing either the NT2 or ET to query the NT1, these failures can be distinguished without having to use loopbacks. FC1 and FC4 could be distinguished by the NT2 by making a query to the NT1. If FC1 exists, the NT1 would respond (and possibly interrupt the yellow alarm signal). If FC4 exists, then the NT1 would not respond. Similarly, the ET could distinguish FC3 and FC2 by querying the NT1.

A.2 Integrated Access with Non-ISDN Services

For some instances of ISDN access, it may be desirable or necessary to combine non-ISDN services with ISDN access. Some reasons for this approach may include cost of providing service, efficiency in the usage of the transmission facilities, or unavailability of separate transmission facilities. A DCS would be used to combine and separate the channels associated with ISDN and the non-ISDN services at one or more points along the PRA path. One possible configuration for such an access is shown in Figure A.2.

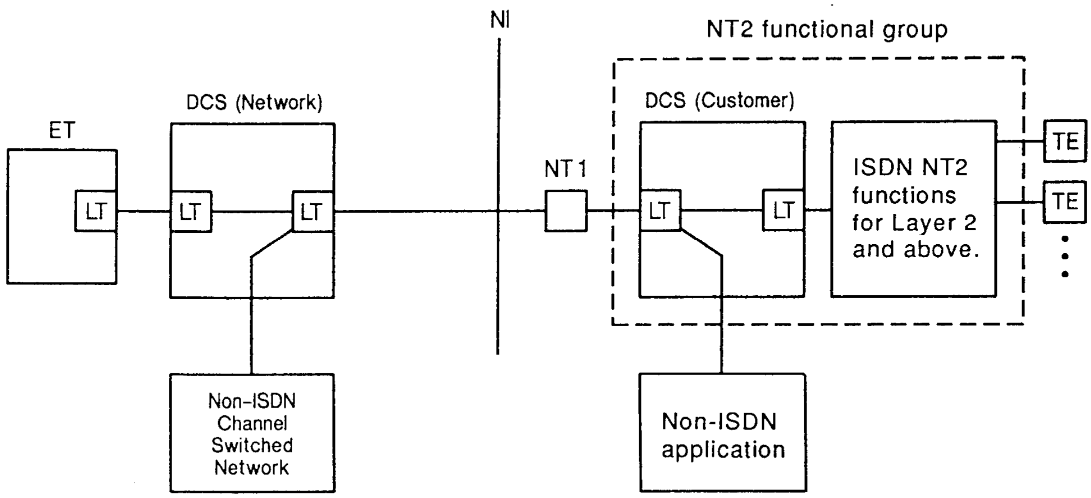


Figure A.2 - Integration of ISDN and Non-ISDN

When DCSs are employed in a PRA, the EOC will terminate on the DCS unless provision is made to connect it through the DCS. (The way in which data present in the EOC passes through the DCS is a subject for further study.) Due to the presence of the DCS, the PRA may contain two or more separate DS1 paths. As a result:

- Performance monitoring information collected at the LT in the ISDN central office, and at the NT in the CI, may not fully represent the performance of the PRA.
- To perform loopback testing, a testing OS may need to communicate with both the network DCS (for loopback control via the EOC) and with the ET (to assure proper management states).

Annex B
(informative)

B Customer Installation Functional Groups & Physical Interfaces

This annex attempts to clarify how the various maintenance capabilities used in the NT1, NT2, and TE functional groups, can be re-grouped in functional subsets, for convenience in considering physical implementations. It then describes how these function subsets relate to physical interfaces and equipment groupings within the customer installation. Note that these functional subsets only include the maintenance-related capabilities of the functional group. Other non-maintenance capabilities such as regeneration, line-equalization, or pulse-shaping are not covered in this annex.

Key concepts and definitions needed in understanding the following discussions are:

- *The NT interface:* A specification of electrical characteristics at the point of connection between the user and the network;
- *S, T, and U reference points:* Not specifications of electrical interfaces or characteristics; rather, they are used to specify the functions that may be implemented across them; and
- *I_a and I_b interfaces:* Specifications of electrical interfaces to user equipment.

The maintenance capabilities used in the NT1, NT2, and TE functional groups can be re-grouped into the following four functional subsets, which can then be applied to the functional groupings (NT1, NT2, TEs) of ISDN primary rate:

1) I_a Functional Sub-set (I_a FS):

    - *Line loopback toward interface I_a:* Controlled by I_a loopback codes in the primary rate EOC. (When this loopback is in equipment that realizes the NT1 functional group, it is referred to in ITU-T Recommendation I.604 as loopback 2.)

2) I_b Functional Sub-set (I_b FS):

    - *Line loopback toward interface I_b (optional):* Controlled by I_b loopback codes in the primary rate EOC. (When this loopback is in equipment that realizes the NT1 functional group, it is referred to in ITU-T Recommendation I.602 as loopback C.)

3) Path-Termination Functional Subset (PT FS):

    - *Recognition of loss of incoming signal/loss of framing.*
    - *Recognition of RAI.*
    - *Generation of RAI.*
    - *Generation of CRC.*

- *Monitoring of CRC and framing:* Monitoring of the CRC is needed to protect the framing. No calculation of performance data is implied.
- *Generation of the performance report message:* Required in the path-termination function that faces the U or T reference points (the path termination that is seen by the network). This function is optional for a path termination that is only used at the S reference point.
- *EOC end-point functions:* The path termination also terminates the EOC. EOC messages are received and transmitted. No EOC messages pass through the path termination. EOC messages for implemented functions are processed.
- *Monitoring of performance report message data (optional):* The path termination must be able to receive a Performance Report Message. However, this function pertains to the processing of the information contained in the report.
- *Calculation/storage of performance monitoring (PM) data (optional):* Deals with the calculation of layer 1 performance parameters, their storage as PM history, and their thresholding. (See 5.2.3 and 5.2.4 for details.).
- *Payload loopback (optional).*
- *Recognition of AIS.*

4) Intermediate Device Functional Subset (ID FS).

- *Recognition of loss of incoming signal.*
- *Generation of AIS.*
- *EOC Monitoring:* The Intermediate Device (ID) must be able to monitor the receive EOC from each side for messages that require it to perform some action (e.g., line loopback).
- Normally, the ID passes EOC messages through transparently. However, it may optionally have the ability to insert messages into the EOC in either direction. This capability is a subject for further study (see Annex A).
- *Monitoring of CRC and framing:* The ID may optionally monitor the received CRC blocks from each side for errors. The ID must *not* generate new CRCs.
- *Monitoring of performance report message data (optional):* Pertains to the processing of the information contained in the performance report message.
- *Calculation/storage of PM data (optional):* This function deals with the calculation of Layer 1 performance parameters, their storage as PM history, and their thresholding. (See 5.2.3 and 5.2.4.)

Figure B.1 shows how these function subsets are used in the various equipment arrangements.

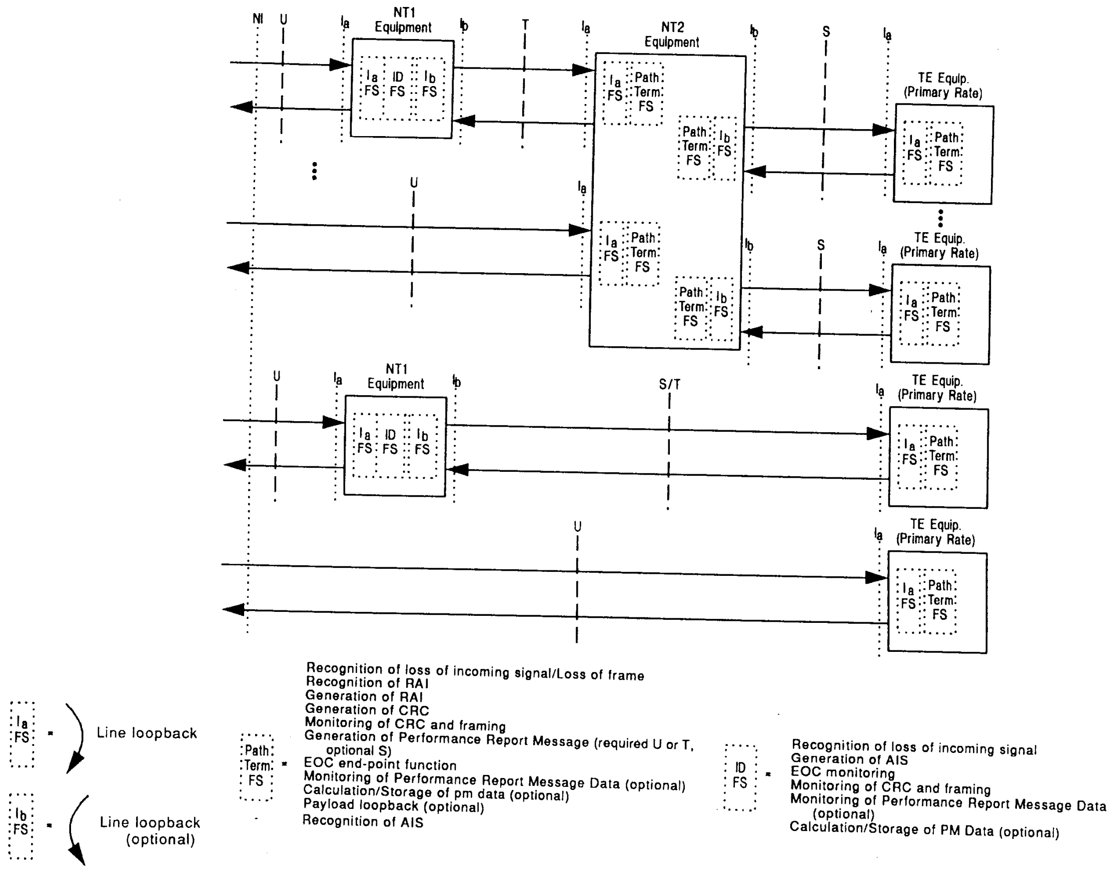


Figure B.1 - Functional Subsets used in PRA Equipment

Annex C
(informative)

C Equipment Interface Operations under Fault Conditions

C.1 Introduction

This annex describes the operation of the PRI under fault conditions from the perspective of the NT1 equipment (C.2), the NT2/TE equipment (C.3), and the ET (C.4). It uses the terminology of ITU-T Recommendation I.431 and I.601, and applies the concepts of these Recommendations to the 1544-kb/s PRI.

Figure C1 shows Fault Conditions (FC) 1 through 4, which may occur when NT1 equipment is provided (also see Figure 7). Indications of these fault conditions should be made available to maintenance processes in the NT2/TE equipment and to maintenance processes in the ET. Currently, signals exist in the 1544-kb/s PRI format to indicate to the NT2/TE whether FC3 or FC2 exists. FC4 and FC1 can be distinguished at the NT2/TE using additional procedures (see 5.1.4). Similarly, the ET can distinguish FC1 and FC4, and can distinguish FC2 and FC3 using additional procedures.

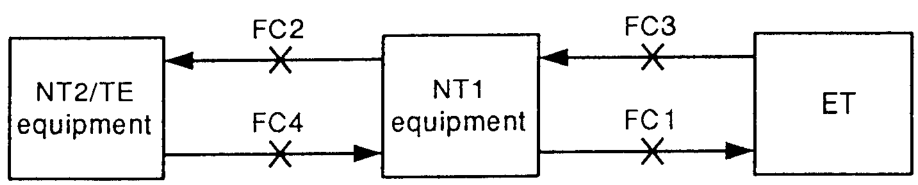
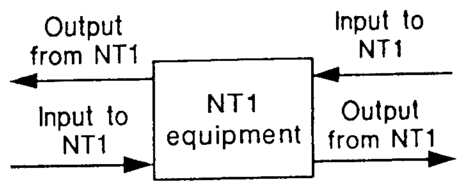


Figure C.1 - Location of Fault Conditions

C.2 NT1 Equipment Operation

NT1 equipment is intended to be consistent with that of a simple regenerator with the following additions: capability to generate an outgoing AIS signal on one side when the incoming signal from the other side is lost, capability to respond to the appropriate 1544-kb/s loopback commands from both sides (see 5.3.1), and optional capability to monitor the operational frames from both sides (see Annex A). Figure C.2 shows that the capability to generate AIS is symmetric with respect to both sides of the NT1. It also shows that normal operational frames pass through the NT1 without the CRC bits being corrected.



Input to NT1	Output from NT1
Normal operational frames	Normal operational frames
RAI	RAI
AIS	AIS
Loss of Receive Signal	AIS

NOTE – The NT1 does not generate RAI.

Figure C.2 - NT1 Input/Output

C.3 NT2/TE States

States are defined as follows for an NT2/TE (also see Figure C.1):

- *F0 state:* Loss of power state;
    - In this state, the NT2/TE can neither transmit nor receive signals.
- *F1 state:* Operational state;
    - The network clock and Layer 1 service is available.
    - The NT2/TE receives operational frames with good CRC and the FEPR.
    - The NT2/TE transmits operational frames with good CRC toward the network.
    - The NT2/TE checks the received frame for CRC and other errors, and generates a FEPR toward the network.
- *F2/F5 state:* FC1 or FC4;

    NOTE: For compatibility with ITU-T recommendations, this state is labeled as F2/F5. However, it should be noted that this is one state in terms of the state table. Within the capabilities of the current North American DS1 and PRI standards, FC1 and FC4 can only be distinguished by sectionalization procedures, not by automatic state changes at the NT2/TE.

    - The network clock is available at the user side.

- The NT2/TE receives operational frames with good CRC and the RAI priority message.
- The NT2/TE transmits operational frames with good CRC toward the network.
- The NT2/TE checks the received frame for CRC and other errors, and generates a FEPR toward the network.

- *F3 state*: FC2[10]
    - The network clock is not available at the user side.
    - The NT2/TE detects loss of incoming signal.
    - The NT2/TE transmits operational frames with good CRC and the RAI priority message toward the network.
- *F4 state:* FC3
    - The network clock is not available at the user side.
    - The NT2/TE detects AIS.
    - The NT2/TE transmits operational frames with good CRC and the RAI priority message toward the network.
- *F6 state:* Power On state
    - This is not a stable state, the NT2/TE can't remain in it.
    - No signal is transmitted toward the interface.
    - The NT2/TE must change the state after identification of a received signal or recognition that no signal is being received (Loss of Signal, Loss of Frame-Alignment event).

C.4 ET States

States are defined as follows for an ET (also see Figure C.2):

- *G0 state:* Loss of Power state
    - In this state, the ET can neither transmit nor receive signals.
- *G1 state:* Operational state
    - Layer 1 service is available.
    - The ET receives operational frames with good CRC and the FEPR.
    - The ET transmits operational frames with good CRC toward the network interface.
    - The ET checks the received frame for CRC and other errors and generates a FEPR toward the network interface.

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[10] The ability to distinguish FC2 and FC3 assumes that the NT1 implements the optional AIS generation as discussed in clause C.2.

- *G2/G5 state:* FC2 or FC3

  NOTE: For compatibility with ITU-T recommendations, this state is labeled as G2/G5. However, it should be noted that this is one state in terms of the state table. Within the capabilities of the current North American DS1 and PRI standards, FC2 and FC3 can only be distinguished by sectionalization procedures, not by automatic state changes at the ET.

  - The ET receives operational frames with good CRC and the RAI priority message.
  - The ET transmits operational frames with good CRC toward the network interface.
  - The ET checks the received frame for CRC and other errors, and generates an FEPR toward the network interface.

- *G3 state:* FC[11]

  - The ET detects loss of incoming signal.
  - The ET transmits operational frames with good CRC and the RAI priority message toward the network interface.

- *G4 state:* FC4

  - The ET detects AIS.
  - The ET transmits operational frames with good CRC and the RAI priority message toward the network interface.

- *G6 state:* Power on state

  - This is not a stable state; the ET cannot remain in it.
  - No signal is transmitted toward the network interface.
  - The ET must change the state after identification of a received signal, or recognition that no signal is being received (loss of signal, loss of frame alignment event).

[11] The ability to distinguish FC1 and FC4 assumes that the NT1 implements the optional AIS generation discussed in clause C.2.

Annex D
(informative)

D Network Interface Function

This annex describes how the network provider and the customer may use the assigned network-use and CI-use EOC code words. These code words may control loopbacks described as follows.

The *Network Interface Function (NIF)* is a generic term used to describe a DS1 interface connector that has network maintenance capability and may be located at the NI. For a PRA, the NIF is optional. An optional line loopback in the NIF, controlled by the network-use EOC codeword, may be used by a network provider to sectionalize PRA physical layer impairments to either the CA or the CI.

Conversely, a line loopback, controlled by the CI-use EOC code word, may be used by a customer to sectionalize between the CA and the CI. The CI-use line loopback may be located in customer-owned equipment at the NI on the customer side.

Annex E
(informative)

E List of Acronyms

AIS	Alarm Indication Signal
AMC	Administration Management Center
CA	Customer Access
CI	Customer Installation
CMC	Customer Management Center
COFA	Change of Frame Alignment
CRC	Cyclic Redundancy Check
CV	Coding Violation
DCS	Digital Crossconnect System
DL	Data Link
DS1	Digital Signal 1
DSX	Digital Signal Crossconnect
EOC	Embedded Operations Channel
ES	Errored Second
ESF	Extended Superfame
ET	Exchange Termination
FLS	Frame Loss Second
IMF	Intermediate Monitoring Function
ISDN	Integrated Services Digital Network
ITU-T	International Telecommunication Union Telecommunication Standardization Sector
LMF	Line Monitoring Function
LT	Line Termination
NE	Network Element
NI	Network Interface
NIF	Network Interface Function
NT	Network Termination
NT1	Network Termination 1
NT2	Network Termination 2
OOF	Out-of-Frame
OS	Operations System
PBX	Private Branch Exchange
PMF	Path Monitoring Function
PRA	Primary Rate Access
PT	Path Termination
RAI	Remote Alarm Indication
RLMF	Remote Line Monitoring Function

SEFE	Severely-Errored Framing Event
SEFES	Severely-Errored Framing Event Seconds
SES	Severely-Errored Second
SF	Superframe
TA	Terminal Adaptor
TE	Terminal Equipment

Annex F
(informative)

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[15] Available from ITU-T at < http://www.itu.int/en/ITU-T/publications/Pages/recs.aspx >.