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Integrated Service Digital Network (ISDN) Circuit-Switched and Packet-Switched Data Bearer Services Performance Specifications

Technical
Reference

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This Technical Reference describes the Network Interface (NI) specifications for Basic Rate and Primary Rate Access to the Integrated Services Digital Network (ISDN).

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INTEGRATED SERVICES DIGITAL NETWORK (ISDN) CIRCUIT-SWITCHED & PACKET-SWITCHED DATA BEARER SERVICES PERFORMANCE SPECIFICATIONS

CONTENTS

INTEGRATED SERVICES DIGITAL NETWORK (ISDN) CIRCUIT-SWITCHED & PACKET-SWITCHED DATA BEARER SERVICES PERFORMANCE SPECIFICATIONS

1. General

This Technical reference describes the Network Interface (NI) specifications for Basic Rate and Primary Rate Access to the Integrated Services Digital Network (ISDN). It defines the electrical, physical, and protocol specifications needed for compatible operations between BellSouth Telecommunications, Inc. (BST) and a customer installation (CI). Digital performance objectives for circuit-switched and packet-switched bearer services are also included in the document. Signals that appear at the NI as a result of the environment (e.g., induced voltages and currents, lightning surges, etc.) are not covered.

The requirements in this document were developed to establish a functional and practical interface. Compliance with these requirements should provide a satisfactory interface in a high percentage of installations. If cases arise that have not been adequately addressed in this document, any resulting problems should be resolved through the cooperation of the customer, BST and the equipment suppliers.

2. Service Description

An Integrated Services Digital Network (ISDN) is a network that provides end-to-end digital connectivity to support a wide range of communications services. It supports both Basic Rate Access (BRA) and Primary Rate Access (PRA). BRA is available from BellSouth as ESSX® ISDN and ISDN Individual Line service. PRA is available from BellSouth as MegaLink® ISDN. There are two basic service types, circuit-switched and packet-switched, that can support the many different customer applications.

2.1 Circuit-Switched Bearer Services

The circuit-switched bearer capability is characterized by the transport of digital data or digitally encoded analog signals. Circuit-switched bearer capability is used to transport a variety of different services; several of which are discussed below.

Bearer Service for Speech - This provides the capability of establishing a connection that can transport speech that has been encoded according to μ-law Pulse Code Modulation (PCM). The essential characteristic of this connection is that processing techniques appropriate for speech, such as 4-wire analog transmission, low-bit-rate voice encoding, and time assignment speech interpolation that do not assure bit integrity may be employed. Performance of voiceband modems is not guaranteed.

Bearer Service for 3.1-kHz Audio - This provides the capability of establishing a connection that can transport μ-law encoded 3.l-kHz information. The network assumes that μ-law encoded, band-limited, audio information is present at the user interface. Transmission processes specific to speech, such as time assignment speech interpolation and low-bit-rate voice encoding, are not employed on 3.l kHz connections, but 4-wire analog transmission may be employed. This bearer service is intended to support the use of voiceband modems and Group I, II, and III facsimile devices.

Bearer Service for 64 kbps Unrestricted Data - This provides the Customer Premises Equipment (CPE) with the capability of establishing, through the switched digital network, a 64 kbps full-duplex connection. The essential characteristic of this connection is that the received bit stream at the destination user interface is identical (within performance limitations) to the transmitted stream at the originating user interface without any restrictions on the user data. Thus, bit integrity is maintained.

Bearer Service for 64 kbps Unrestricted Data Rate Adapted From 56 kbps Data - This provides the capability of establishing, through the switched digital network, a 56 kbps full duplex connection. The essential characteristic of this connection is that the 56 kbps user data is carried within a 64 kbps B-channel and that the received bit stream of user data at the destination user interface is identical (within performance limits) to the transmitted bit stream of user data at the originating user interface. Customer Installation CPE will provide the rate adaptation from the 56 kbps rate to the 64 kbps rate of the B-channel in a manner which ensures that all zero octets are not transmitted. This bearer service may be used with BST AccuPulse® Service (Public Switched Digital Service).

Bearer Service for Switched DS1/Switched Fractional DS1 (SWF-DS1) - This provides the Customer Premises Equipment (CPE) with the capability of establishing, through the switched digital network, calls to and from a PRA at N times 64 kbps rates (N ranges from 2 to 24). The 384 kbps rate (N equals 6) is referred to as an H_0 channel and the 1.536 Mbps rate (N equals 24) is referred to as an H_{11} channel. The requirements for SWF-DS1 are defined in TR-NWT-001203, *Generic Requirements for the Switched DS1/Switched Fractional DS1 Service Capability from an ISDN Interface (SWF-DS1/ISDN)*. The essential characteristic of this connection is that the received bit stream at the destination user interface is identical (within performance limitations) to the transmitted stream at the originating user interface without any restrictions on the user data. Thus, bit integrity is maintained.

2.2 Packet-Switched Bearer Service

Packet-switched bearer service provides for the transparent transfer of user information in a packetized manner over the D-channel (low-speed - 9.6 kbps) or a B-channel (high-speed - 64 kbps). The packetization of the user data must conform to specifications in the CCITT X.25 standard.

3. ISDN Access

There are two methods to access BST's ISDN. Basic Rate Access provides the user with two 64 kbps B-channels and one 16 kbps D-channel. Primary Rate Access provides the user with 24 64 kbps channels, of which one may be used as the D-channel. The capability to serve multiple PRAs over a single D-channel is provided by the Non-Facility Associated Signaling (NFAS) feature. Figure 1 provides a generic model illustrating the relative location of the Network Interface (NI) to the functional elements of an ISDN.

3.1 Physical Layer

3.1.1 Basic Rate Access

Basic Rate Access (BRA) provides two 64 kbps B-channels and one 16 kbps D-channel with a combined transport of 144 kbps (160 kbps including overhead bits) from a Customer Installation to an ISDN end office. This is provided via a two-wire non-loaded metallic facility using a 2B1Q (2 Binary bits transmitted as 1 Quaternary symbol or quat) line code. The quaternary coding scheme is shown in Table 1.

Table 1 - 2B1Q Line Code Specifications

First bit	Second bit	Quaternary symbol	Transmitted voltage level
1	0	+3	2.5 v
1	1	+1	5/6 v
0	1	-1	-5/6 v
0	0	-3	-2.5 v

With this coding scheme 160 kbps can be transmitted at a rate of 80,000 quats per second (80 kilobaud). Technical details on the interface using the 2B1Q line code are contained in ANSI T1.601-1992, *ISDN Basic Access Interface for Use on Metallic Loops for Application on the Network Side of the NI*. BST will terminate BRA 2-wire lines in a modular 8-pin jack, RJ49C, connecting pins 4 and 5 with the T and R leads.

3.1.2 Primary Rate Access

Primary Rate Access (PRA) provides 23 64 kbps B-channels and one 64 kbps D-channel with a combined transport of 1.536 Mbps (1.544 Mbps including overhead bits) to an ISDN end office. This DS1 signal must be transported in a frame consisting of a set of 192 information bits preceded by one framing bit, for a total of 193 bits per frame. The 192 information bits are partitioned into 24 eight-bit time slots. The DS1 signal will be framed using the Extended Superframe Format (ESF). To provide clear channel capability on the 64 kbps channels, the line code will be bipolar with eight-zero substitution coding (B8ZS). Further technical details on the DS1 interface are contained in ANSI T1.408-1990, *ISDN Primary Rate - Customer Installation Metallic Interfaces Layer 1 Specification.*

3.2 Data Link and Network Layers

The protocols that specify the messages and procedures for the establishing, maintaining and clearing of network connections at the ISDN user interface for the support of circuit-switched calls are defined in ANSI T1.602-1996, *Integrated Services Digital Network (ISDN) - Data Link Layer Signaling Specifications for Application at the User-Network Interface*, and T1.607-1990, *Integrated Services Digital Network (ISDN) - Layer 3 Signaling Specifications for Circuit-Switched Bearer Services for Digital Subscriber Signaling System Number 1 (DSS1)*. Messages and procedures for the control of packet-switched connections are defined in ANSI T1.608-1991, *Integrated Services Digital Network (ISDN) - Signaling Specifications for X.25 Packet-Switched Bearer Services for Digital Subscriber Signaling System Number 1 (DSS1)*.

3.3 Vendor Specifications

Complete network interface specifications for ISDN access, including protocol definitions, can be found in the following vendor documentation listed according to the manufacturer of the serving ISDN central office switching equipment:

AT&T:

235-900-341, *ISDN Basic Rate Interface Specification*
235-900-342, *5ESS Switch ISDN Primary Rate Interface Specification*

Northern Telecom:

NIS S208-6, *ISDN Basic Rate Access User-Network Interface Specification*
NIS A211-1, *ISDN Primary Rate Access User-Network Interface Specification*

Siemens Stromberg-Carlson:

Book 0740, *ISDN - Basic Rate Interface (BRI) User-Network Interface Specification*
Book 0750, *ISDN Primary Rate Interface (PRI) User-Network Interface Specification*

NOTE: Specifications documentation provided by individual switch manufacturers is generally based upon the most current software generic available.

4. Performance Specifications

4.1 Circuit-Switched Performance

This section contains performance parameter definitions and performance objectives for digital circuit-switched bearer capability in an ISDN. These objectives relate to performance as seen by the customer between the customer and another customer (IntraLATA, Customer Network Interface - Customer Network Interface). The objectives assume no interworking with non-ISDN networks and the ten worst-performing days in a calendar year are excluded. Figure 2 illustrates the different segments that compose an ISDN between the two customer interfaces. The parameters are separated into three categories; access parameters, information transfer parameters and disengagement parameters.

4.1.1 Access Parameters

Call Set-Up / Alerting Delay - The call set-up delay is the length of time that starts when a SETUP or last address information message is sent and ends when the corresponding CONNect message returns. The alerting delay is similar to the call set-up delay and is applicable in the case of manual answering terminals and some automatic answering terminals. The alerting delay is the length of time that starts when a SETUP or last address information message is sent and ends when the corresponding ALERTing message returns.

Call Set-Up Error Probability - Call set-up error is defined to occur on any call set-up attempt in which a CONNect message is returned, but the connection is not to the interface designated by the connection request; i.e. a network-caused wrong number. The call set-up error probability is the ratio of total call set-up attempts that results in an error to the total call set-up attempts.

Call Set-Up Failure Probability - Call set-up failure is defined to occur on any valid call set-up attempt in which a CONNect message is not returned within a given time.[1] The call set-up failure probability is the ratio of total call set-up attempts that results in a failure to the total call set-up attempts. The major factor contributing to this parameter's performance is network blocking due to trunk congestion. Therefore, the performance should be comparable to that of the Public Switched Telephone Network (PSTN) blocking performance.

4.1.2 Information Transfer Parameters

Errored Second Ratio - An errored second is a one second interval during which one or more errored bits are observed on a given connection. The errored second ratio is the ratio of errored seconds to total seconds in a specified time period. A period with no signal present shall be considered a period of errored bits.

Severely Errored Second Ratio - A severely errored second is a one second interval during which a bit error ratio equal to or worse that 10^{-3} is observed on a given connection. The severely errored second ratio is the ratio of severely errored seconds to total seconds in a specified time period.

Premature Disconnect Probability - A premature disconnect on a connection is characterized by the receipt of a disconnect from the network without a corresponding request being sent. The premature disconnect probability is the probability, in any given second, that a connection experiences an unwanted disconnect.

4.1.3 Disengagement Parameters

Disconnect Delay - The disconnect delay is the length of time that starts when a DISConnect message is sent and ends when that DISConnect is received at the other end of the connection.

Release Delay - The release delay is the length of time that starts when a DISConnect message is sent from the clearing party and ends when the corresponding RELease message is received at the clearing party's interface.

Call Clearing Failure Probability - A call clearing failure occurs when a DISConnect or RELease message occurs at one end of a connection and there is no corresponding clearing message at the other end of the connection.

[1] T1.607 specifies a timer, T301, with a default value of 3 min. for this measure.

4.1.4 Circuit-Switched Performance Objectives

ISDN circuit-switched bearer services, under normal conditions, will perform at an average level equal to or better than the objectives in Table 2.

Table 2 - Circuit-Switched Bearer Service Performance Objectives

Access Parameter Objectives	
Call Set-up / Alerting Delay (1 B-channel)	1200 milliseconds
Call Set-up Error Probability	1 in 100,000 call set-up attempts
Information Transfer Parameter Objectives	
Errored Second Ratio (64 - 384 kbps)	0.30% Errored Seconds
Errored Second Ratio (448 - 1536 kbps)	0.60% Errored Seconds
Severely Errored Second Ratio	0.02% Severely Errored Seconds
Premature Disconnect Probability	2×10^{-6} per second
Disengagement Parameter Objectives	
Disconnect Delay	500 milliseconds
Release Delay	220 milliseconds
Call Clearing Failure Probability	1 in 100,000 call clear attempts

4.2 Packet-Switched Performance

This section contains performance parameter definitions and performance objectives for X.25 bearer services in ISDN. These objectives relate to performance as seen by the customer between the customer and another customer (IntraLATA, Customer Network Interface - Customer Network Interface). Figure 2 illustrates the different segments that compose an ISDN between the two customer interfaces. The performance parameters contained in this section are defined in ANSI T1.504-1989, *Packet-Switched Data Communication Service - Performance Parameters*. The ten worst-performing days in a calendar year are excluded. The parameters are separated into three categories; access parameters, information transfer parameters and disengagement parameters.

4.2.1 Access Parameters

Call Set-up Delay - The call set-up delay is the sum of two one-way delays. The first delay is the length of time that starts when a call request is initiated and ends when the corresponding incoming call packet arrives at the far end. The second delay is the length of time that starts when a call accepted packet is sent from the far end and ends when the corresponding call accepted packet arrives at the originating end. The objective assumes an access speed of 9.6 kbps; an access speed of 56 kbps would decrease the delay by 69 ms.

Call Set-up Error Probability - A call set-up error is defined to occur when the network responds to a valid call request by erroneously establishing a virtual call to a destination DTE other than the one designated in the call request; i.e. a wrong number. The call set-up error probability is the ratio of total call set-up attempts that result in a call set-up error to the total call attempts.

Call Set-up Failure Probability - Call set-up failure is defined to occur on any call attempt in which a call accepted packet is not returned within a given time[2] after a call attempt is made. The call set-up failure probability is the ratio of total call attempts that results in a call set-up failure to the total call set-up attempts.

4.2.2 Information Transfer Parameters

Throughput Capacity - Throughput for a connection is the number of user data bits successfully transferred (no bits lost, added or errored) in one direction across the connection. Throughput capacity is the steady-state throughput rate that the connection is capable of supporting. This rate applies to data packets with a maximum user data field length of 128 octets and assumes proper user selection of parameters (e.g. sufficiently large window size).

Data Packet Transfer Delay - This delay refers to the successful transfer of data packets and is the period of time that starts when a data packet enters an interface and ends when that packet exits the terminating interface. This delay objectives assumes data packets with a maximum user data field length of 128 octets and an access speed of 9.6 kbps; an access speed of 56 kbps would decrease the delay by 189 ms.

Residual Error Ratio - The residual error ratio is the ratio of total errored, lost, misdelivered and duplicated user data bits to the total user data bits.
Reset Probability - A reset on a connection is characterized by the receipt of a reset packet from the network without a corresponding request being sent. The reset probability is the probability, in any given second, that a connection experiences an unwanted reset. Resets that are the result of user action or the actions of other networks are excluded.

Premature Disconnect Probability - A premature disconnect on a connection is characterized by the receipt of a disconnect from the network without a corresponding request being sent. The premature disconnect probability is the probability, in any given second, that a connection experiences an unwanted disconnect.

4.2.3 Disengagement Parameters

Clear Indication Delay - The clear indication delay is the length of time that starts when a clear request packet is sent and ends when the corresponding clear request is received at the terminating end of the connection. The objective assumes an access speed of 9.6 kbps; an access speed of 56 kbps would decrease the delay by 14 ms.

Call Clearing Failure Probability - A call clearing failure occurs when a clear request packet occurs at one end of a connection and there is no corresponding clearing message at the other end of the connection. The call clearing failure probability is the ratio of failed call clear attempts to the total clear attempts.

4.2.4 Packet-Switched Performance Objectives

ISDN packet-switched bearer services, under normal conditions, will perform at an average level equal to or better than the objectives in Table 3.

[2] T1.504 specifies 200 seconds for this timeout period.

Table 3 - Packet-Switched Bearer Service Performance Objectives

Access Parameter Objectives	
Call Set-up Delay	1390 milliseconds
Call Set-up Error Probability	1 in 100,000 call set-up attempts
Call Set-up Failure Probability	5 in 1000 call set-up attempts
Information Transfer Parameter Objectives	
Throughput Capacity	50% of throughput class
Data Packet Transfer Delay	680 milliseconds
Residual Error Ratio	1 in 10^9 user data bits
Reset Probability	1 x 10^{-6} per second
Premature Disconnect Probability	2 x 10^{-6} per second
Disengagement Parameter Objectives	
Clear Indication Delay	830 milliseconds
Call Clearing Failure Probability	1 in 100,000 call clear attempts

5. REFERENCES

ANSI T1.408-1990, *ISDN Primary Rate - Customer Installation Metallic Interfaces Layer 1 Specification.*

ANSI T1.504-1989, *Packet-Switched Data Communication Service - Performance Parameters*.

ANSI T1.517-1995, *Integrated Services Digital Networks (ISDN) - Performance Parameters and Objectives*.

ANSI T1.601-1992, *ISDN Basic Access Interface for Use on Metallic Loops for Application on the Network Side of the NI*.

ANSI T1.602-1996, *Integrated Services Digital Network (ISDN) - Data Link Layer Signaling Specifications for Application at the User-Network Interface*

ANSI T1.607-1990, *Integrated Services Digital Network (ISDN) - Layer 3 Signaling Specifications for Circuit-Switched Bearer Services for Digital Subscriber Signaling System Number 1 (DSS1).*

ANSI T1.608-1991, *Integrated Services Digital Network (ISDN) - Signaling Specifications for X.25 Packet-Switched Bearer Services for Digital Subscriber Signaling System Number 1 (DSS1).*

Bellcore TR-NWT-001203, *Generic Requirements for the Switched DS1/Switched Fractional DS1 Service Capability from an ISDN Interface (SWF-DS1/ISDN).*

CCITT G.711, *Pulse code Modulation (PCM) of Voice Frequencies.*

Recommendation X.25, *Interface Between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for Terminals Operating in the Packet Mode and Connected to Public Data Networks by Dedicated Circuits*, CCITT

235-900-341, *ISDN Basic Rate Interface Specification*, AT&T

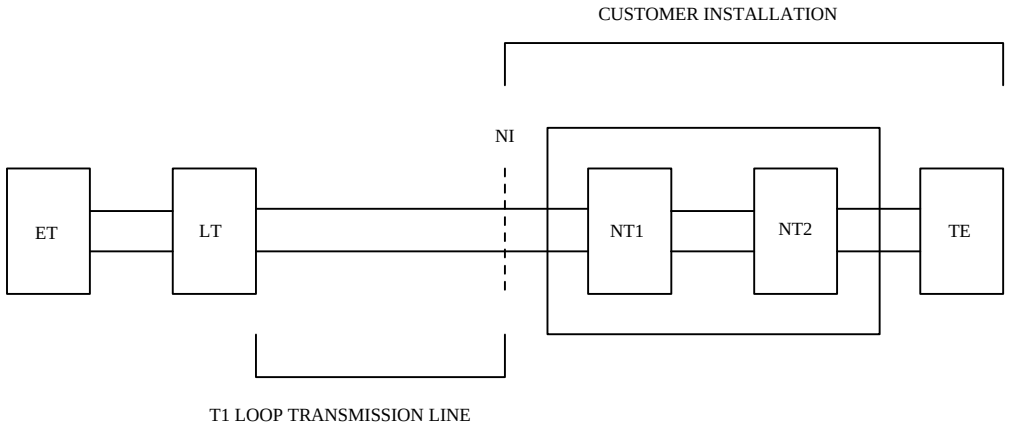
235-900-342, *5ESS Switch ISDN Primary Rate Interface Specification*, AT&T

NIS S208-6, *ISDN Basic Rate Access User-Network Interface Specification*, Northern Telecom

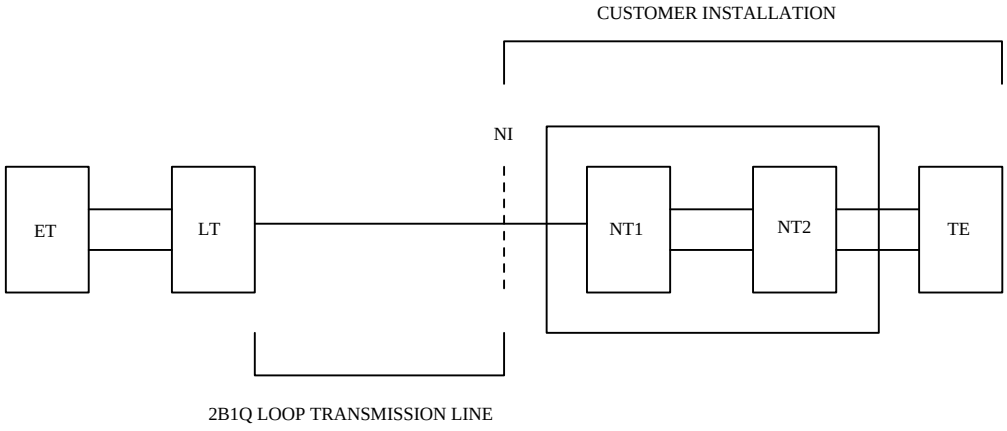
NIS A211-1, *ISDN Primary Rate Access User-Network Interface Specification*, Northern Telecom

Book 0740, *ISDN - Basic Rate Interface (BRI) User-Network Interface Specification*, Siemens Stromberg-Carlson

Book 0750, *ISDN Primary Rate Interface (PRI) User-Network Interface Specification*, Siemens Stromberg-Carlson



1-1 PRIMARY RATE ACCESS



1-2 BASIC RATE ACCESS

ET - Exchange Termination

NT - Network Termination

NI - Network Interface

TE - Terminal Equipment

LT - Line Termination

Figure 1 - ISDN Functional Elements and Interfaces

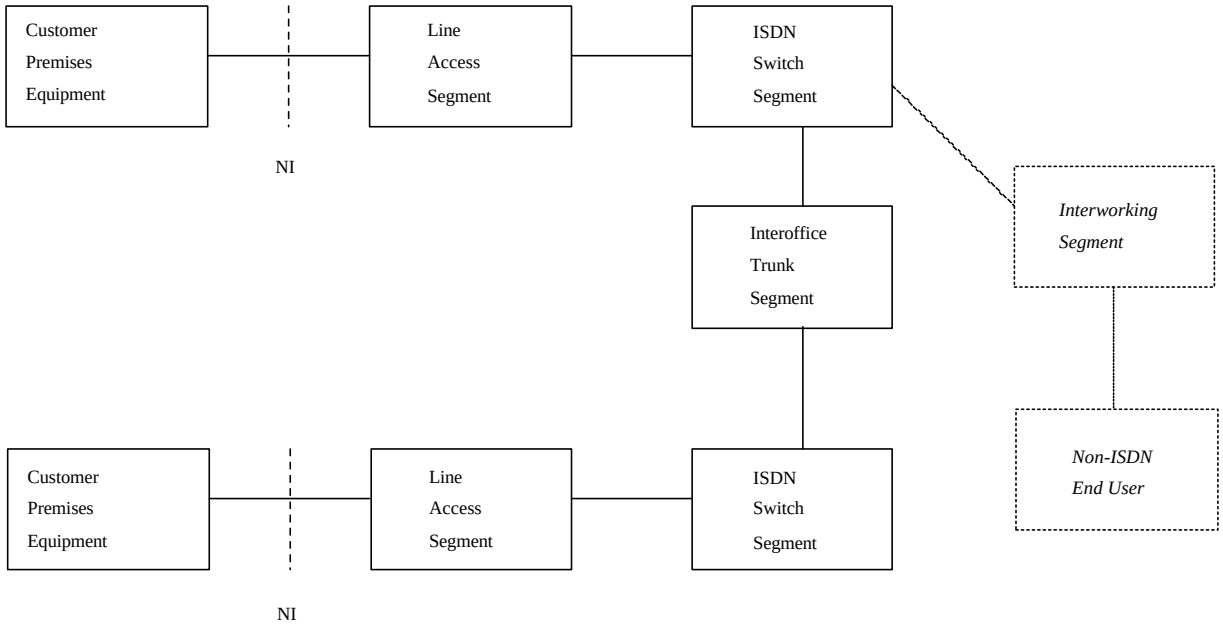


Figure 2 - ISDN Segment Model