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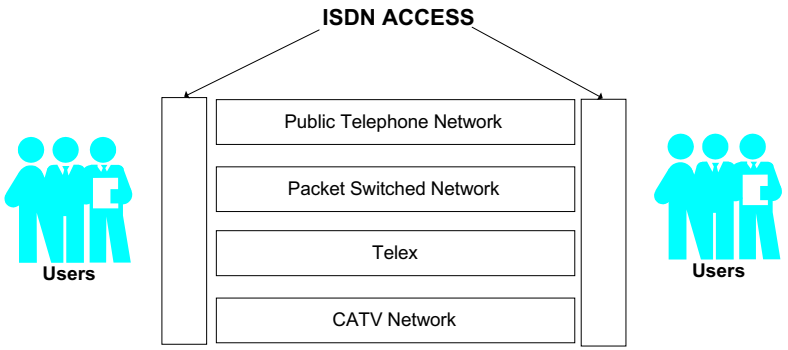
ISDN

ITU SR-NWT-001953 1991-06, ETS 300 102-1 1990-12,
AT&T 801-802-100 1989-05

ISDN (Integrated Services Digital Network) is an all digital communications line that allows for the transmission of voice, data, video and graphics, at very high speeds, over standard communication lines. ISDN provides a single, common interface with which to access digital communications services that are required by varying devices, while remaining transparent to the user. Due to the large amounts of information that ISDN lines can carry, ISDN applications are revolutionizing the way businesses communicate.

ISDN is not restricted to public telephone networks alone; it may be transmitted via packet switched networks, telex, CATV networks, etc.



ISDN applications

The following protocols are described in this chapter:

- LAPD: Link Access Protocol - Channel D.
- ISDN: Integrated Services Digital Network.

LAPD

ITU Q.921 (Blue Book)

The LAPD (Link Access Protocol - Channel D) is a layer 2 protocol which is defined in CCITT Q.920/921. LAPD works in the Asynchronous Balanced Mode (ABM). This mode is totally balanced (i.e., no master/slave relationship). Each station may initialize, supervise, recover from errors, and send frames at any time. The protocol treats the DTE and DCE as equals.

The format of a standard LAPD frame is as follows:

Flag	Address field	Control field	Information	FCS	Flag

LAPD frame structure

Flag

The value of the flag is always (0x7E). In order to ensure that the bit pattern of the frame delimiter flag does not appear in the data field of the frame (and therefore cause frame misalignment), a technique known as Bit Stuffing is used by both the transmitter and the receiver.

Address field

The first two bytes of the frame after the header flag is known as the address field. The format of the address field is as follows:

8	7	6	5	4	3	2	1
SAPI						C/R	EA1
TEI							EA2

LAPD address field

EA1 First Address Extension bit which is always set to 0.

C/R Command/Response bit. Frames from the user with this bit set to 0 are command frames, as are frames from the network with this bit set to 1. Other values indicate a response frame.

SAPI Service Access Point Identifier. Valid values are as follows:

0	Call-Control procedures.
1	Packet-mode communications using I.451 call-control procedures.
16	Packet communication conforming to X.25 level 3.
63	Layer 2 management procedures.

EA2 Second Address Extension bit which is always set to 1.

TEI Terminal Endpoint Identifier. Valid values are as follows:

0-63	Used by non-automatic TEI assignment user equipment.
64-126	Used by automatic TEI assignment equipment.
127	Used for a broadcast connection meant for all Terminal Endpoints.

Control field

The field following the Address Field is called the Control Field and serves to identify the type of the frame. In addition, it includes sequence numbers, control features and error tracking according to the frame type.

FCS

The Frame Check Sequence (FCS) enables a high level of physical error control by allowing the integrity of the transmitted frame data to be checked. The sequence is first calculated by the transmitter using an algorithm based on the values of all the bits in the frame. The receiver then performs the same calculation on the received frame and compares its value to the CRC.

Window size

LAPD supports an extended window size (modulo 128) where the number of possible outstanding frames for acknowledgement is raised from 8 to 128. This extension is generally used for satellite transmissions where the acknowledgement delay is significantly greater than the frame transmission times. The type of the link initialization frame determines the modulo of the session and an "E" is added to the basic frame type name (e.g., SABM becomes SABME).

Frame types

The following are the Supervisory Frame Types in LAPD:

RR Information frame acknowledgement and indication to receive more.

REJ Request for retransmission of all frames after a given sequence number.

RNR Indicates a state of temporary occupation of station (e.g., window full).

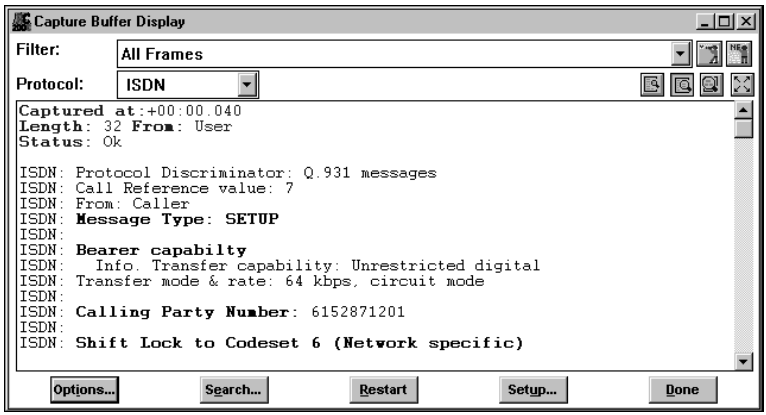
The following are the Unnumbered Frame Types in LAPD:

DISC Request disconnection.
UA Acknowledgement frame.
DM Response to DISC indicating disconnected mode.
FRMR Frame reject.
SABM Initiator for asynchronous balanced mode. No master/slave relationship.

SABME SABM in extended mode.
UI Unnumbered Information.
XID Exchange Information.

There is one Information Frame Type in LAPD:

Info Information transfer frame.



ISDN decode

International Variants of ISDN

The organization primarily responsible for producing the ISDN standards is the CCITT. The CCITT study group responsible for ISDN first published a set of ISDN recommendations in 1984 (Red Books). Prior to this publication, various geographical areas had developed different versions of ISDN. This resulted in the CCITT recommendation of a common ISDN standard for all countries, in addition to allocated variants definable for each country.

The use of nation-specific information elements is enabled by using the Codeset mechanism which allows different areas to use their own information elements within the data frames.

The following is a description of most ISDN variants:

National ISDN1 (Bellcore)

SR-NWT-001953 1991-06
This variant is used in the USA by Bellcore. It has four network-specific message types. It does not have any single octet information elements. In addition to Codeset 0 elements it has four Codeset 5 and five Codeset 6 information elements.

National ISDN-2 (Bellcore)

SR-NWT-002361 1992-12
The main difference between National ISDN-1 and ISDN-2 is parameter downloading via components (a component being a sub-element of the Extended Facility information element). These components are used to communicate parameter information between ISDN user equipment, such as an ISDN telephone, and the ISDN switch.

Other changes are the addition of the SEGMENT, FACILITY and REGISTER message types and the Segmented Message and Extended Facility information elements. Also, some meanings of field values have changed and some new accepted field values have been added.

5ESS (AT&T)

AT&T 801-802-100 1989-05
This variant is used in the USA by AT&T. It is the most widely used of the ISDN protocols and contains 19 network-specific message types. It has no

Codeset 5, but does have 18 Codeset 6 elements and an extensive information management element.

Euro ISDN (ETSI)

ETS 300 102-1 1990-12

This variant is to be adopted by all of the European countries. Presently, it contains single octet message types and has five single octet information elements. Within the framework of the protocol there are no Codeset 5 and Codeset 6 elements, however each country is permitted to define its own individual elements.

VN3, VN4 (France)

DGPT: CSE P 22-30 A 1994-08

These variants are prevalent in France. The VN3 decoding and some of its error messages are translated into French. It is a sub-set of the CCITT document and only has single octet message types. The more recent VN4 is not fully backward compatible but closely follows the CCITT recommendations. As with VN3, some translation has taken place. It has only single octet message types, five single octet information elements, and two Codeset 6 elements.

1TR6 (Germany)

1 TR 6 1990-08

This variant is prevalent in Germany. It is a sub-set of the CCITT version, with minor amendments. The protocol is part English and part German.

ISDN 30 [DASS-2] (England)

BTNR 190 1992-07

This variant is used by British Telecom in addition to ETSI (see above). At layers 2 and 3 this standard does not conform to CCITT structure. Frames are headed by one octet and optionally followed by information. However most of the information is IA5 coded, and therefore ASCII decoded

Australia

AP IX-123-E

This protocol is being superseded by a new Australian protocol. (The name of the protocol has not been released). It is a subset of the CCITT standard and has only single octet message types and information elements; it only has Codeset 5 elements.

TS014 Australia

TS014 (Austel) 1995

This is the new Australian ISDN PRI standard issued by Austel. This standard is very similar to ETSI.

NTT-Japan

INS-NET Interface and Services 1993-03

The Japanese ISDN service provided by NTT is known as INS-Net and its main features are as follows:

- Provides a user-network interface that conforms to the CCITT Recommendation Blue Book.
- Provides both basic and primary rate interfaces.
- Provides a packet-mode using Case B.
- Supported by Signalling System No. 7 ISDN User Part with the network.
- Offered as a public network service.

ARINC 746

ARINC Characteristic 746-4 1996-04

In passenger airplanes today there are phones in front of each passenger. These telephones are connected in a T1 network and the conversation is transferred via a satellite. The signalling protocol used is based on Q.931, but with a few modifications and is known as ARINC 746. The leading companies in this area are GTE and AT&T. In order to analyze ARINC, the LAPD variant should also be specified as **ARINC**.

ARINC 746 Attachment 11

ARINC Characteristic 746-4 1996-04

ARINC (Aeronautical Radio, INC.) Attachment 11 describes the Network Layer (layer 3) message transfer necessary for equipment control and circuit switched call control procedures between the Cabin Telecommunications Unit (CTU) and SATCOM system, North American Telephone System (NATS), and Terrestrial Flight Telephone System (TFTS). The interface described in this attachment is derived from the CCITT recommendations Q.930, Q.931 and Q.932 for call control and the ISO/OSI standards DIS 9595 and DIS 9596 for equipment control. These Network Layer messages should be transported in the information field of the Data Link Layer frame.

ARINC 746 Attachment 17

ARINC Characteristic 746-4 1996-04

ARINC (Aeronautical Radio, INC.) Attachment 17 represents a system which provides passenger and cabin crew access to services provided by the

CTU and intelligent cabin equipment. The distribution portion of the CDS transports the signalling and voice channels from headend units to the individual seat units. Each zone within the aircraft has a zone unit that controls and services seat units within that zone.

Northern Telecom - DMS 100

NIS S208-6 Issue 1.1 1992-08

This variant represents Northern Telecom's implementation of National ISDN-1. It provides ISDN BRI user-network interfaces between the Northern Telecom ISDN DMS-100 switch and terminals designed for the BRI DSL. It is based on CCITT ISDN-1 and Q Series Recommendations and the ISDN Basic Interface Call Control Switching and Signalling Requirements and supplementary service Technical References published by Bellcore.

DPNSS1

BTNR 188 1995-01

DPNSS1 (Digital Private Network Signalling System No. 1) is a common-channel signalling system used in Great Britain. It extends facilities normally only available between extensions on a single PBX to all extensions on PBXs that are connected together in a private network. It is primarily intended for use between PBXs in private networks via time-slot 16 of a 2048 kbit/s digital transmission system. Similarly it may be used in time-slot 24 of a 1.544 kbit/s digital transmission system. Note that the LAPD variant should also be selected to be DPNSS1.

Swiss Telecom

PTT 840.73.2 1995-06

The ISDN variant operated by the Swiss Telecom PTT is called SwissNet. The DSS1 protocol for SwissNet is fully based on ETS. Amendments to this standard for SwissNet fall into the category of definitions of various options in the standard and of missing requirements. They also address SwissNet-specific conditions, e.g., assuring compatibility between user equipment and SwissNet exchanges of different evolution steps.

QSIG

ISO/IEC 11572 1995

QSIG is a modern, powerful and intelligent inter-private PABX signalling system. QSIG standards specify a signalling system at the Q reference point which is primarily intended for use on a common channel; e.g. a G.703 interface. However, QSIG will work on any suitable method of connecting

the PINX equipment. The QSIG protocol stack is identical in structure to the DSSI protocol stack. Both follow the ISO reference model. Both can have an identical layer 1 and layer 2 (LAPD), however, at layer 3 QSIG and DSS1 differ.

ISDN Frame Structure

Shown below is the general structure of the ISDN frame.

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

ISDN frame structure

Protocol discriminator
The protocol used to encode the remainder of the Layer.

Length of call reference value
Defines the length of the next field. The Call reference may be one or two octets long depending on the size of the value being encoded.

Flag
Set to zero for messages sent by the party that allocated the call reference value; otherwise set to one.

Call reference value
An arbitrary value that is allocated for the duration of the specific session, which identifies the call between the device maintaining the call and the ISDN switch.

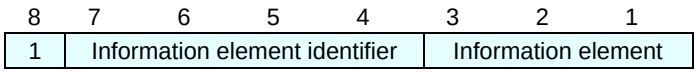
Message type
Defines the primary purpose of the frame. The message type may be one octet or two octets (for network specific messages). When there is more than one octet, the first octet is coded as eight zeros. A complete list of message types is given in *ISDN Message Types* below.

ISDN Information Elements

There are two types of information elements: single octet and variable length.

Single octet information elements

The single octet information element appears as follows:



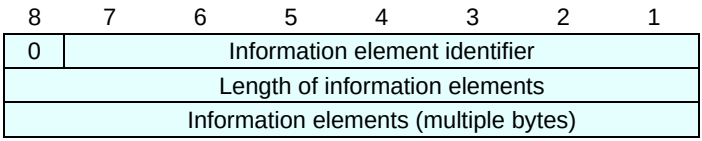
Single octet information element

The following are the available single octet information elements:

1 000 ----	Reserved
1 001 ----	Shift
1 010 0000	More data
1 010 0001	Sending Complete
1 011 ----	Congestion Level
1 101 ----	Repeat indicator

Variable length information elements

The following is the format of the variable length information element:



Variable length information element

The information element identifier identifies the chosen element and is unique only within the given Codeset. The length of the information element informs the receiver as to the amount of the following octets belonging to each information element. The following are possible variable length information elements:

0 0000000	Segmented Message
0 0000100	Bearer Capability
0 0001000	Cause
0 0010100	Call identify
0 0010100	Call state
0 0011000	Channel identification
0 0011100	Facility

0 0011110	Progress indicator
0 0100000	Network-specific facilities
0 0100111	Notification indicator
0 0101000	Display
0 0101001	Date/time
0 0101100	Keypad facility
0 0110100	Signal
0 0110110	Switchhook
0 0111000	Feature activation
0 0111001	Feature indication
0 1000000	Information rate
0 1000010	End-to-end transit delay
0 1000011	Transit delay selection and indication
0 1000100	Packet layer binary parameters
0 1000101	Packet layer window size
0 1000110	Packet size
0 1101100	Calling party number
0 1101101	Calling party subaddress
0 1110000	Called party number
0 1110001	Called Party subaddress
0 1110100	Redirecting number
0 1111000	Transit network selection
0 1111001	Restart indicator
0 1111100	Low layer compatibility
0 1111101	High layer compatibility
0 1111110	User-user
0 1111111	Escape for extension
Other values	Reserved

ISDN Message Types

The following are possible ISDN message types:

Call Establishment

000 00001	Alerting
000 00010	Call Proceeding
000 00011	Progress
000 00101	Setup
000 00111	Connect
000 01101	Setup Acknowledge
000 01111	Connect Acknowledge

Call Information Phase

001 00000	User Information
001 00001	Suspend Reject
001 00010	Resume Reject
001 00100	Hold
001 00101	Suspend
001 00110	Resume
001 01000	Hold Acknowledge
001 01101	Suspend Acknowledge
001 01110	Resume Acknowledge
001 10000	Hold Reject
001 10001	Retrieve
001 10011	Retrieve Acknowledge
001 10111	Retrieve Reject

Call Clearing

010 00101	Disconnect
010 00110	Restart
010 01101	Release
010 01110	Restart Acknowledge
010 11010	Release Complete

Miscellaneous

011 00000	Segment
011 00010	Facility
011 00100	Register
011 01110	Notify
011 10101	Status inquiry
011 11001	Congestion Control
011 11011	Information
011 11101	Status

ISDN Terminology

BRI

The Basic Rate Interface is one of the two services provided by ISDN. BRI is comprised of two B-channels and one D-channel (2B+D). The B-channels each operate at 64 Kbps and the D-channel operates at 16 Kbps. It is used by single line business customers for typical desk-top type applications.

C/R

C/R refers to Command or Response. The C/R bit in the address field defines the frame as either a command frame or a response frame to the previous command.

Codeset

Three main Codesets are defined. In each Codeset, a section of the information elements are defined by the associated variant of the protocol:

Codeset 0	The default code, referring to the CCITT set of information elements.
Codeset 5	The national specific Codeset.
Codeset 6	The network specific Codeset.

The same value may have different meanings in various Codesets. Most elements usually appear only once in each frame.

In order to change codesets two methods are defined:

Shift	This method enables a temporary change to another Codeset. Also termed as non-locking shift, the shift only applies to the next information element.
Shift Lock	This method implements a permanent change until indicated otherwise. Shift-Lock may only change to a higher Codeset.

CPE

Customer Premises Equipment - refers to all ISDN compatible equipment connected at the user sight. Examples of devices are telephone, PC, Telex, Facsimile, etc. The exception is the FCC definition of NT1. The FCC views the NT1 as a CPE because it is on the customer sight, but the CCITT views NT1 as part of the network. Consequently the network reference point of the network boundary is dependent on the variant in use.

ISDN channels B, D and H

The three logical digital communication channels of ISDN perform the following functions:

B-Channel	Carries user service information including: digital data, video, and voice.
D-Channel	Carries signals and data packets between the user and the network.
H-Channel	Performs the same function as B-Channels, but operates at rates exceeding DS-0 (64 Kbps).

ISDN devices

Devices connecting a CPE and a network. In addition to facsimile, telex, PC, telephone, ISDN devices may include the following:

TA — Terminal Adapters - devices that are used to portray non-ISDN equipment as ISDN compatible.

LE — Local Exchange - ISDN central office (CO). The LE implements the ISDN protocol and is part of the network.

LT — Local Termination - used to express the LE responsible for the functions associated with the end of the Local Loop.

ET — Exchange Termination - used to express the LE responsible for the switching functions.

NT — Network Termination equipment exists in two forms and is referred to accordingly. The two forms are each responsible for different operations and functions.

- NT1 - Is the termination of the connection between the user sight and the LE. NT1 is responsible for performance, monitoring, power transfer, and multiplexing of the channels.
- NT2 - May be any device that is responsible for providing user sight switching, multiplexing, and concentration: LANs, mainframe computers, terminal controllers, etc. In ISDN residential environments there is no NT2.

TE — Terminal Equipment - any user device e.g.: telephone or facsimile. There are two forms of terminal equipment:

- TE1 - Equipment is ISDN compatible.
- TE2 - Equipment is not ISDN compatible.

ISDN reference points

Reference points define the communication points between different devices and suggest that different protocols may be used at each side of the point. The main points are as follows:

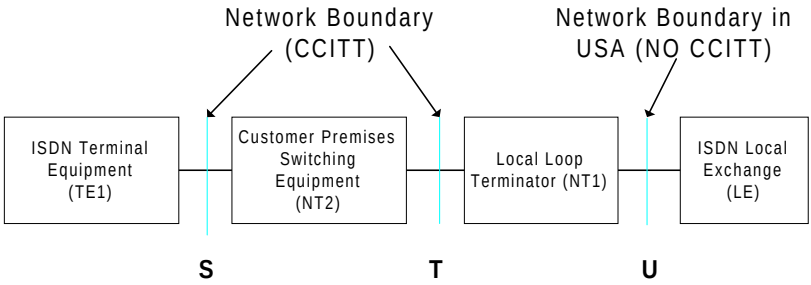
R A communication reference point between a non-ISDN compatible TE and a TA.

S A communication reference link between the TE or TA and the NT equipment.

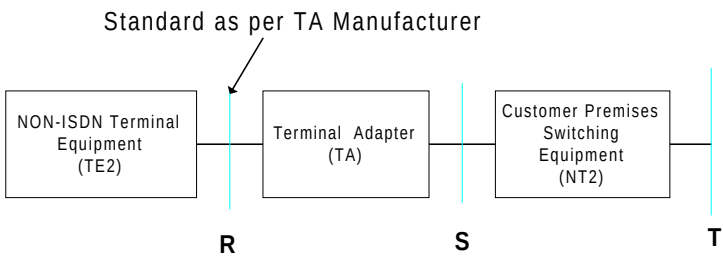
T A communication reference point between user switching equipment and a Local Loop Terminator.

U A communication reference point between the NT equipment and the LE. This reference point may be referred to as the network boundary when the FCC definition of the Network terminal is used.

The following diagram illustrates the ISDN Functional Devices and Reference Points:



Compatible ISDN Devices and Reference Points



Incompatible ISDN Devices and Reference Points

LAPD

The Link Access Protocol on the D-channel. LAPD is a bit orientated protocol on the data link layer of the OSI reference model. Its prime function is ensuring the error free transmission of bits on the physical layer (layer 1).

PRI

The Primary Rate Interface is one of the two services provided by ISDN. PRI is standard dependent and thus varies according to country. In North America, PRI has twenty-three B-channels and one D-channel (23B+D). In Europe, PRI has thirty B-channels and one D-channel (30B+D).

The American B- and D-channels operate at an equal rate of 64 Kbps. Consequently, the D-channel is sometimes not activated on certain interfaces, thus allowing the time slot to be used as another B-channel. The 23B+D PRI operates at the CCITT designated rate of 1544 Kbps.

The European PRI is comprised of thirty B-channels and one D-channel (30B+D). As in the American PRI all the channels operate at 64 Kbps. However, the 30B+D PRI operates at the CCITT designated rate of 2048 Kbps.

SAPI

Service Access Point Identifier, the first part of the address of each frame.

TEI

Terminal End Point Identifier, the second part of the address of each frame.