

# Integrated Services Digital Network (ISDN)

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## Background

*Integrated Services Digital Network (ISDN)* is comprised of digital telephony and data-transport services offered by regional telephone carriers. ISDN involves the digitalization of the telephone network, which permits voice, data, text, graphics, music, video, and other source material to be transmitted over existing telephone. The emergence of ISDN represents an effort to standardize subscriber services, user/network interfaces, and network and internetwork capabilities. ISDN applications include high-speed image applications (such as Group IV facsimile), additional telephone lines in homes to serve the telecommuting industry, high-speed file transfer, and video conferencing. Voice service is also an application for ISDN. This chapter summarizes the underlying technologies and services associated with ISDN.

## ISDN Components

ISDN components include terminals, terminal adapters (TAs), network-termination devices, line-termination equipment, and exchange-termination equipment. ISDN terminals come in two types. Specialized ISDN terminals are referred to as *terminal equipment type 1 (TE1)*. Non-ISDN terminals, such as DTE, that predate the ISDN standards are referred to as *terminal equipment type 2 (TE2)*. TE1s connect to the ISDN network through a four-wire, twisted-pair digital link. TE2s connect to the ISDN network through a TA. The ISDN TA can be either a standalone device or a board inside the TE2. If the TE2 is implemented as a standalone device, it connects to the TA via a standard physical-layer interface. Examples include EIA/TIA-232-C (formerly RS-232-C), V.24, and V.35.

Beyond the TE1 and TE2 devices, the next connection point in the ISDN network is the *network termination type 1 (NT1)* or *network termination type 2 (NT2)* device. These are network-termination devices that connect the four-wire subscriber wiring to the conventional two-wire local loop. In North America, the NT1 is a *customer premises equipment (CPE)* device. In most other parts of the world, the NT1 is part of the network provided by the carrier. The NT2 is a more complicated device that typically is found in digital *private branch exchanges (PBXs)* and that performs Layer 2 and 3 protocol functions and concentration services. An NT1/2 device also exists as a single device that combines the functions of an NT1 and an NT2.

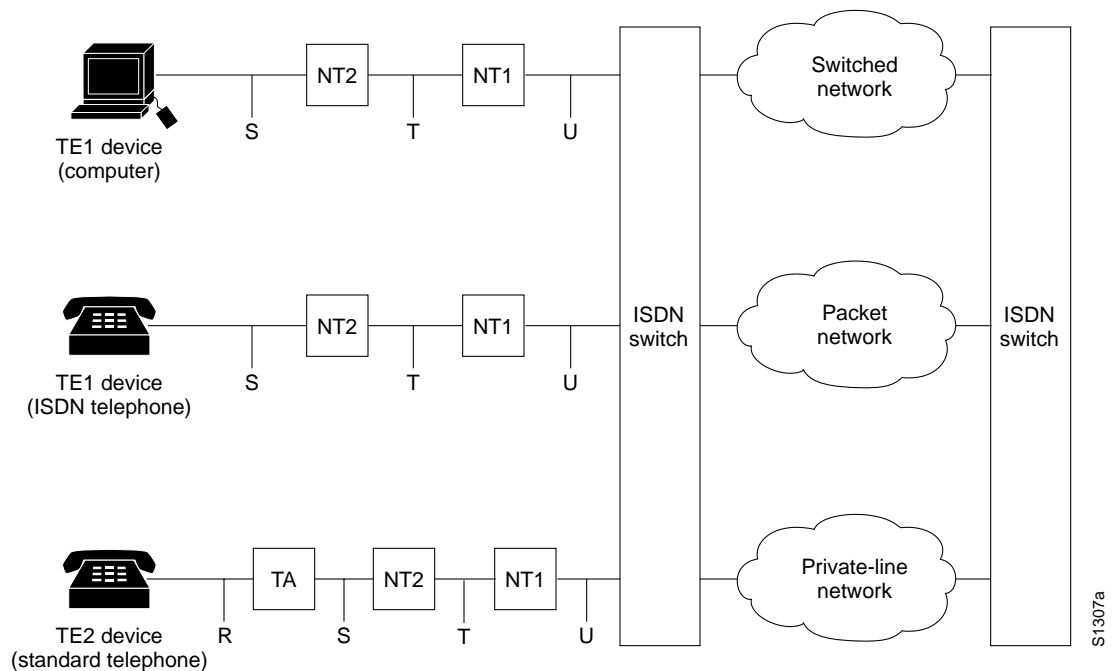
ISDN specifies a number of reference points that define logical interfaces between functional groupings, such as TAs and NT1s. ISDN reference points include the following:

- *R*—The reference point between non-ISDN equipment and a TA.
- *S*—The reference point between user terminals and the NT2.
- *T*—The reference point between NT1 and NT2 devices.

- *U*—The reference point between NT1 devices and line-termination equipment in the carrier network. The U reference point is relevant only in North America, where the NT1 function is not provided by the carrier network.

Figure 12-1 illustrates a sample ISDN configuration and shows three devices attached to an ISDN switch at the central office. Two of these devices are ISDN-compatible, so they can be attached through an S reference point to NT2 devices. The third device (a standard, non-ISDN telephone) attaches through the reference point to a TA. Any of these devices also could attach to an NT1/2 device, which would replace both the NT1 and the NT2. In addition, although they are not shown, similar user stations are attached to the far right ISDN switch.

**Figure 12-1 Sample ISDN configuration illustrates relationships between devices and reference points.**



## Services

The ISDN *Basic Rate Interface* (BRI) service offers two *B channels* and one *D channel* (2B+D). BRI B-channel service operates at 64 kbps and is meant to carry user data; BRI D-channel service operates at 16 kbps and is meant to carry control and signaling information, although it can support user data transmission under certain circumstances. The D channel signaling protocol comprises Layers 1 through 3 of the OSI reference model. BRI also provides for framing control and other overhead, bringing its total bit rate to 192 kbps. The BRI physical-layer specification is International Telecommunication Union Telecommunication Standardization Sector (ITU-T) (formerly the Consultative Committee for International Telegraph and Telephone [CCITT]) I.430.

ISDN *Primary Rate Interface* (PRI) service offers 23 B channels and one D channel in North America and Japan, yielding a total bit rate of 1.544 Mbps (the PRI D channel runs at 64 Kbps). ISDN PRI in Europe, Australia, and other parts of the world provides 30 B channels plus one 64-Kbps D channel and a total interface rate of 2.048 Mbps. The PRI physical-layer specification is ITU-T I.431.

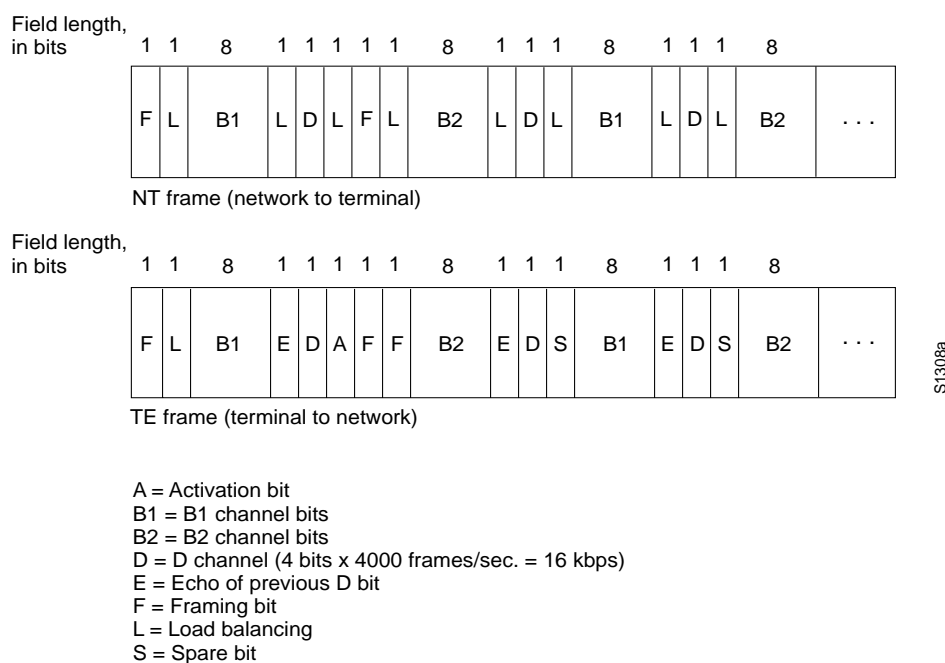
## Layer 1

ISDN physical-layer (Layer 1) frame formats differ depending on whether the frame is outbound (from terminal to network) or inbound (from network to terminal). Both physical-layer interfaces are shown in Figure 12-2).

The frames are 48 bits long, of which 36 bits represent data. The bits of an ISDN physical-layer frame are used as follows:

- *F*—Provides synchronization
- *L*—Adjusts the average bit value
- *E*—Ensures contention resolution when several terminals on a passive bus contend for a channel
- *A*—Activates devices
- *S*—Unassigned
- *B1*, *B2*, and *D*—Handles user data

**Figure 12-2 ISDN Physical-layer frame formats differ depending on their direction.**



Multiple ISDN user devices can be physically attached to one circuit. In this configuration, collisions can result if two terminals transmit simultaneously. ISDN therefore provides features to determine link contention. When an NT receives a D bit from the TE, it echoes back the bit in the next E-bit position. The TE expects the next E bit to be the same as its last transmitted D bit.

Terminals cannot transmit into the D channel unless they first detect a specific number of ones (indicating “no signal”) corresponding to a pre-established priority. If the TE detects a bit in the echo (E) channel that is different from its D bits, it must stop transmitting immediately. This simple technique ensures that only one terminal can transmit its D message at one time. After successful D- message transmission, the terminal has its priority reduced by requiring it to detect more continuous ones before transmitting. Terminals cannot raise their priority until all other devices on

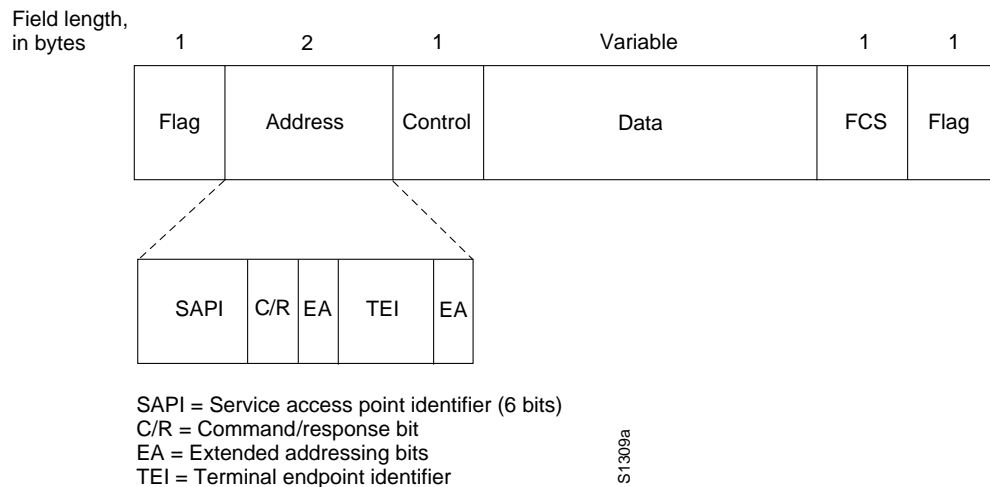
the same line have had an opportunity to send a D message. Telephone connections have higher priority than all other services, and signaling information has a higher priority than non-signaling information.

## Layer 2

Layer 2 of the ISDN signaling protocol is *Link Access Procedure, D channel (LAPD)*. LAPD is similar to *High-Level Data Link Control (HDLC)* and *Link Access Procedure, Balanced (LAPB)* (see Chapter 16, “Synchronous Data Link Control and Derivatives,” and Chapter 17, “X.25,” for more information on these protocols). As the expansion of the LAPD acronym indicates, this layer it is used across the D channel to ensure that control and signaling information flows and is received properly. The LAPD frame format (see Figure 12-3) is very similar to that of HDLC and, like HDLC, LAPD uses *supervisory, information, and unnumbered* frames. The LAPD protocol is formally specified in ITU-T Q.920 and ITU-T Q.921.

The LAPD *Flag* and *Control* fields are identical to those of HDLC. The LAPD *Address* field can be either 1 or 2 bytes long. If the extended address bit of the first byte is set, the address is 1 byte; if it is not set, the address is 2 bytes. The first Address-field byte contains *identifier service access point identifier (SAPI)*, which identifies the portal at which LAPD services are provided to Layer 3.

**Figure 12-3 LAPD frame format is similar to HDLC and LAPB.**



The C/R bit indicates whether the frame contains a command or a response. The *terminal end-point identifier (TEI)* field identifies either a single terminal or multiple terminals. A TEI of all ones indicates a broadcast.

## Layer 3

Two Layer 3 specifications are used for ISDN signaling: ITU-T (formerly CCITT) I.450 (also known as ITU-T Q.930) and ITU-T I.451 (also known as ITU-T Q.931). Together, these protocols support user-to-user, circuit-switched, and packet-switched connections. A variety of call-establishment, call-termination, information, and miscellaneous messages are specified, including SETUP, CONNECT, RELEASE, USER INFORMATION, CANCEL, STATUS, and DISCONNECT. These

messages are functionally similar to those provided by the X.25 protocol (see Chapter 17, "X.25," for more information). Figure 12-4, from ITU-T I.451, shows the typical stages of an ISDN circuit-switched call.

**Figure 12-4** An ISDN circuit-switched call moves through various stages to its destination.

