Integrated Services Digital Network (ISDN) is comprised of digital telephony and data-transport services offered by regional telephone carriers. ISDN involves the digitization of the telephone network, which permits voice, data, text, graphics, music, video, and other source material to be transmitted over existing telephone wires. 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 videoconferencing. Voice service is also an application for ISDN. This article summarizes the underlying technologies and services associated with ISDN.

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ISDN Devices

ISDN devices 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 groups, 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: Sample ISDN Configuration Illustrates Relationships Between Devices and Reference Points 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: Sample ISDN Configuration Illustrates Relationships Between Devices and Reference Points

Services

There are two types of services associated with ISDN:

- BRI
- PRI

ISDN BRI Service

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-Telecommunications Standards Section (ITU-T) (formerly the Consultative Committee for International Telegraph and Telephone [CCITT]) I.430.

ISDN PRI Service

ISDN Primary Rate Interface (PRI) service offers 23 B channels and 1 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.

ISDN Specifications

This section describes the various ISDN specifications for Layer 1, Layer 2, and Layer 3.

Figure: Sample ISDN Configuration Illustrates Relationships Between Devices and Reference Points

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: ISDN Physical Layer Frame Formats Differ Depending on Their Direction.

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** - Is unassigned
- **B1**, **B2**, and **D** - Handle user data

Figure: ISDN Physical Layer Frame Formats Differ Depending on Their Direction
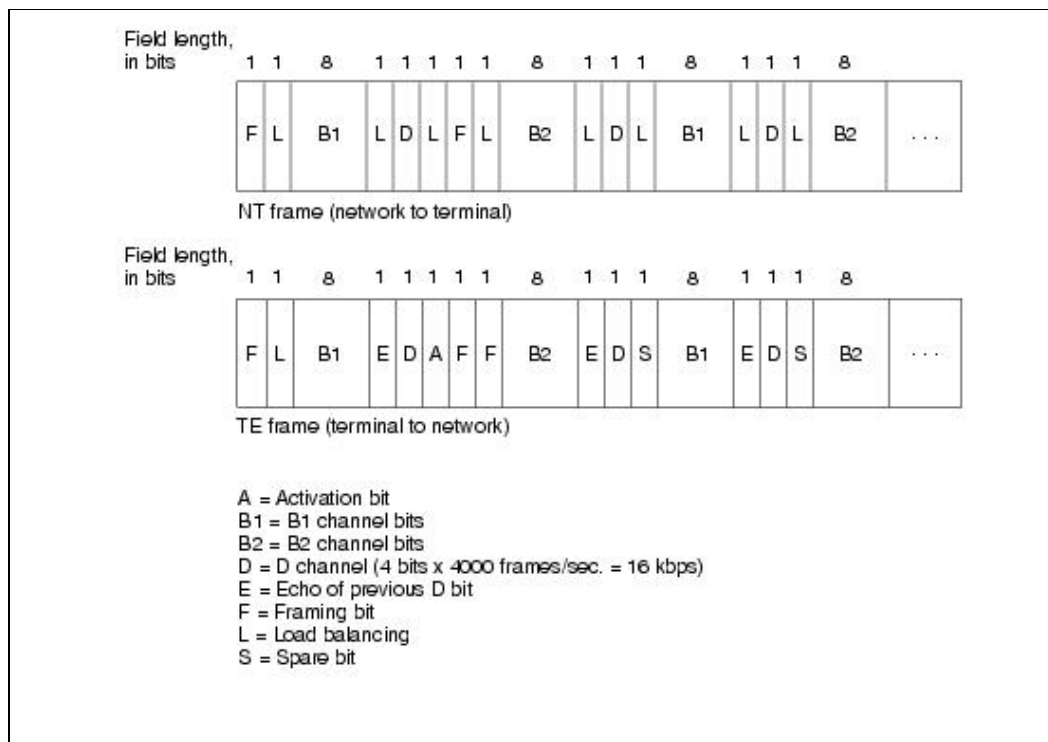

Multiple ISDN user devices can be physically attached to one circuit. In this configuration, collisions can result if two terminals transmit simultaneously. Therefore, ISDN provides features to determine link contention. When an NT receives a D bit from the TE, it echoes back the bit in the next E-bit 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 nonsignaling 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). As the expansion of the LAPD acronym indicates, this layer is used across the D channel to ensure that control and signaling information flows and is received properly. The LAPD frame format (see <u>Figure: LAPD Frame Format Is Similar to That of HDLC and LAPB</u>)is very similar to that of HDLC; 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.

Figure: LAPD Frame Format Is Similar to That of HDLC and LAPB
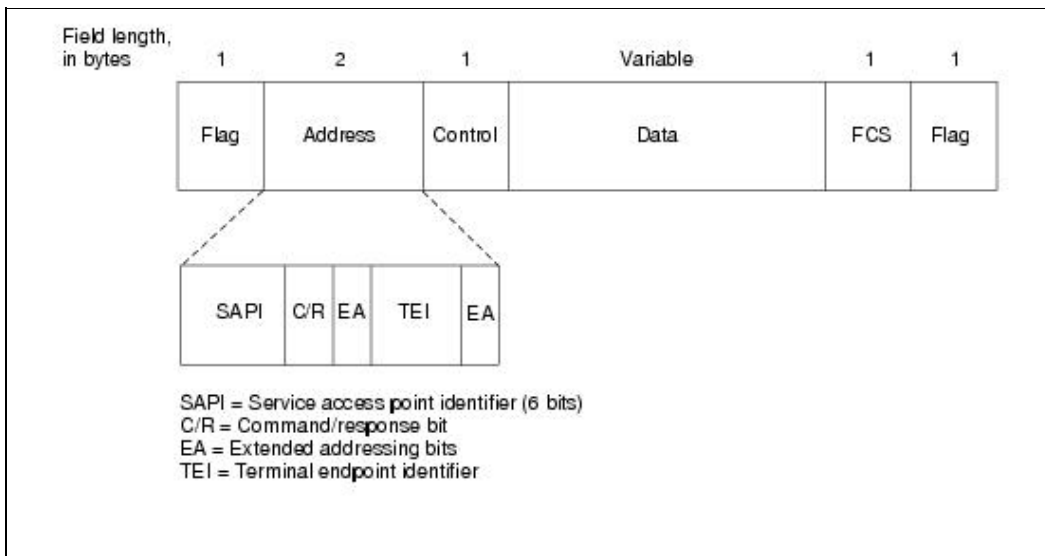
The LAPD Flag and Control fields are identical to those of HDLC. The LAPD Address field can be either 1 or 2 bytes long. If the extended address bit of the first byte is set, the address is 1 byte; if it is not set, the address is 2 bytes. The first Address-field byte contains the service access point identifier (SAPI), which identifies the portal at which LAPD services are provided to Layer 3. The C/R bit indicates whether the frame contains a command or a response. The Terminal Endpoint 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.

<u>Figure: An ISDN Circuit-Switched Call Moves Through Various Stages to Its Destination</u>, from ITU-T I.451, shows the typical stages of an ISDN circuit-switched call.

Figure: An ISDN Circuit-Switched Call Moves Through Various Stages to Its Destination

Integrated_Services_Digital_Network
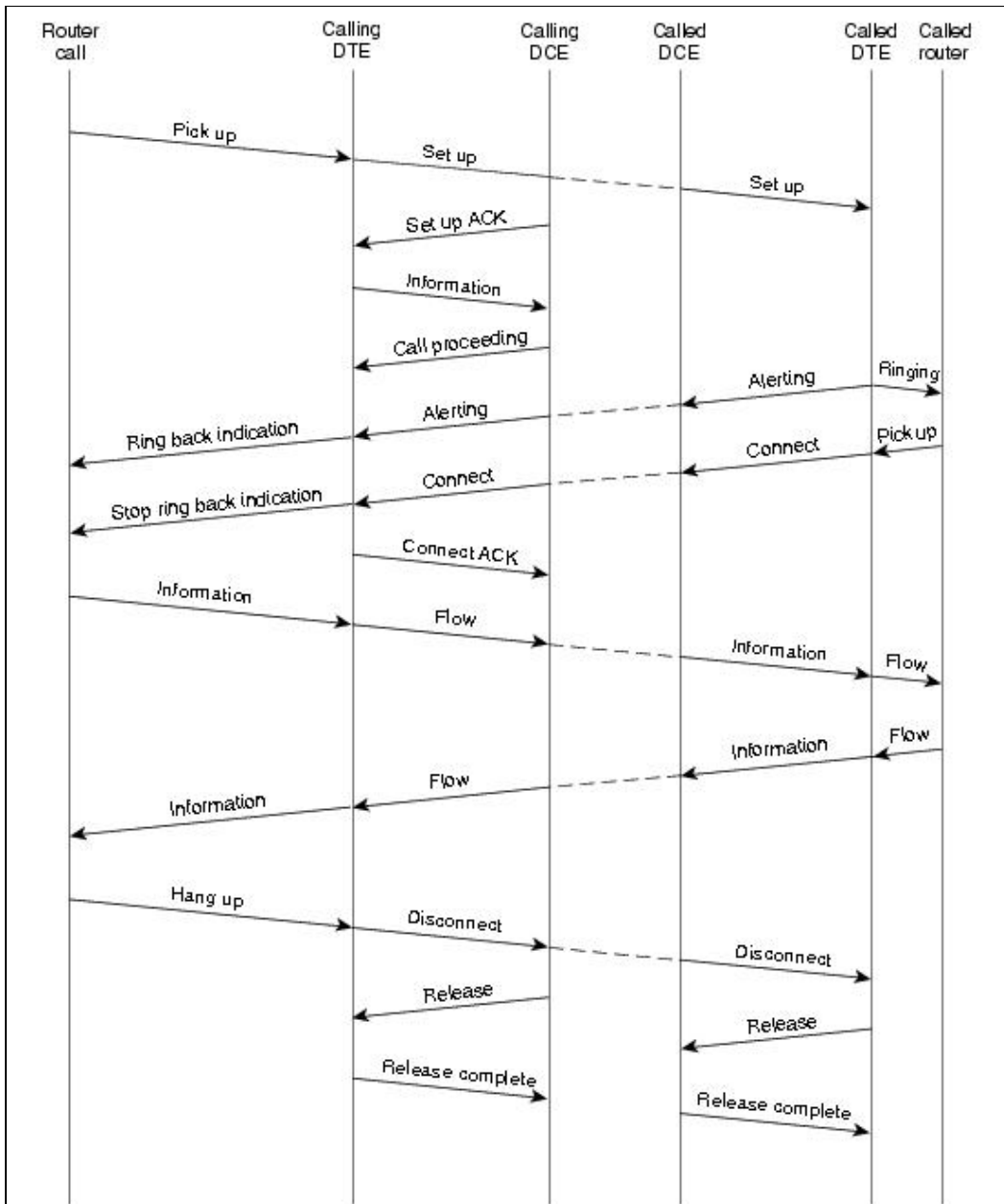
Summary

ISDN is comprised of digital telephony and data-transport services offered by regional telephone carriers. ISDN involves the digitization of the telephone network to transmit voice, data, text, graphics, music, video, and other source material over existing telephone wires.

ISDN devices include the following:

- Terminals
- Terminal adapters (TAs)
- Network-termination devices
- Line-termination equipment
- Exchange-termination equipment

The ISDN specification references specific connection points that define logical interfaces between devices.

Figure: An ISDN Circuit-Switched Call Moves Through Various Stages to Its Destination   6

ISDN uses the following two types of services:

- Basic Rate Interface (BRI, which offers two B channels and one D channel (2B+D)
- Primary Rate Interface (PRI), which offers 23 B channels and 1 D channel in North America and Japan, and 30 B channels and 1 D channel in Europe and Australia

ISDN runs on the bottom three layers of the OSI reference model, and each layer uses a different specification to transmit data.

Review Questions

Q - *Which reference point for ISDN logical devices is relevant only in North America?*

A - U, the reference point between NT1 devices and line-termination equipment in the carrier network.

Q - *What are the two speeds of ISDN PRI services?*

A - In North America and Japan, 23 B channels (1.472 Mbps) plus 1 D channel (64 kbps); in Europe and Australia, 31 B channels (1.984 Mbps) plus 1 D channel (64 kbps).

Q - *Of the 48 bits in the ISDN physical layer frame formats, how many bits represent data?*

A - 36.