Integrated Services Digital Network (ISDN)

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Lecture Objectives

- **Discuss the objectives of ISDN**
- **Describe the ISDN architecture, channel structure and standard interfaces**
- **Provide a systems-level overview of ADSL**
- **Reading Assignment : Stallings, Appendix A**
- **Other sources : Roger Freeman, *Telecommunications System Engineering*, 3rd edition, 1996 (Chapter 13)**
- **On the web: ADSL Forum (www.adsl.com)**

Evolution of ISDN (1)

- **Integration**
  - **Before WWII, integration of telegraph/telex and voice**
  - **More recently, integration of fax and voice**
  - **ISDN objective: integrate digital voice, 64-kbps data, telex, fax, slow-scan video**
  - **Broadband ISDN (BISDN): all of the above plus video, multimedia, …**

Evolution of ISDN (2)

- **Channel**
  - **Analog public switched telecommunications network based on the 4-kHz voice channel**
  - **Present digital network based on PCM: 64-kbps voice channel**
  - **In-channel signaling and framing corrupted the 64-kbps channel, so integration of data required a drop-back to 56-kbps**
  - **ISDN : local interface to a "digital pipe" enables higher data rates**

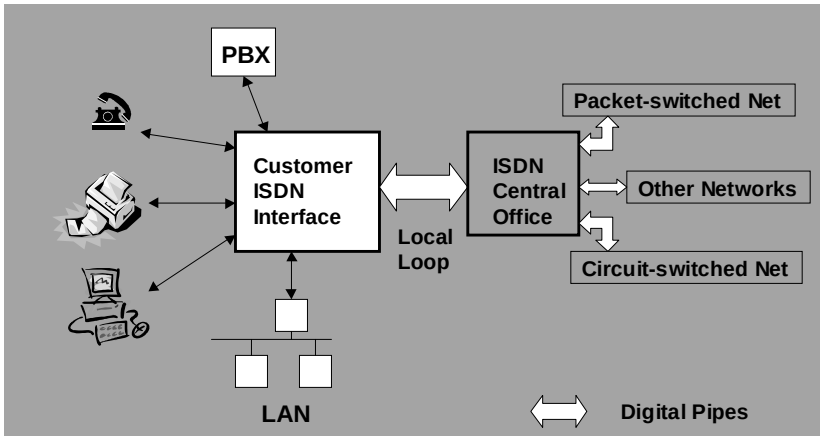
Principles of ISDN (1)

- **Support of voice and non-voice applications in the same network**
  - **interfaces and data transmission facilities standardized by ITU-T**
- **Switched and non-switched connections**
  - **packet & circuit switching, leased lines**
- **64-kbps channel**
  - **chosen because at the time was the standard rate for digitized voice**

Principles of ISDN (2)

- **Layered protocol structure**
  - **mapped into OSI model (advantages in utilizing existing standards as well as in developing new ones)**
- **Variety of configurations**
  - **according to specific national situations & state of technology**

ISDN Conceptual View



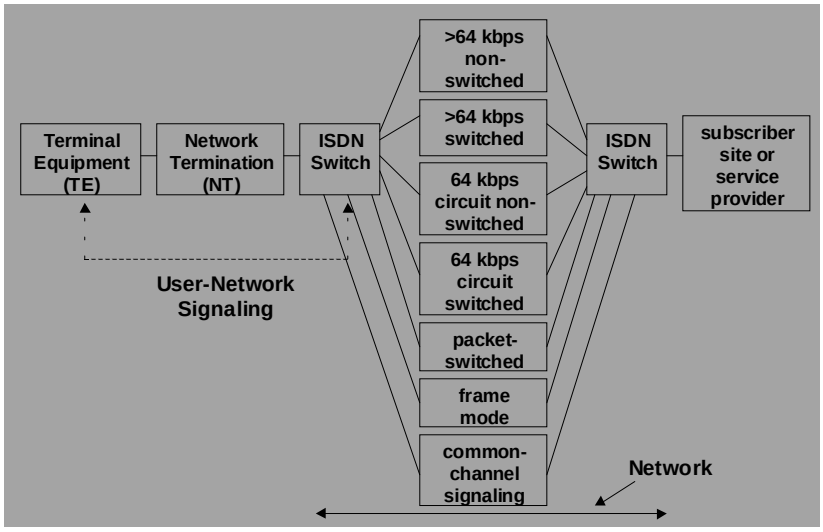
Benefits of ISDN (1)

- **To the <u>user</u> : cost savings and flexibility**
  - **integration of voice/data means users do not have to buy multiple services to meet multiple needs**
  - **single access line to all services**
  - **services tailored to diverse requirements (information volume, traffic pattern, response time, interface types)**

Benefits of ISDN (2)

- To network providers
  - standards support universality and larger potential market for services, drive down equipment costs
- To manufacturers
  - larger potential market, economies of scales
  - standards decrease risk of obsolescence
- To enhanced service providers
  - simplified user access

ISDN Architecture (1)



ISDN Architecture (2)

- **Circuit-switched capabilities : 64-kbps**
- **Non-switched capabilities : 64 kbps dedicated link, higher data rate provided by BISDN**
- **Switched capabilities : > 64 kbps switched connections using ATM as part of BISDN**
- **Packet-switching capabilities : as provided by other data networks**
- **Frame-mode capabilities : supporting frame relay**
- **Common-channel signaling capabilities : used to control the network and provide call management. Internal to the network, SS7 is used.**

ISDN Channels (1)

- **Standard bit rates:**
  - **B-channel : 64 kbps**
  - **D-channel : 16 or 64 kbps**
  - **H-channel : 384 (H0), 1536 (H11), 1920 (H12) kbps**
- **B-channel is the basic user channel**
  - **can carry digital data, PCM-encoded digital voice, or a mixture of lower-rate traffic**
  - **with mixed traffic, all traffic must be destined for the same end-point (carried over the same circuit)**

ISDN Channels (2)

- **B-channel (continued)**
  - **supports circuit-switched, packet-switched (exchange of data via X.25) and semipermanent connections**
  - **in the case of circuit-switched connections, common-channel signaling is used**
- **D-channel is dual-purpose**
  - **carries signaling information to control circuit-switched calls on B-channel**
  - **may be used to carry low-speed data applications (e.g., videotex, telemetry)**

ISDN Channels (3)

- **H-channel is a high-speed channel**
  - **can be used as a single trunk or subdivided by the user**
  - **fast fax, video, high-speed data, high-quality audio and multiplexed information streams at lower data rates**
- **These channel types are grouped into transmission structures that are offered as a package to the user**

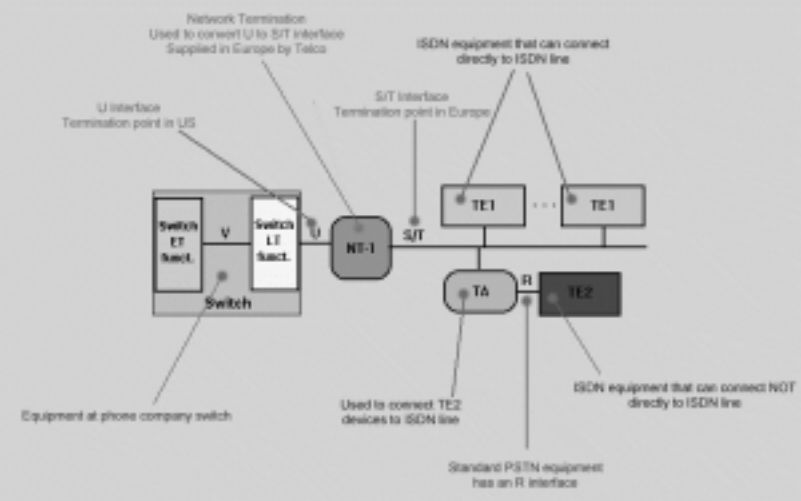
Transmission Structures (1)

- **Basic access**
  - **Intended to meet the needs of individual users (residences, small offices)**
  - **Composition: 2B+D (16 kbps D-channel) + synchronization and framing = 192 kbps**
  - **Most existing two-wire local loops can support this interface**

Transmission Structures (2)

- **Primary service**
  - **Users w/ greater capacity requirements (offices w/ a PBX or LAN)**
  - **In U.S.: 23B+D (64 kbps D-channel) = 1.544 Mbps (T1)**
  - **In Europe: 30B+D (64 kbps D-channel) = 2.048 Mbps (E1)**
  - **May also be used to support H-channels (e.g. 3H0+D supplies a 1.544 Mbps interface)**

Interfaces (1)



Interfaces (2)

- **In U.S., telephone company provides users with U interface**
  - **single-pair two-wire interface from phone switch**
  - **only a single device can be connected**
  - **NT-1 connects to U interface**
  - **in other parts of the world, phone company can provide the NT-1 and users get S/T interface**
- **Network Termination 1 (NT-1) converts 2-wire U interface into 4-wire S/T (system/terminal) interface**

Interfaces (3)

- **Network Termination 1 (NT1)**
  - **physical and electrical termination on user's premises (OSI L1)**
  - **line maintenance, multiplexes several channels (synchronous TDM), supports multiple devices (multidrop)**
- **Technically, need an NT2 device to convert T into S**
  - **layers 2/3 functions**
  - **usually NT2 integrated into other ISDN devices**

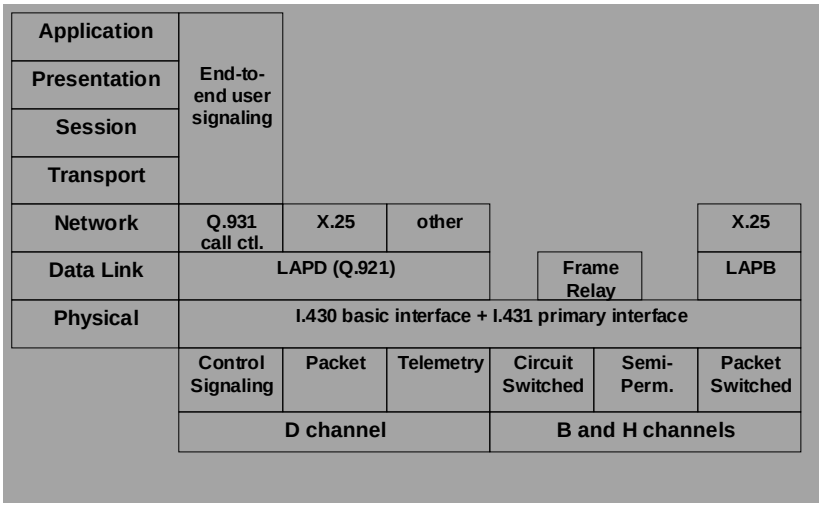
Interfaces (4)

- **S/T interfaces support multiple devices**
  - **one pair for transmitting, the other for receiving**
  - **ISDN-capable phones and fax machines, video-conferencing equipment, bridges, routers and terminal adapters can connect to S/T interface -- these are called Terminal Equipment 1 (TE1)**
- **Terminal Equipment 2 (TE2) is not ISDN-capable but has a POTS interface (common modems, phone, fax)**
  - **must connect through a Terminal Adapter (TA), sometimes called "ISDN modems"**

Interfaces (5)

- **TE2 connects to TA through R (rate) interface**
- **Local loop connection is called Line Termination (LT) function**
- **Connection to other switches within the phone network is the Exchange Termination (ET) function**
- **V interface between LT and ET**

ISDN Protocol Architecture

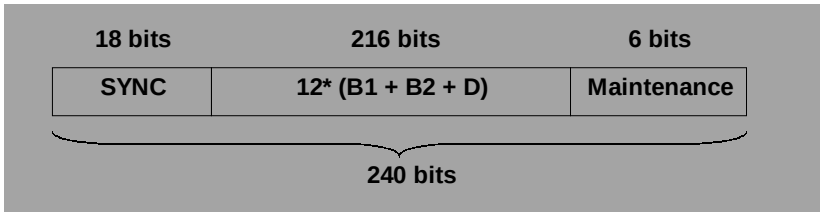


Physical Layer

- **2B1Q (2 binary, 1 quaternary) most common signaling method on U interface**
- **2 bits per symbol**
- **80 kbaud, 160 kbps**

Bits	Quaternary Symbol	Voltage Level
00	-3	-2.5
01	-1	-0.833
10	+3	+2.5
11	+1	+0.833

Physical Layer Frame Format



- **Each frame 1.5 msec long**
- **SYNC field (9 quaternaries) : +3 +3 -3 -3 -3 +3 -3 +3 -3**
- **12 * (8 bits from each B channel + 2 bits from D)**
- **Maintenance contains CRC, other operation info.**

Link Access Protocol - D Channel (LAPD)

- **Layer 2 protocol**
- **Almost identical to LAP-B used w/ X.25 (based on HDLC)**
- **Provides unacknowledged information-transfer service (unnumbered frames, error detection to discard frame but no error control or flow control) and acknowledged information transfer**

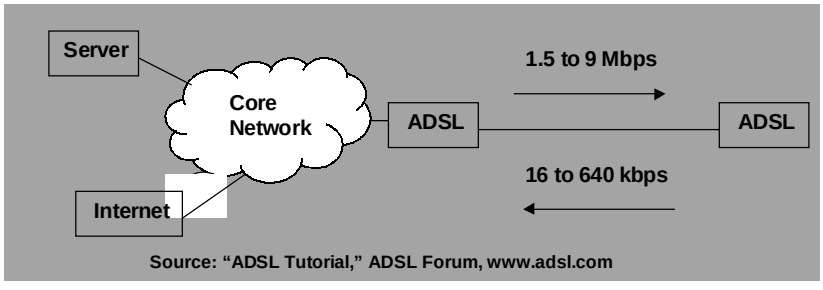
Practical Issues (1)

- **Not available everywhere (typically, must be within 18,000 ft of the telephone company equipment that services you)**
- **Pricing (typical):**
  - **Installation charge (one-time)**
  - **Recurring monthly charge**
  - **Usage charge (typically a couple of cents per minute)**

Practical Issues (2)

- **When does it make sense to subscribe?**
  - **Internet access, remote office (individuals and small businesses)**
  - **For continuous access, a leased line (e.g. T1) may make more sense than switched ISDN**
  - **Cable modems and ADSL are alternatives**

Asymmetric Digital Subscriber Line (ADSL)



Source: "ADSL Tutorial," ADSL Forum, www.adsl.com

Asymmetric Digital Subscriber Line (ADSL)

- **Physical layer transmission protocol (new modem technology)**
- **Converts existing twisted-pair telephone lines into access paths for multimedia and high speed data communications**
- **Three information channels**
  - **high speed downstream channel**
  - **medium speed upstream channel**
  - **POTS or ISDN channel**

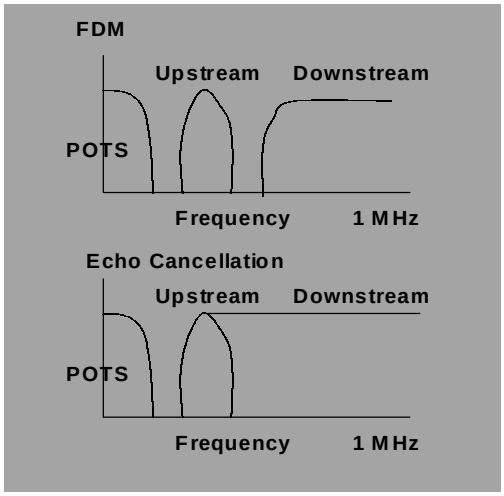
ADSL Technology (I)

Downstream Bearer Channels	
n x 1.536 Mbps	1.536 Mbps
	3.072 Mbps
	4.608 Mbps
	6.144 Mbps
n x 2.048 Mbps	2.048 Mbps
	4.096 Mbps
Duplex Bearer Channels	
C Channel	16 kbps
	64 kbps
Optional Channels	160 kbps
	384 kbps
	544 kbps
	576 kbps

ADSL Technology (II)

- **Data rates consistent with No. American and European digital hierarchies**
- **ADSL modems will accommodate ATM and IP protocols**
- **Downstream rates depend on length of copper wire, wire gauge, presence of bridge taps, etc.**
- **ADSL modems incorporate forward error correction**

ADSL Technology (III)



ADSL Technology (IV)

- **4 KHz region at the DC end of the band is split off for POTS**
- **FDM assigns separate bands for upstream and downstream data; downstream path is divided by TDM into several channels**
- **In echo cancellation, upstream and downstream bands overlap (same technique as V.34 modems)**

ADSL Advantages

- **Advantages - cost effectiveness to providers and added value to users**
  - **Less costly than fiber alternatives**
  - **"Always on" connectivity more convenient, enables remote office**
  - **Quality of connectivity is increased, enables new applications such as videoconferencing**

ADSL Challenges

- **Seamless deployment (can expectations be met?)**
- **Greater emphasis on user requirements (the technology is not important to users, the applications it enables are)**
- **Speed and ubiquity of deployment will vary from region to region**
- **Competition from cable modems**

Lecture Summary

- **ISDN supports a wide range of voice and non-voice applications in the same network. It provides a range of services using a limited set of connection types and multi-purpose user-network interface arrangements. (From Recommendation I.120 - 1988)**
- **ADSL transforms ordinary phone lines into high-speed digital lines for fast Internet access, interactive multimedia applications, telecommuting, video on demand, etc. (From ADSL Forum)**