Computer Networks

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Chapter 2:Physical Layer and Network Media

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Internetworking Devices:

- Hubs
- Repeaters
- Bridges
- Switches
- Routers

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Repeaters, Hubs, Bridges, Switches and Routers

Network layer	Router
Data link layer	Bridge, switch
Physical layer	Repeater, hub

Fig: Which device is in which layer.

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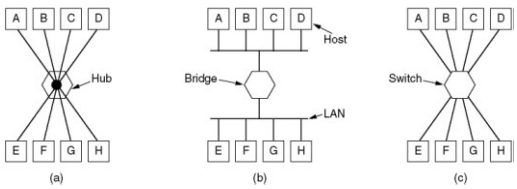

a) A hub. (b) A bridge. (c) a switch.

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HUB

- Also called An Ethernet hub, active hub, network hub, repeater hub, multiport repeater or hub
- Has multiple input/output (I/O) ports
- Also called Multi-port Repeater
  - In which a signal introduced at the input of any port appears at the output of every port except the original incoming.
- A HUB works at the physical layer (layer 1) of the OSI model
- Hubs are now largely obsolete, having been replaced by network switches except in very old installations or specialized applications.

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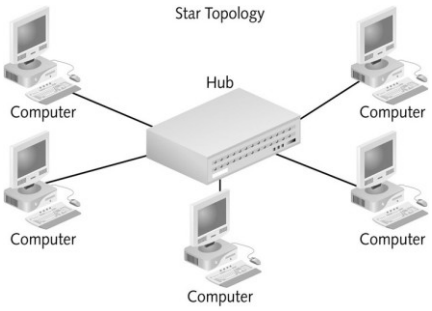

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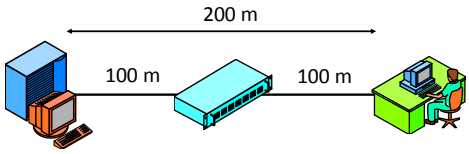
10Base-T & 100Base-TX wiring

- Wiring
  - 100 meters maximum distance hub-to-station
  - Can use multiple hubs (max 4) to increase the distance between any two stations



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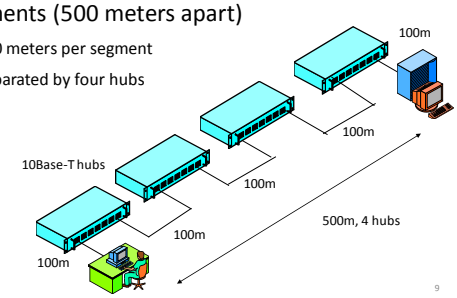
Multiple Hubs in 10Base-T

- Farthest stations in 10Base-T can be five segments (500 meters apart)
  - 100 meters per segment
  - Separated by four hubs



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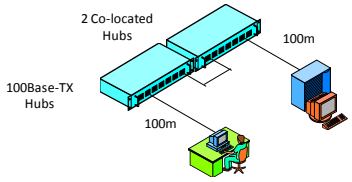
Multiple Hubs in 100Base-TX

- Limit of ***Two Hubs*** in 100Base-TX
  - Must be within a few meters of each other
  - Maximum span :200 meters
  - Shorter distance span than 10Base-T



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Repeaters

- Regenerate the signal
- Provide more flexibility in network design
- Extend the distance over which a signal may travel down a cable
- Example → Ethernet HUB
- Connect together one or more Ethernet cable segments of any media type
- Works at Layer 1 of OSI model
- Forwards every frames; has no filtering capability

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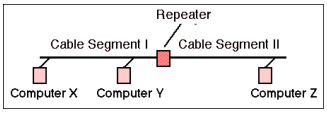
Ethernet Repeaters and Hubs

- Used between a pair of segments



- Provide signal amplification and **regeneration** to restore a good signal level before sending it from one cable segment to another

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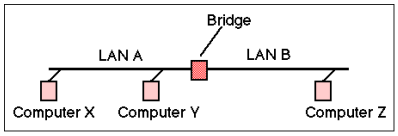
Ethernet Bridge

- Join two LAN segments (A,B), constructing a larger LAN
- Filter traffic passing between the two LANs and may enforce a security policy separating different work groups located on each of the LANs.



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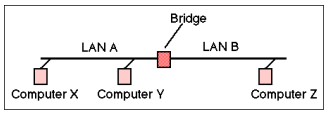
Ethernet Bridges

- Simplest and most frequently used → Transparent Bridge (meaning that the nodes using a bridge are unaware of its presence).



- Bridge could forward all frames, but then it would behave rather like a repeater
- Bridges are smarter than repeaters!

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Ethernet Bridges: Working

- Bridges work at the Media Access Control Sub-layer of the OSI model
- A bridge stores the hardware addresses observed from frames received by each interface
- Uses this information to learn which frames need to be forwarded by the bridge.
- Each bridge has two connections (ports) and there is a table associated with each port.
  - A bridge observes each frame that arrives at a port
  - extracts the source address from the frame
  - and places that address in the port's routing table

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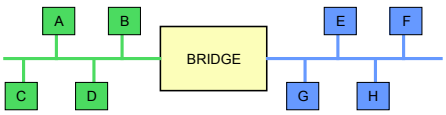
Working contd..
Selective Forwarding



- If A sends a frame to E - the frame must be forwarded by the bridge.
- If A sends a frame to B - there is no reason to forward the frame.

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Ethernet Switch → Modern LANs

- Typically connects individual computers
  - A switch is essentially the same as a bridge
  - though typically used to connect hosts, not LANs
- Richer management capability.
- Logically partition the traffic to travel only over the network segments on the path between the source and the destination (reduces the wastage of bandwidth)

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Benefits/Advantages

- Improved security
  - users are less able to tap-in into other user's data
- Better management
  - control who receives what information (i.e. Virtual LANs)
  - limit the impact of network problems
- Dedicated access
  - Host has direct connection to the switch
  - rather than a shared LAN connection

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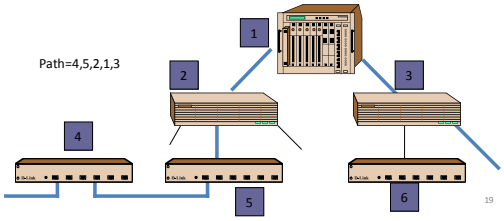
Ethernet Switches

- No limit on number of Ethernet switches between farthest stations
  - So no distance limit on size of switched networks
- Ethernet Switches ***must*** be arranged in a Hierarchy (or daisy chain)
  - Only one possible path between any two stations, switches



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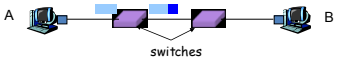
Cut-Through Switching

- Start transmitting as soon as it reads destination address.
  - Transmit the head of the packet via the outgoing link while still receiving the tail via the incoming link
  - Much faster
  - Cannot detect corrupt packets
  - Destination is responsible for detecting corrupt packets
  - Can propagate the corrupt packets to the network



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Store and Forward Mode switching

- Read the whole packet before transmit
- Slower than the cut-through mode
- More accurate since corrupt packets can be detected using the FCS
- More suit to large LAN since they will not propagate error packets

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Router

- Layer 3 Devices
- Network Layer in OSI and Internet layer in TCP/IP protocol stack
- Main Function
  - Routing of Packets (Based on Routing Table)
  - Path Selection(Best Path) to forward the packets
  - Internetwork Communications

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Router: Working

- Only packets with known network addresses will be passed - hence reduce traffic
- Routers can listen to a network and identify its busiest part
- Will select the most cost effective path for transmitting packets
- Routing table is formed based on communications between routers using "Routing Protocols"
- Routing Protocols collect data about current network status and contribute to selection of the best path

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Switches Versus Routers

Switches	Routers
▪ Layer 2 device	▪ Layer 3 device
▪ Fast	▪ Slow
▪ Inexpensive	▪ Expensive
▪ No benefits of alternative routing	▪ Benefits of alternative routing
▪ No hierarchical addressing	▪ Hierarchical addressing
▪ switches maintain switch tables, implement filtering, learning algorithms	▪ routers maintain routing tables, implement routing algorithms

"Switch where you can; route where you must"

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Comparing Hubs, Switches, Routers

	Hub/ Repeater	Bridge/ Switch	Router
Traffic isolation	no	yes	yes
Plug and Play	yes	yes	no
Efficient routing	no	no	yes
Cut through	yes	yes	no

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Transmission Medium

- Anything that can carry information from a source to a destination
- Classes (Types)
  - Guided Transmission Media
  - Unguided Transmission Media
- Guided Transmission Media
  - provide a physical path along which the signals are propagated.
- Unguided Transmission Media
  - employ an antenna for transmitting through air or vacuum

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- Guided Transmission media
  - Twisted pair
  - Coaxial
  - Fiber
- Unguided Transmission media
  - Bluetooth
  - Wi-Fi /WLAN (Wireless LAN)
  - Infrared
  - Satellite Communication
    - Microwaves
    - Radio Waves

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Twisted Pair Cable

A twisted pair consists of two insulated copper wires arranged in a regular spiral pattern.
The purpose of twisting the wire is to eliminate electrical interference from other wires and outside sources.
Twisting the wires cancels any electrical noise from the adjacent pair.

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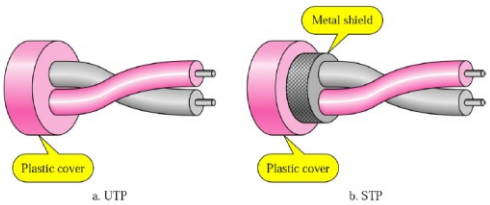
Twisted Pair Cable: STP and UTP



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Twisted Pair

- Advantages
  - Protect against cross talk & interference
  - Easy to add computers to network
  - Well understood technology
  - Less expensive
- Disadvantages
  - Least secure
  - Distance limitations
  - Requires more expensive hubs

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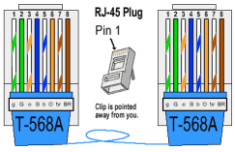
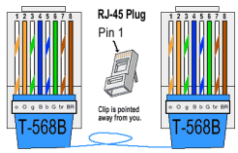
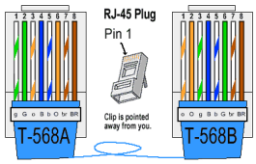


T-568A Straight-Through Ethernet Cable



T-568B Straight-Through Ethernet Cable



RJ-45 Crossover Ethernet Cable

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- A straight-through cable has identical ends.
- A crossover cable has different ends.
- A straight-through is used as a patch cord in Ethernet connections.
- A crossover is used to connect two Ethernet devices without a hub or for connecting two hubs.
- A crossover has one end with the Orange set of wires switched with the Green set.
- Odd numbered pins are always striped, even numbered pins are always solid colored.
- Brown is always on the right, and pin 1 is on the left.
- Orange set of wires are used for transmission of data
- Green set of wires are used for receiving data

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Twisted Pair Types

- **Category 1**—Used for telephone communications. Not suitable for transmitting data.
- **Category 2**—Capable of transmitting data at speeds up to 4 megabits per second (Mbps).
- **Category 3**—Used in 10BASE-T networks. Can transmit data at speeds up to 10 Mbps.
- **Category 4**—Used in Token Ring networks. Can transmit data at speeds up to 16 Mbps.
- **Category 5** – a tighter twist, same number of wires, just less crosstalk and higher speeds (100 Mbps)

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- **Category 6** (250 MHz) – 4 pairs of 24 American Wire Gauge (AWG) copper wires. Category 6 cable is currently the fastest standard for UTP.
- **Category 7** (600 MHz) is upcoming.
- All twisted pair is "unshielded" except for some stuff used by IBM in the early 80s.
- These unshielded wires are referred to as "UTP" or "Unshielded Twisted Pair"

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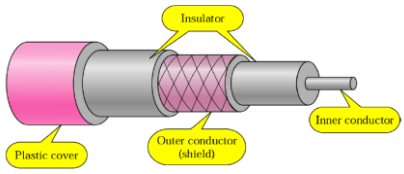
Coaxial Cable



It consists of a hollow outer cylindrical conductor that surrounds a single inner wire conductor.
The inner conductor is held in place by either regularly spaced insulating rings or a solid dielectric material.
The outer conductor is covered with a jacket or shield.
Coaxial cable can be used over longer distances and support more stations on a shared line than twisted pair.

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Coaxial Cable

- Advantages
  - Transmits up to 10Mbps over 500m
  - Easy to install
  - Low maintenance
  - Good resistance to noise over long distances
- Disadvantages
  - Inflexible
  - Low security
  - Limited distance

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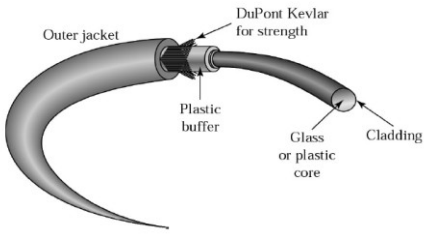
Thicknet and Thinnet

- **ThickNet**: This type of coaxial cabling is used with Ethernet 10Base5 networks and is able to span distances of up to 500 meters. RG-8/U cable is used as thick cable in thicknet based LAN network.
- **ThinNet:** A much thinner and more flexible type of coaxial cable, ThinNet is used on Ethernet 10Base2 networks and can span distances of up to 185 meters. RG-58/U is used as thin cable in thinnet based LAN network.

Optical fiber



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- We must have a light source in order to send the data. It sends a ray of light for each 1 bit, and no light for a 0 bit.
- We must have a detector to detect the light signal. The detector emits an electric pulse for each light ray it detects.
- The slowest part of the system is the conversion that happens at either end

Composition

- Consist extremely thin cylinder glass called Core
- Surrounded by a concentric layer known as cladding
- Each glass strand passes signals in only one direction, a cable includes two strands in separate jackets.

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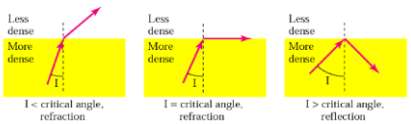

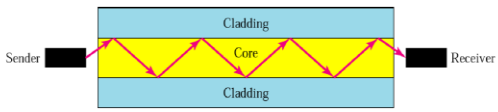

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Fiber Optics: Advantages

- High data rate and wide bandwidth
- Low attenuation (data loss)
- Longer distance - 2 and 5 km with Multimode fiber or over 25 km with Single Mode fiber
- Small cable diameter fits anywhere
- No sparks if cut
- No shock hazard
- Secure communications
- Longer life expectancy than copper or coaxial cable
- Cabling of the future

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Optical Fiber :Disadvantages

- Expensive
- Difficult to install
- Require two cables to transmit & receive data
- Require special connections

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Infrared Transmission

- Unguided infrared waves are widely used for short-range communication.
- The remote controls used for televisions, VCRs, and stereos all use infrared communication.
- They are relatively directional, cheap, and easy to build
- have a major drawback: they do not pass through solid objects.

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Radio waves

- Radio waves are a type of electromagnetic radiation with wavelengths in the electromagnetic spectrum longer than infrared light.
- Radio waves have frequencies from 3 KHz to as high as 300 GHz
- Transmitted through Omni-directional antennas
- Can travel long distances
- Very sensible to interference

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- Applications:
  - TV & radio broadcasting
  - Cordless phones

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Microwave

- They range from 1 GHz to 300 GHz
- Unidirectional => Antennas must be aligned
- Propagation is line-of-sight (earth curvature is a problem)
- Cannot penetrate walls
- Higher data range than radio waves
- Part of the spectrum is regulated from authorities

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Application

- long-distance telephone communication
- mobile phones
- television broadcast

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Assignment

- Ethernet Cable Standards (UTP and Fiber Cable Standards)

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Switching

- Switching is the techniques by which nodes control or switch data to transmit it between specific points in a network.
- There are three different types of switching:
  - circuit switching
  - message switching
  - packet switching

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Circuit Switching

- It establishes a path between sender and receiver isolated from paths used by other pairs of sender and receiver
- A physical connection is needed for the phone call to go through.
- This used to be done by a person at a switchboard.
  - Now it is done automatically.
- Setting up the circuit can still take time, depending on how far the call is going and how many switches it passes through.

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- Three general properties defines a circuit switched paradigm
  - Point-to-point communication
  - Separate steps for circuit creation, use and termination
  - Performance equivalent to an isolated physical path

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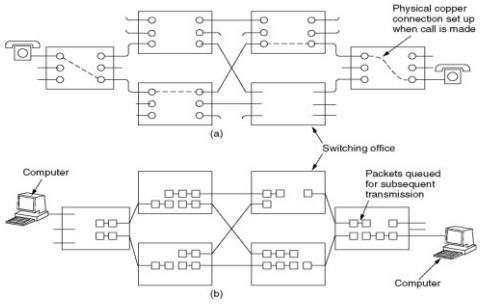

(a) Circuit switching
(b) Packet switching

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Packet Switching

- There is no physical connection for packet switching.
- The data is broken up into packets by the sender and they are sent to the switching office.
- The first packet can easily be sent to the next switching office before the second packet has arrived.
- This makes packet switching useful for busy networks.
- Two Types of Packet Switching
  - Datagram Packet Switching
  - Virtual Circuit Packet Switching

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Packet Switching: Datagram Packet Switching

- No need to establish the connection between the source and destination.
- Route chosen on packet by packet basis.
- Packets may be stored until delivered => (Store and Forward)
- Different packets may follow different routes.
- Packets may arrive out of order at the destination.

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Packet Switching: Virtual Circuit Switching

- Route is chosen at the start of session and it is only a logical connection.
- All Packets associated with a session follow the same path.
- Packets are labeled with a VC# designated the route.
- The VC number must be unique on a given link.
- Packets are forwarded more quickly. (No Routing Decisions)
- Example : Asynchronous Transfer Mode

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Circuit vs Packet Switching

Item	Circuit-switched	Packet-switched
Call setup	Required	Not needed
Dedicated physical path	Yes	No
Each packet follows the same route	Yes	No
Packets arrive in order	Yes	No
Is a switch crash fatal	Yes	No
Bandwidth available	Fixed	Dynamic
When can congestion occur	At setup time	On every packet
Potentially wasted bandwidth	Yes	No
Store-and-forward transmission	No	Yes
Transparency	Yes	No
Charging	Per minute	Per packet

Comparison of Circuit and Packet Switching

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Message Switching

- No physical path is set up between the sender and receiver.
- The whole message (or block of data) is sent to the switching office.
- Once it has been received, it is inspected for errors and is then sent to the next switching office.
- This method is not used anymore.

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ISDN

- Integrated Service Digital Network
- ITU Standard For global Digital Communication.
- It was Developed in 1984 to replace Analog Telephone System.
- Allow the Complete Integration of both Voice, Video and Data within a Single System.

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ISDN Features

- Support for switched and non-switched applications
  - both circuit-switched and packet-switched connections
  - also supports non-switched services in the form of dedicated lines
- Reliance on 64-kbps connections
  - fundamental block of ISDN
  - chosen because it was the standard rate for digitized voice

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- Intelligence in the network
  - sophisticated services beyond simple setup a circuit-switched call
  - sophisticated network management and maintenance capabilities
- Layered protocol architecture
  - user access to ISDN protocol is a layered architecture that can be mapped to OSI model
    - Already developed standards for OSI may be used for ISDN (e.g. X.25)
    - New ISDN standard can be based on existing ones (LAPD based on LAPB)
    - Standards can be developed independently for various layers and functions

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- Variety of configurations
  - More than one physical configuration is possible for implementing ISDN

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ISDN Channels

- B-channel
  - 64 kbps
  - basic user channel
  - can carry digital data, PCM-encoded digital voice, or a mixture of lower-rate traffic
  - supports circuit-switched, packet-switched
- D-channel
  - 16 or 64 kbps
  - carries signaling information to control circuit switched calls on B-channel
    - ➢who is calling
    - ➢type of call
    - ➢calling what number

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- H-channel
  - 384 (H0), 1536 (H11), 1920 (H12) kbps
  - 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

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ISDN Interfaces

- Also called ISDN Service Types
- Basic Rate Interface(BRI)
  - 2B channels + 1 D channel
  - 2 × 64 + 16= 144 kbps (192 kbps total)

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- Primary Rate Interface(PRI)
  - Especially for LAN
  - T1 connection: 23B+D
    - ➢American Standards
    - ➢Data rate 23*64Kbps + 64Kbps + 8bits header
    - ➢Information = 1544kbs = 1.544Mbps
  - E1 Connection: 30B+D
    - ➢European Standards
    - ➢30*64Kbps + 64Kbps +64Kbps
    - ➢2048Kbps=2.048Mbps
    - ➢Last D channel for Framing and Synchronization in E1 Connections

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Thank you!!!!

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