Module 5 - Cabling the LAN

Computer Networks I

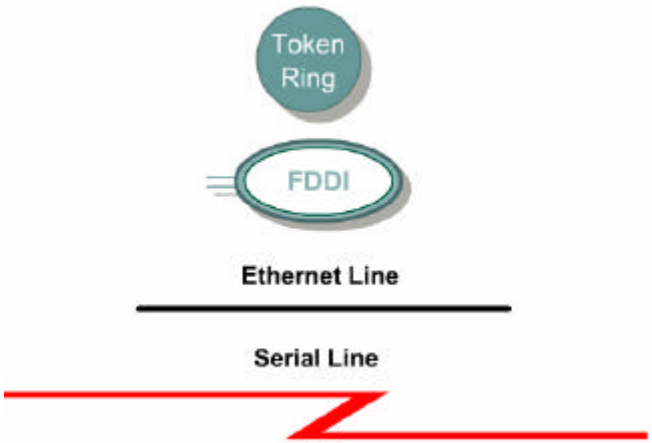
Objectives

Students completing this module should be able to:

- Identify characteristics of Ethernet networks.
- Describe the function of peer-to-peer networks.
- Describe and differentiate between serial, Integrated Services Digital Network (ISDN), digital subscriber line (DSL), and cable modem WAN connections.
- Identify router serial ports, cables, and connectors.
- Identify and describe the placement of equipment used in various WAN configurations.
- Describe the function, advantages, and disadvantages of repeaters, hubs, bridges, switches, and wireless network components.
- Describe the function, advantages, and disadvantages of client-server networks.

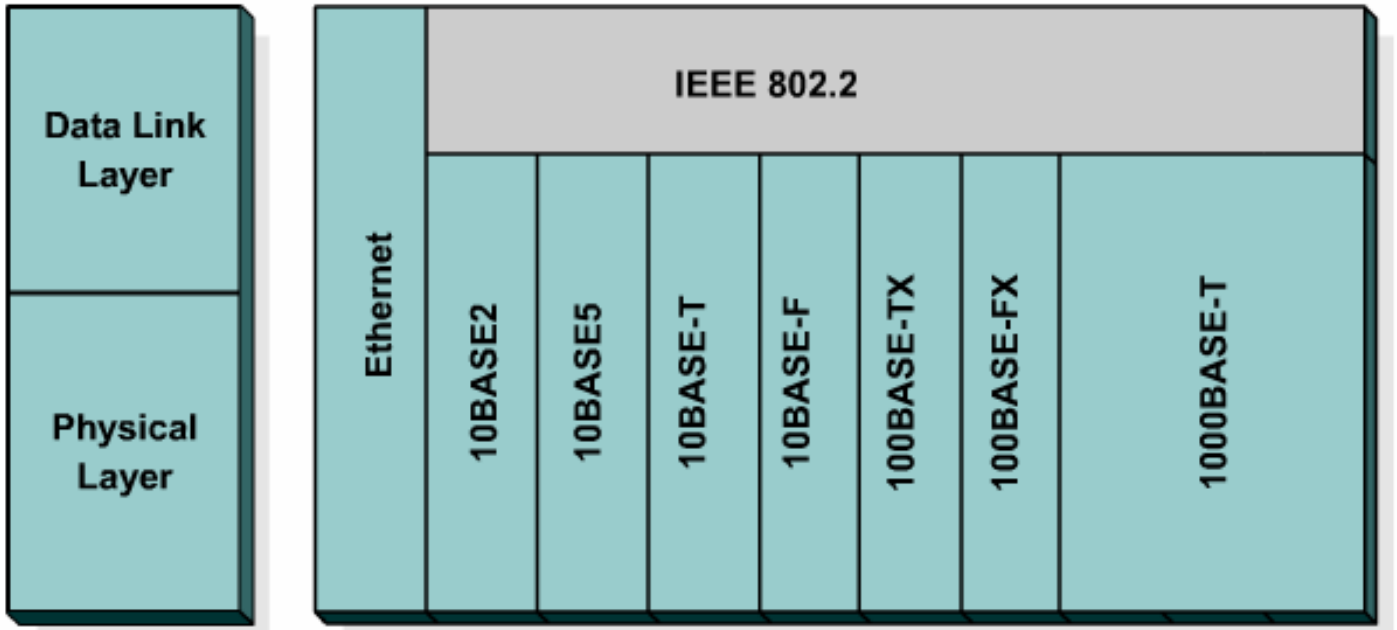
LAN physical layer

- Various symbols are used to represent media types
  - Token Ring is represented by a circle.
  - Fiber Distributed Data Interface (FDDI) is represented by two concentric circles
  - Ethernet is represented by a straight line.
  - Serial connections are represented by a lightning bolt.
- Networking media are considered Layer 1, or physical layer, components of LANs.
- Each media has advantages and disadvantages in the areas of:
  - Cable length
  - Cost
  - Ease of installation
  - Susceptibility to interference



LAN physical layer

- The figure shows a subset of physical layer implementations that can be deployed to support Ethernet.
- The principal medium that will be studied is Category 5 unshielded twisted-pair cable (Cat 5 UTP).



Standardized by Institute of Electrical and Electronics Engineers (IEEE) in	Digital, Intel, Xerox, (DIX) Standard	802.3 Specifications for 10-Mbps Ethernet	802.3u Specifications for 100-Mbps (Fast) Ethernet	802.3z Specifications for 1000-Mbps (Gigabit) Ethernet
	(First Imple-mentation)			802.3ab (Gigabit Ethernet over UTP).

Ethernet in the campus

	Ethernet 10BASE-T Implementation	Fast Ethernet Implementation	Gigabit Ethernet Implementation
End-user Level (End-user device to workgroup device)	Provides connectivity for low-to medium-volume applications.	Gives high-performance PC workstations 100-Mbps access to the server.	Not typically used at this level.
Workgroup Level (Workgroup device to backbone)	Not typically used at this level.	Provides connectivity between the end user and workgroups. Provides connectivity from the workgroup to backbone. Provides connectivity from the server block to the backbone layer.	Provides high-performance connectivity to the enterprise server block.
Backbone Level	Not typically used at this level.	Provides connectivity from the workgroup server block to the backbone.	Provides high-speed backbone and network device connectivity.

Ethernet media and connector requirements

	10BASE2	10BASE5	10BASE-T	100BASE-TX	100BASE-FX	1000BASE-CX	1000BASE-T	1000BASE-SX	1000BASE-LX
Media	50-ohm coaxial (Thinnet)	50-ohm coaxial (Thicknet)	EIA/TIA Category 3, 4, 5 UTP, two pair	EIA/TIA Category 5 UTP, two pair	62.5/125 multimode fiber	STP	EIA/TIA Category 5 UTP, four pair	62.5/50 micro multimode fiber	62.5/50 micro multimode fiber; 9-micron single-mode fiber
Maximum Segment Length	185 m (606.94 feet)	500 m (1640.4 feet)	100 m (328 feet)	100 m (328 feet)	400 m (1312.3 feet)	25 m (82 feet)	100 m (328 feet)	275 m (853 feet) for 62.5 micro fiber; 550 m (1804.5 feet) for 50 micro fiber	440 m (1443.6 feet) for 62.5 micro fiber; 550 m (1804.5 feet) for 50 micro fiber; 3 to 10 km (1.86 to 6.2 miles) on single-mode fiber
Topology	Bus	Bus	Star	Star	Star	Star	Star	Star	Star
Connector	BNC	Attachment unit interface (AUI)	ISO 8877 (RJ-45)	ISO 8877 (RJ-45)	Duplex media interface connector (MIC) ST or SC connector	ISO 8877 (RJ-45)	ISO 8877 (RJ-45)	SC connector	SC connector

- Standardized in EIA/TIA-568 Commercial Building Telecommunications
- Wiring Standards by Electronic Industries Association and the Telecommunications Industry Association (EIA/TIA) standards body.

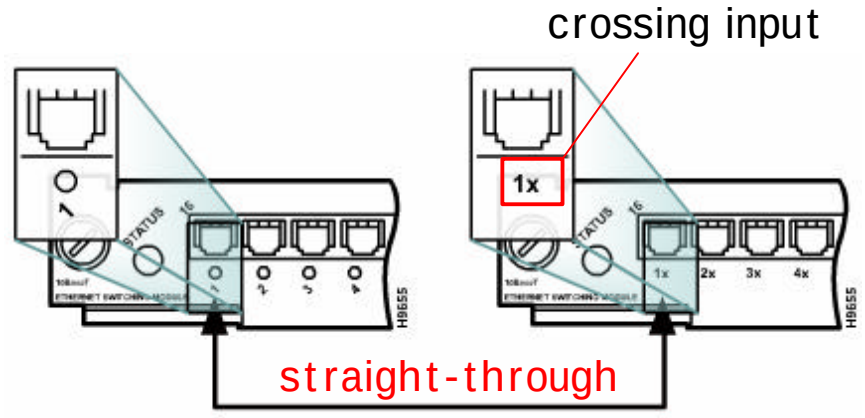
Connection media

- The registered jack (RJ-45) connector and jack are the most common.
- Also in use are 15-pin Attachment Unit Interface (AUI) connectors. An AUI allows to connect to different media with the appropriate transceiver.
- A transceiver is an adapter that converts one type of connection interface to another. Typically, a transceiver converts an AUI to RJ-45, coax, or fiber optic connector.

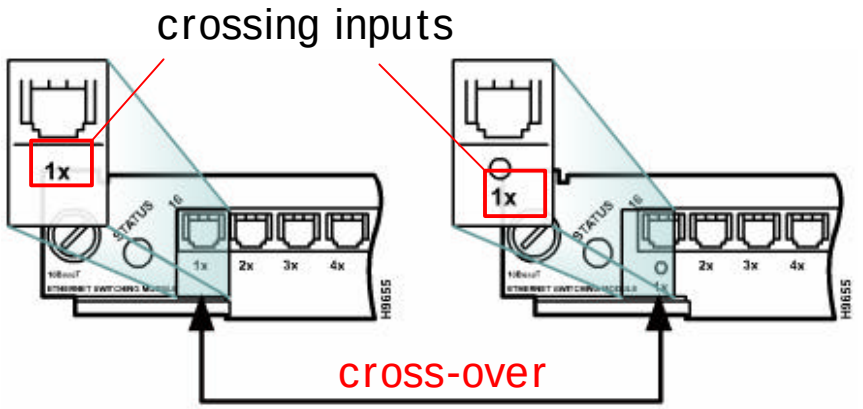
UTP implementation

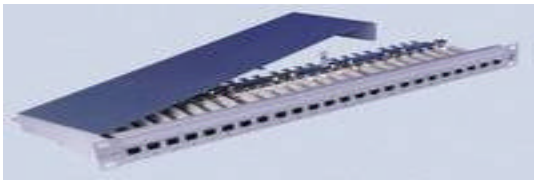
- EIA/TIA specifies an RJ-45 connector for UTP cable (RJ: **R**egistered **J**ack . 45 refers to a specific wiring sequence)

Punch-down connector



Wall outlet



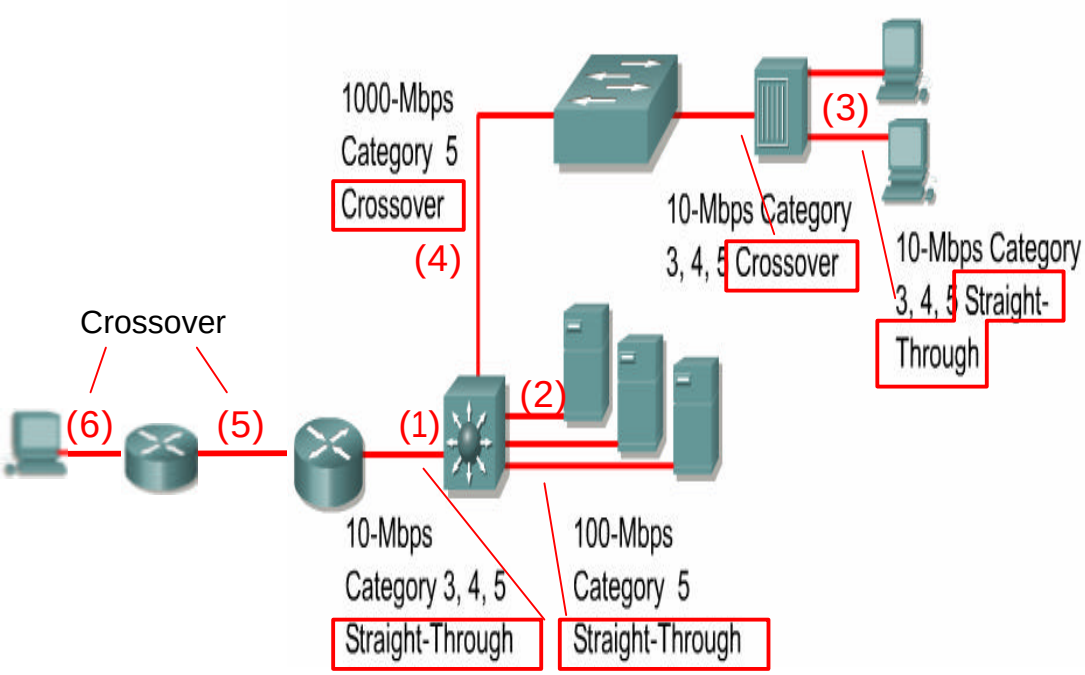


Patch panel

UTP implementation

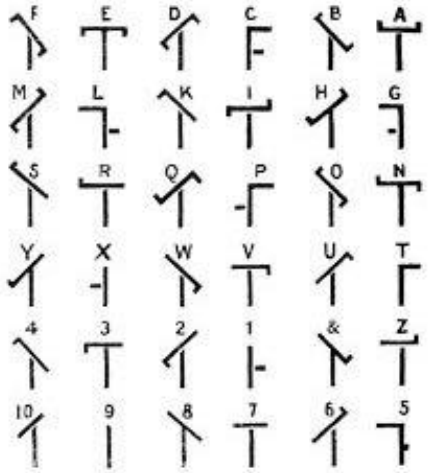
- Use straight-through cables for the following cabling:
  - Switch to router (1)
  - Switch to PC or server (2)
  - Hub to PC or server (3)
- Use crossover cables for the following cabling:
  - Switch to switch (4)
  - Switch to hub
  - Hub to hub
  - Router to router (5)
  - PC to PC
  - Router to PC (6)

The category of UTP cable required is based on the type of Ethernet that is chosen.



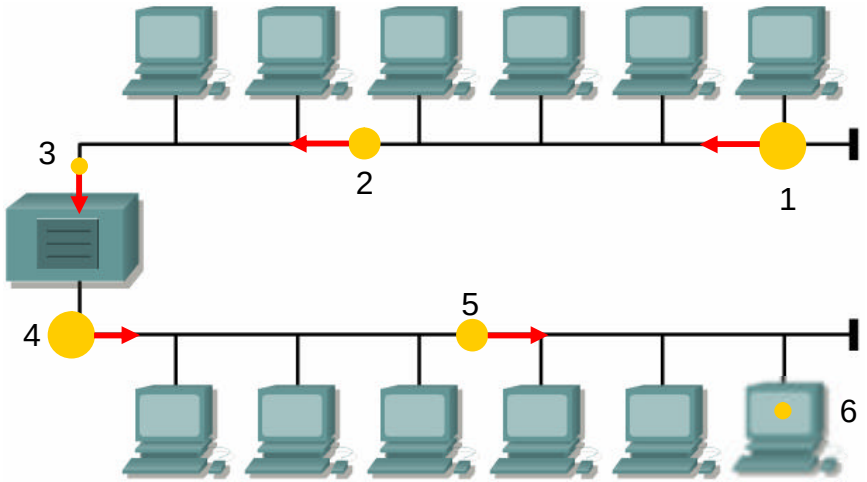
Repeaters

- A repeater receives a signal, regenerates it, and passes it on.
- It can regenerate and retime network signals at the bit level, to allow longer transmission distance on the media.
- The Four Repeater Rule for 10-Mbps Ethernet states that no more than four repeaters can be used between hosts on a LAN. This rule is used to limit latency added by each repeater.
- Too much latency on the LAN increases the number of late collisions (coming) and makes the LAN less efficient.



Napoleon's Secret Weapon: Chappe Telegraph

2-port 10Base2 Ethernet Repeater



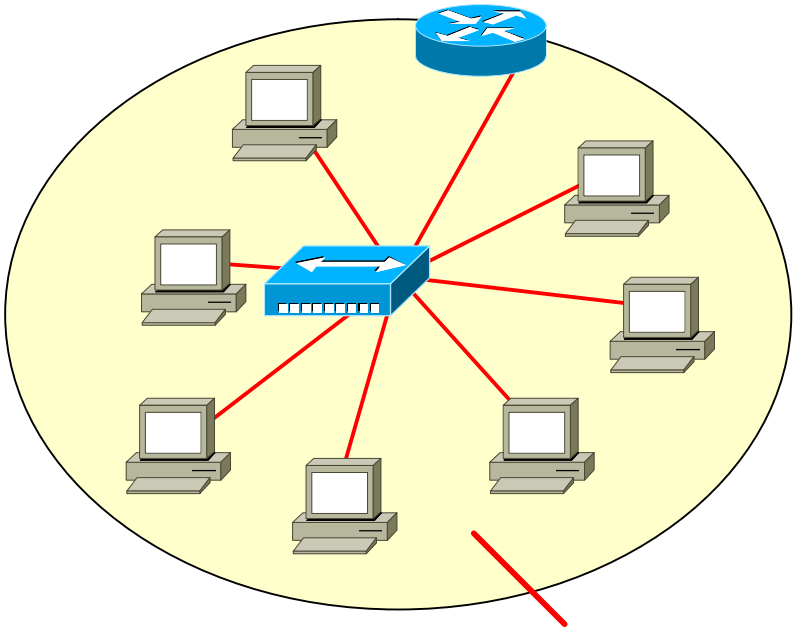
Hubs

- A typical repeater has just 2 ports. a hub generally has from 4…24 ports. Hubs are actually multiport repeaters.
- Hubs are most commonly used in Ethernet 10BASE-T or 100BASE-T networks.
- Using a hub creates a star network topology.
- A hub repeates signals on all its other ports except for the port on which the data was received
- Hubs come in three basic types:

- **Passive Hub**
  - does not boost or clean the signal.
  - is used only to share the physical media
  - does not need electrical power.
- **Active Hub**
  - needs power to regenerate the incoming signal before passing it out to the other ports.
- **Intelligent Hub**
  - are sometimes called smart hubs.
  - function as active hubs, but also include a microprocessor chip and diagnostic capabilities.
  - are more expensive than active hubs, but are useful in troubleshooting situations.

Hubs and Collisions

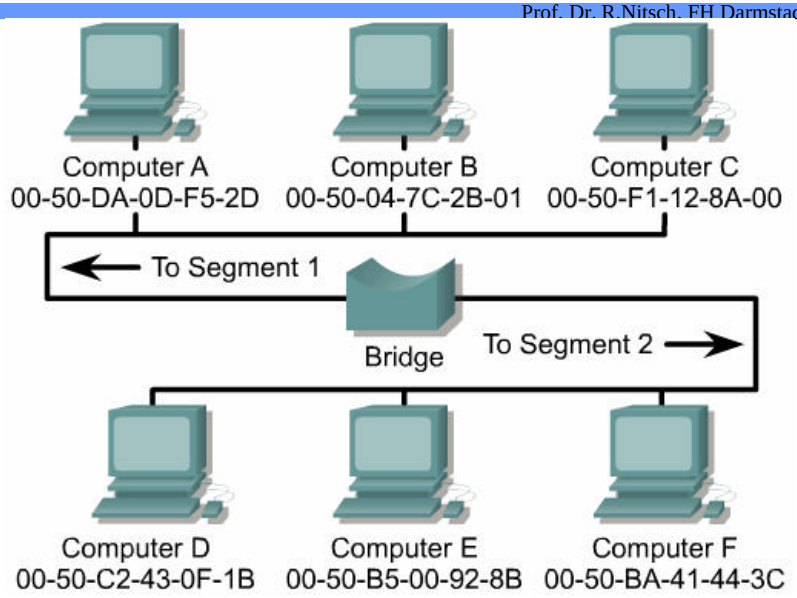
- Devices attached to a hub receive all traffic traveling through the hub.
- The more devices there are attached to the hub, the more likely there will be collisions.
- A collision occurs when two or more workstations send data over the network wire at the same time.
- All data is corrupted when a collision occurs.
- Every device connected to the same network segment is said to be a member of that collision domain.
- Sometimes hubs are called concentrators, because hubs serve as a central connection point for an Ethernet LAN.



1 Ethernet segment
1 Collision Domain

Bridges

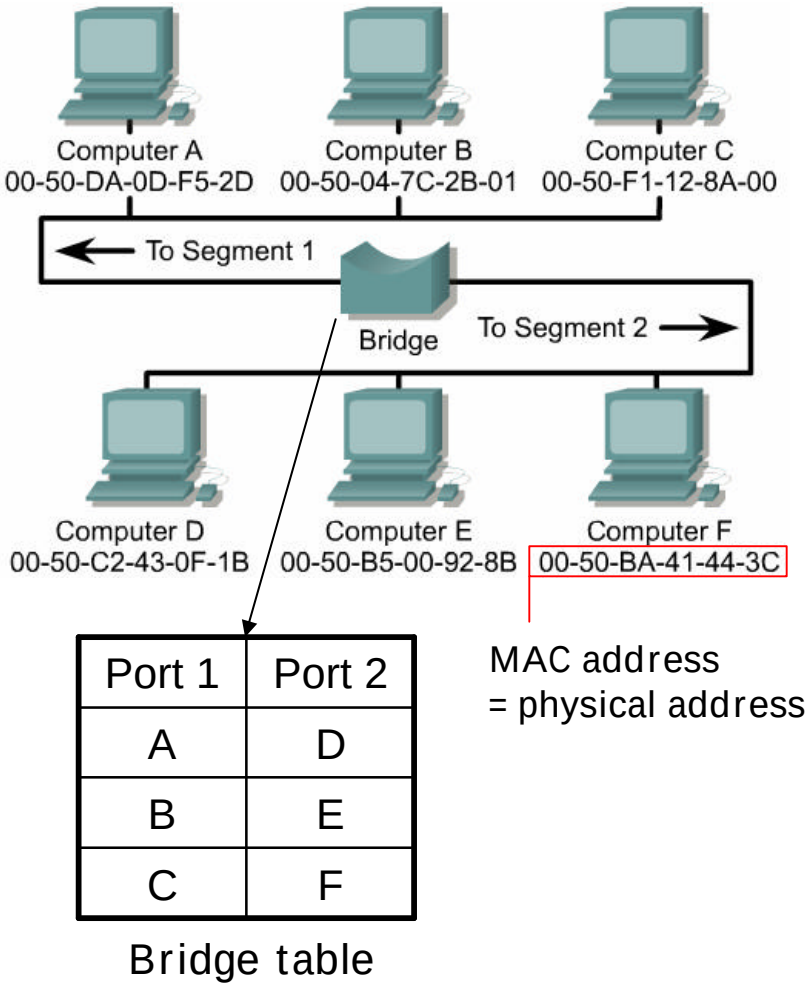
- Bridges break up a large LAN into smaller, more easily managed LAN segments.
- This decreases the amount of traffic on a single segment and extends the geographical area past what a single segment can support.
- Network segments can also be connected by switches, routers, and gateways.
- Switches and bridges operate at the Data Link layer of the OSI model.
- Bridge (as well as switches) make intelligent decisions based on their MAC table about whether or not to pass signals on to the next segment of a network (coming).



Bridges: Working Principle ▸

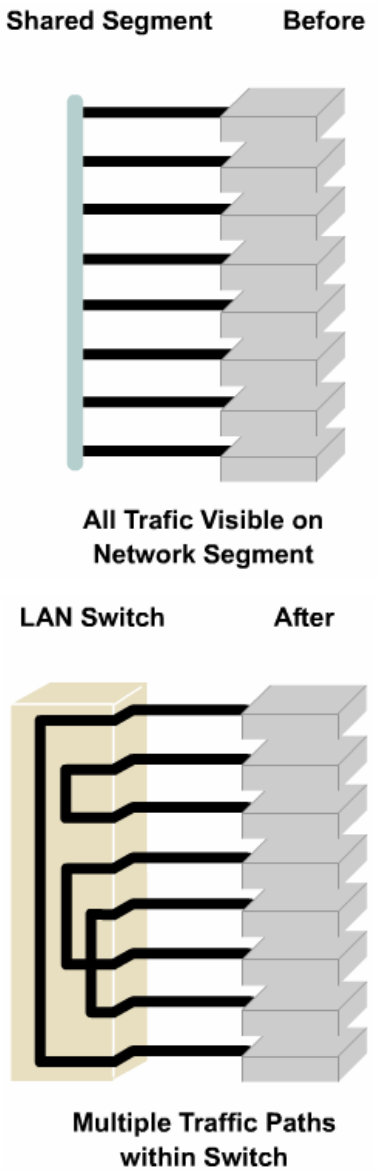
Bridges: Working Principle

- When a bridge receives a frame on the network, the destination MAC address is looked up in the bridge table to determine whether to filter (discard), flood, or copy the frame onto another segment.
- This decision process occurs as follows:
  - If the destination device is on the same segment as the frame, the bridge blocks (filters) the frame from going on to other segments.
  - If the destination device is on a different segment, the bridge forwards the frame to the appropriate segment.
  - If the destination address is unknown to the bridge (not in the bridge table), the bridge forwards the frame to all segments except the one on which it was received. This process is known as flooding.



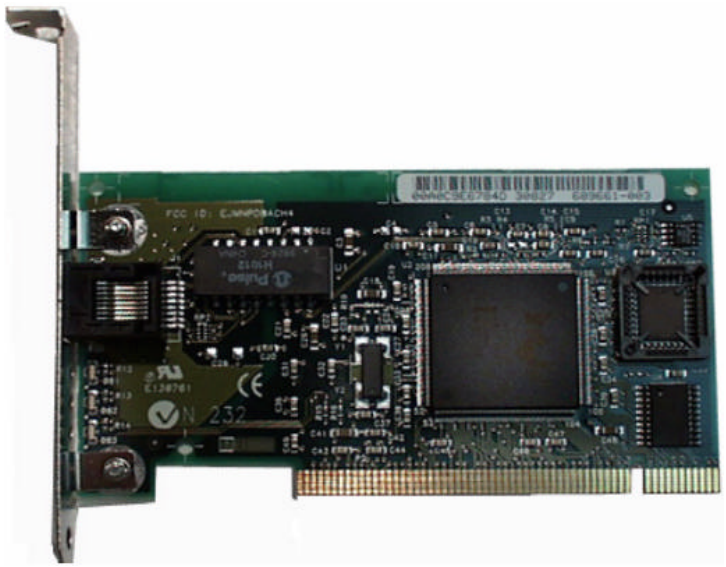
Switches

- A switch is like a multiport bridge.
- Like bridges, switches learns the MAC addresses of active devices connected to its ports. It is a OSI Layer-2 device.
- Switches use this information to build forwarding tables (similar to bridge tables)
- Switching lessens congestion in Ethernet LANs by reducing the traffic and increasing the bandwidth.
- Switches can easily replace hubs because switches work with existing cable infrastructures.
- All switching equipment performs two basic operations:
  1. Switching data frames: a process by which a frame is received on an input medium and then transmitted to an output medium.
  2. Build and maintain switching tables and search for loops.
- Switches operate at much higher speeds than bridges and can support new functionality, such as virtual LANs.
- an Ethernet switch allows many users to communicate in parallel through the use of virtual circuits and dedicated network segments in a virtually collision-free environment.
- This maximizes the bandwidth available on the shared medium.



Host Connectivity

- NIC connect a host device to the network
- NICs are considered Layer 2 devices because each NIC carries a unique code called a MAC address.
- In diagrams, NICs have no standardized symbol. Wherever a dot is seen on a topology map, it represents either a NIC interface or port, which acts like a NIC.



Wireless

- Wireless networks use Radio Frequency (RF), laser, infrared (IR), or satellite/microwaves to carry signals from one computer to another without a permanent cable connection.
- Commonly used in mobile applications. Examples of mobile use include commuters, airplanes, satellites, remote space probes, space shuttles, and space stations.
- Core devices are called transmitters and receivers. For two-way communication, each device requires a transmitter and a receiver which usually are build into a single device called transceiver.
- The two most common wireless technologies used for networking are IR and RF.
- Weaknesses of IR technology:
  - Workstations and digital devices must be in the line of sight of the transmitter
  - All digital devices of the IR network must be in one room.
  - IR signals can get weakened or obstructed by people walking across the room or by moisture in the air.

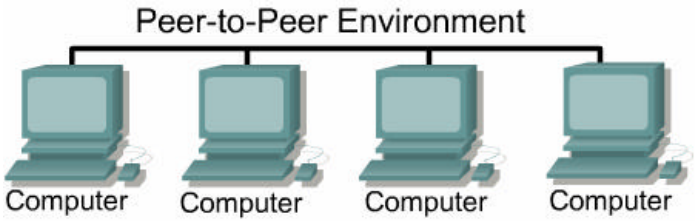
Wireless with Radio Frequencies

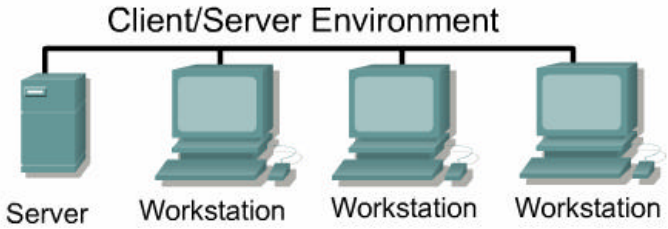
- Radio Frequency technology allows devices to be in different rooms or even buildings.
- Use is restricted by limited range of radio signals.
- RF technology can be on single or multiple carrier frequencies.
  - A single radio frequency is
    - subject to outside interference and geographic obstructions.
    - easily monitored by others, which makes the transmissions of data insecure.
- Spread spectrum technique avoids these problems by using multiple frequencies to increase the immunity to noise and to make it difficult for outsiders to intercept data transmissions. Two approaches currently being used for WLAN transmissions
  - Frequency Hopping Spread Spectrum (FHSS) and
  - Direct Sequence Spread Spectrum (DSSS).
- The technical details of how these technologies work are beyond the scope of this course.

Peer-to-Peer Networks

- Networked computers take on different roles or functions in relation to each other.
  - Some types of applications require computers to function as equal partners (peers).
  - Other types of applications distribute their work so that one computer (server) functions to serve a number of others (clients) in an unequal relationship.

- Peer-to-peer network:
  - Computers act as equal partners, or peers.
  - Each computer can take on the client function or the server function.
  - Users control their own resources (shared files, required passwords,…). There is no central point of control or administration
  - Are relatively easy to install and operate.
  - Works well with 10 or fewer computers.
  - Do not scale well





Advantages

Less expensive to implement.
Does not require additional specialized network administration software
Does not require a dedicated network administrator.

Disadvantages

Does not scale well to large networks and administration becomes unmanageable.
Each user must be trained to perform administrative tasks.
Less secure.
All machines sharing the resources negatively impact the performance.

Client/Server Network

- Network services are located on a dedicated computer called a server.
- clients request - server responds: Servers are designed to handle requests from many clients simultaneously.
- The server is a central computer with additional processing power, memory, and specialized software that is continuously online.
- Before a client can access the server resources, the client must be identified and be authorized to use the resource.
- Usually each user on clients is assigned an account name and password.
- Identification (by username) and authentication (by password) is verified by an authentication service.
- Centralization of user accounts, security, and access control, server-based networks simplify the administration of large networks.
- The concentration of files and applications on servers makes back-up and maintenance an easier job.

Advantages

Provides for better security.
Easier to administer when the network is large because administration is centralized.
All data can be backed up on one central location.

Disadvantages

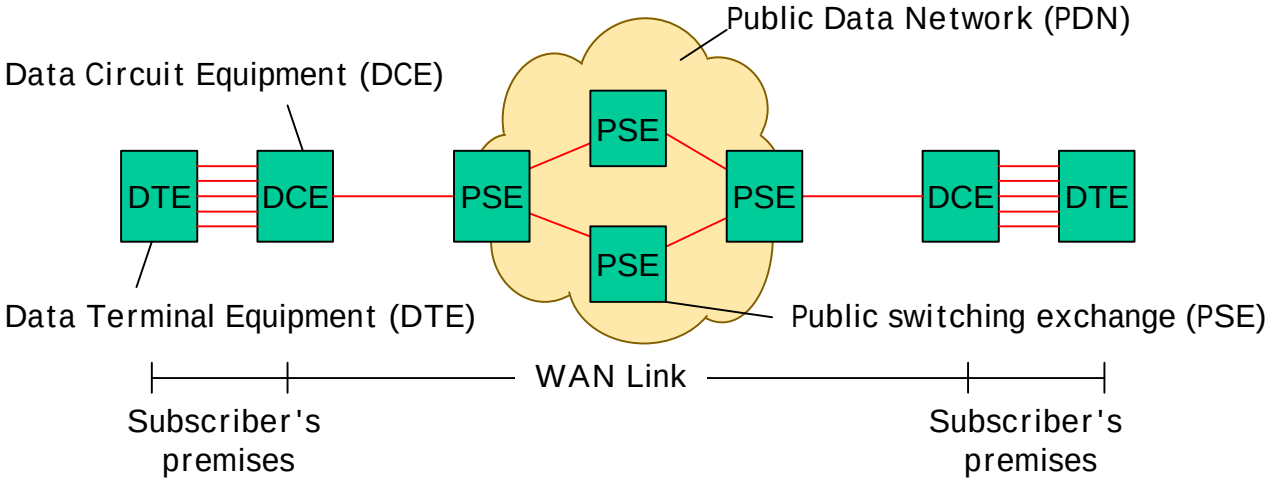
Requires expensive specialized network administrative and operational software
Requires expensive, more powerful hardware for the server machine.
Requires a professional administrator.
Has a single point of failure. User data is unavailable if the server is down.

WAN Physical Layer

- Physical layer implementations vary depending on the distance, the speed, and the type of service itself.
- Serial connections are used to support WAN services such as dedicated leased lines that run Point-to-Point Protocol (PPP) or Frame Relay.
- Speeds: 2400 bps (Modem) ; 1544 kbps (T1); 2.048 kbps (E1), ...
- ISDN:
  - offers dial-on-demand connections or dial backup services.
  - ISDN Basic Rate Interface (BRI) offers two 64 kbps bearer channels (B channels) for data, and one delta channel (D channel) at 16 kbps used for signaling and other link-management tasks.
- DSL service can achieve T1/E1 speeds over the existing telephone line.
- Cable services use cable modems and the existing coaxial cable TV line.

Wide Area Networks - DTE/DCE

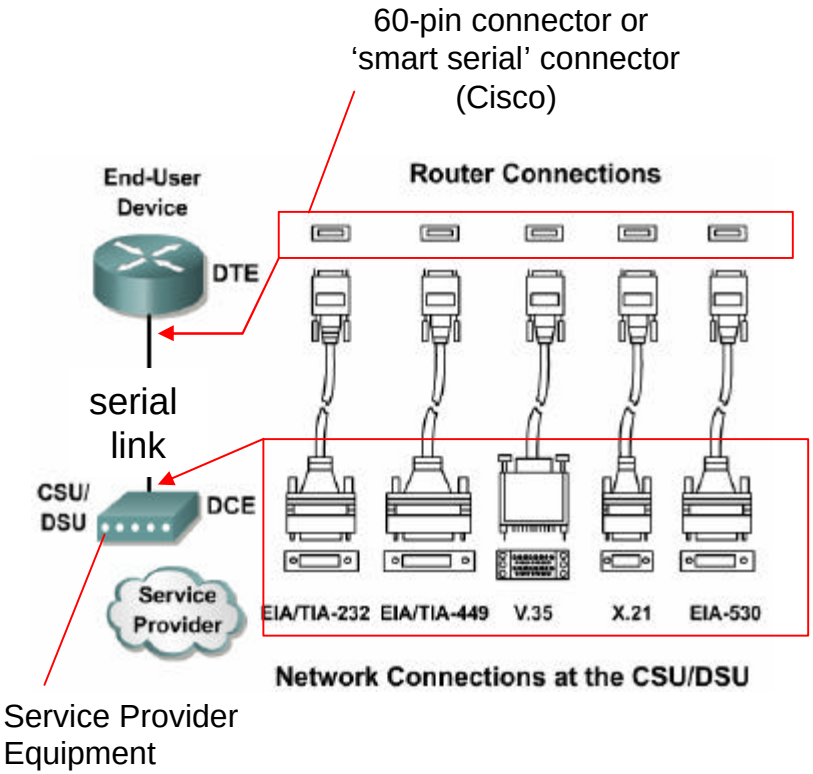
- Wide Area Networks (WANs) are networks that link DTEs or LANs over long physically distances.

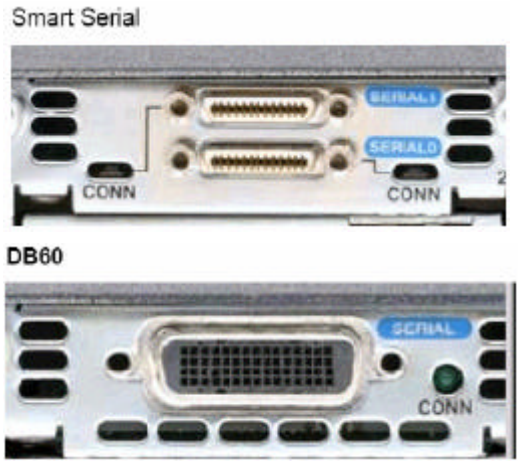


- The DCE provides full-duplex, bit-serial, synchronous transmission between DTE and local PSE.
- All wires in a cable for DTE to DCE communication go straight from pin x to pin x. But wiring a cable for DTE to DTE (nullmodem cable) or DCE to DCE requires that some wires are crossed.
- DCEs are responsible for clocking. They provide clocking signals to determine the data transmission rate. DTEs receive and process the clocking signals from the DCEs.
- DCE is used as a generic term for modems, channel/data service units (CSU/DSU), Multiplexers.
- DTE is used as a generic term for NICs, Hubs, Switches and Bridges. Routers are configured by software to act as DTE or DCE.

WAN Physical Interface Standards

- Physical layer standards define
  - the form of the electrical signals to be used,
  - The complete range of additional signals that control the order and timing of data transfer across the appropriate interface.
  - Type of transmission media
  - suggested transmission distances
  - guaranteed maximum transmission distances
  - Type and dimension of the connectors.
- Standards in common use are EIA/TIA-232, EIA/TIA-449, V.35, X.21, EIA-530,...

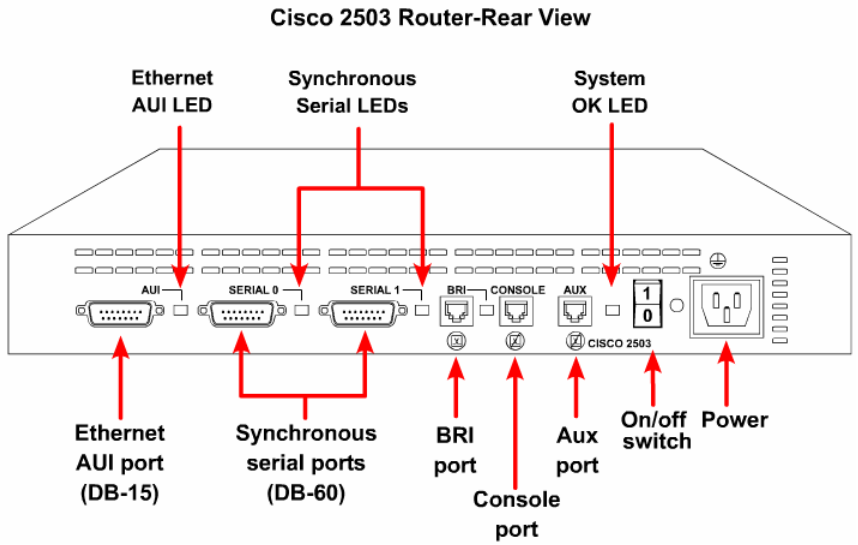


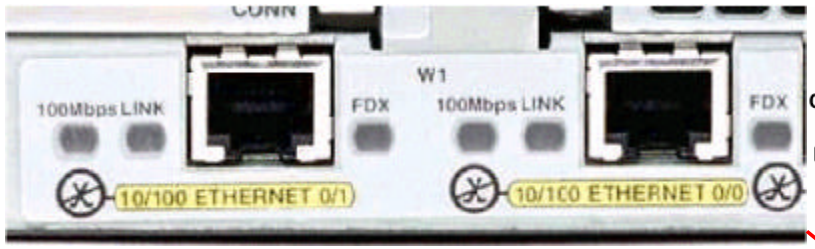


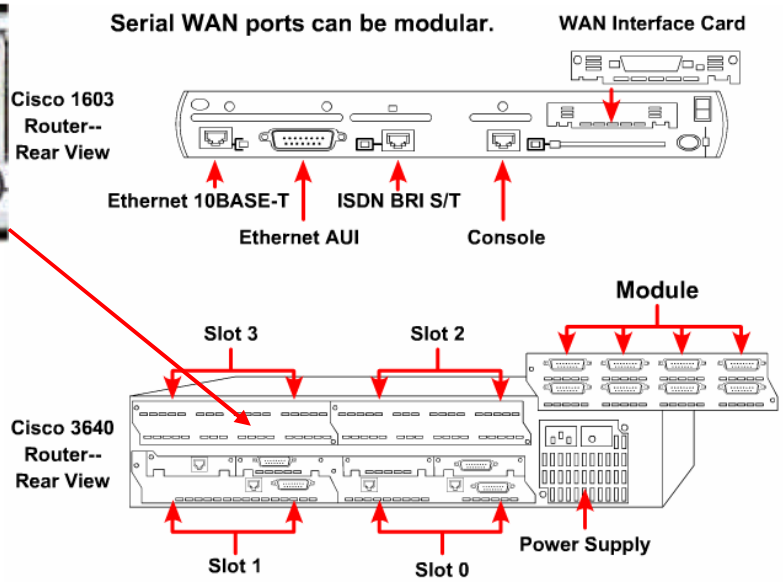
Data (bps)	Distance (Meters) EIA/TIA-232	Distance (Meters) EIA/TIA-449
2400	60	1250
4800	30	625
6900	15	312
19,200	15	156
38,400	15	78
115,200	3.7	—
T1 (1.544 Mbps)	—	15

Routers and their interfaces

- Routers are responsible for providing connectivity to the WAN.
- Routers will either have fixed or modular ports.
- The type of port being used will affect the syntax used later to configure each interface

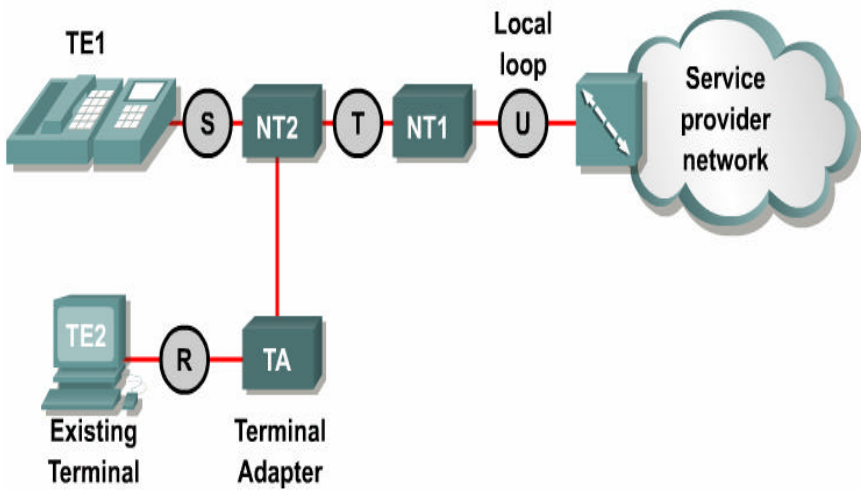






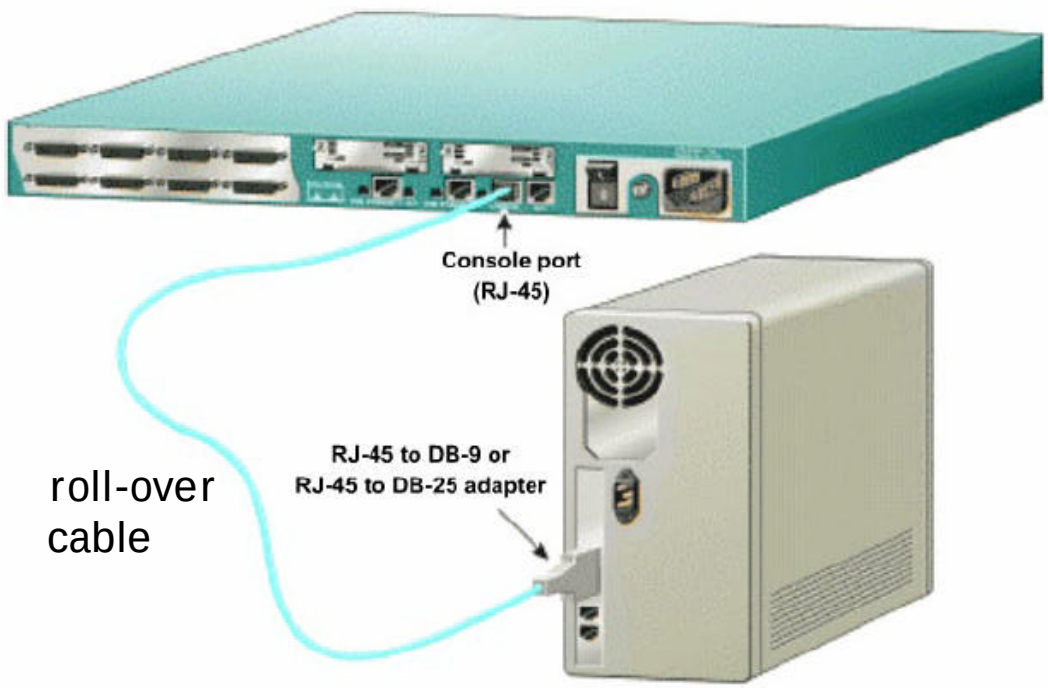
Routers and ISDN Interfaces

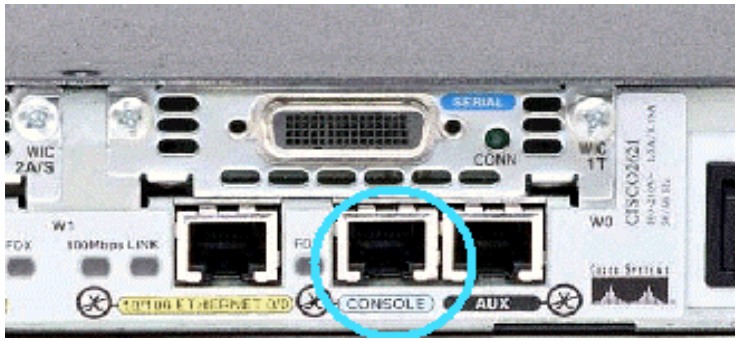
- Routers provide two types of ISDN interfaces: BRI S/T and BRI U. Determine who is providing the Network Termination 1 (NT1) device in order to determine which interface type is needed.
- An NT1 is an intermediate device located between the router and the service provider ISDN switch.
- The NT1 is used to connect four-wire subscriber wiring to the conventional two-wire local loop.
- In North America, the customer typically provides the NT1, while in the rest of the world the service provider provides the NT1 device.
- To interconnect the ISDN BRI port to the service-provider device, use a UTP Category 5 straight-through cable.



Setting up console connections

- The console port allows monitoring and configuration of a Cisco hub, switch, or router.
- The cable used between a terminal and a console port is a rollover cable, with RJ-45 connectors.
- Next, configure the terminal emulation application (Hyperterminal) with the following common equipment (COM) port settings: 9600 bps, 8 data bits, no parity, 1 stop bit, and no flow control.
- The AUX port is used to provide out-of-band management through a modem. Configuration settings for AUX and COM port are identical.





Summary

- A network interface card (NIC) provides network communication capabilities to and from a PC.
- Use a crossover cable to connect between two similar devices, such as switches, routers, PCs, and hubs.
- Use a straight-through cable to connect between different devices, such as connections between a switch and a router, a switch and a PC, or a hub and a router.
- There are two major types of LANs, peer-to-peer and client/server.
- WANs use serial data transmission. WAN connection types include ISDN, DSL, and cable modems.
- A router is usually the DTE and needs a serial cable to connect to a DCE device like a CSU/DSU.
- The ISDN BRI has two types of interfaces, S/T and U interfaces. To interconnect the ISDN BRI port to the service-provider device, a UTP Category 5 straight-through cable with RJ-45 connectors, is used.
- A phone cable and an RJ-11 connector are used to connect a router for DSL service.
- Coaxial cable and a BNC connector are used to connect a router for cable service.
- Rollover cable is used to connect a terminal and the console port of an internetworking device.