

Lecture (03)

Ethernet Protocol & Network Hardware Components

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Agenda

- Ethernet Protocol/ and cable types
- Network interface card
- Network nodes
- Servers
- Clients
- Storage area network
- Network printers

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Ethernet Protocol

- The first two layers of the OSI model deal with the physical structure of the network
- the most popular set of protocols for the Physical and Data Link layers is *Ethernet*.
- Ethernet is defined by the IEEE standard known as 802.3
- Various flavors of Ethernet operate at different speeds and use different types of media.

Application
Presentation
Session
Transport
Network
Data Link
Physical

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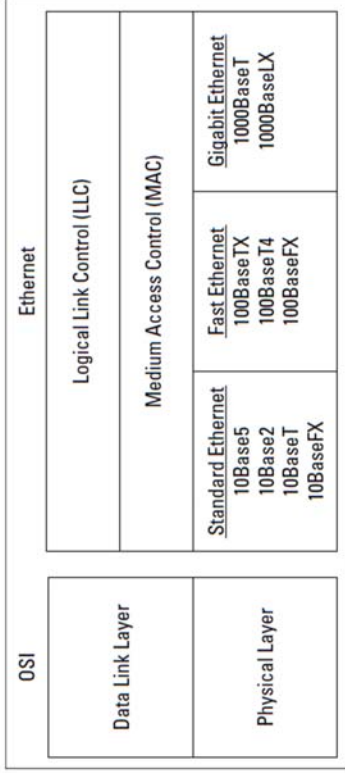
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- However, all the versions of Ethernet are compatible with each other, so you can mix and match them on the same network by using devices such as
 - bridges,
 - hubs, and
 - switches to
- link network segments that use different types of media.
- Ethernet comes in three different speed versions:
 - 10 Mbps, known as *Standard Ethernet*;
 - 100 Mbps, known as *Fast Ethernet*; and
 - 1,000 Mbps, known as *Gigabit Ethernet*

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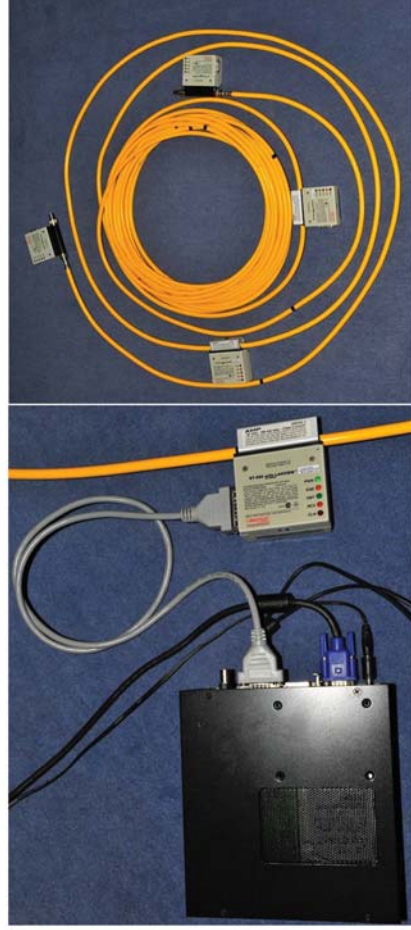
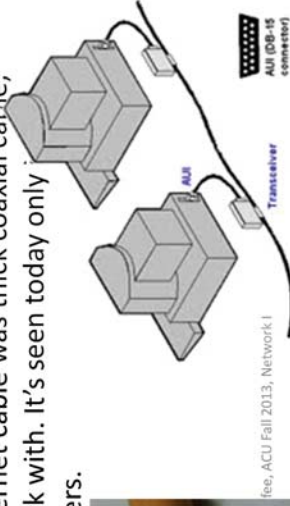
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- Ethernet divides the Data Link layer into two separate layers known as the *Logical Link Control (LLC) layer* and the *Medium Access Control (MAC) layer*.



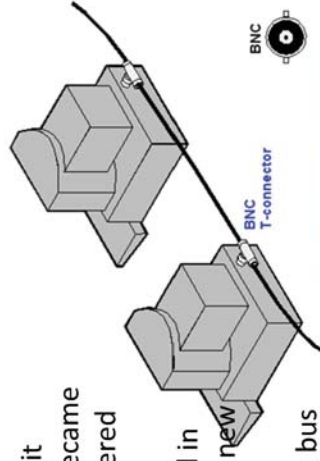
1. Standard Ethernet

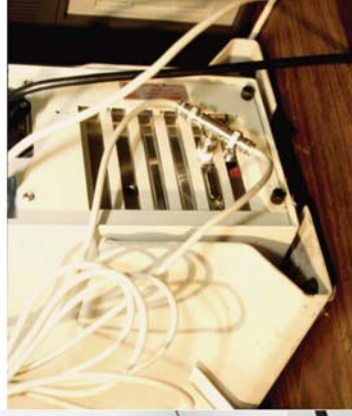
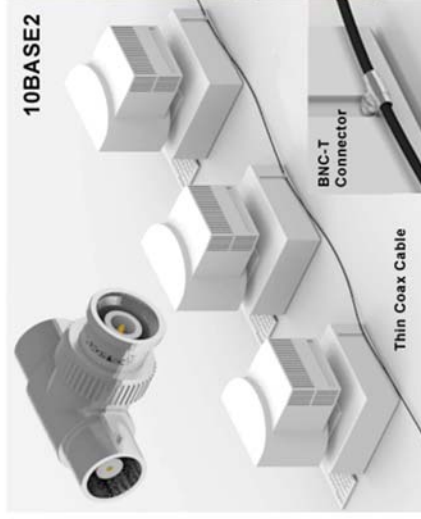
- the original Ethernet, it runs at 10 Mbps, considered fast in the 1970s but is pretty slow by today's standards
- Standard Ethernet comes in four types, depending on the type of cable used to string the network together:
- 10Base5:** The original Ethernet cable was thick coaxial cable, heavy, and difficult to work with. It's seen today only in museums. Up to 500 meters.



10Base2:

- thinner type of coaxial cable (it resembles television cable) became popular in the 1980s and lingered into the early 1990s.
- Plenty of 10Base2 cable is still in use, but it's rarely installed in new networks (up to 200 meters)
- 10Base2 (like 10Base5) uses a bus topology, so wiring a 10Base2 network involves running cable from one computer to the next until all the computers are connected in a segment.



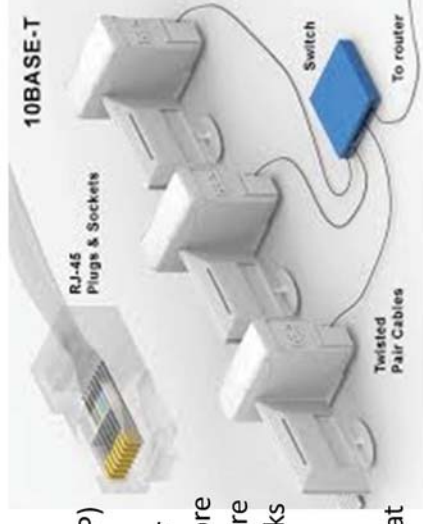


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• 10BaseT:

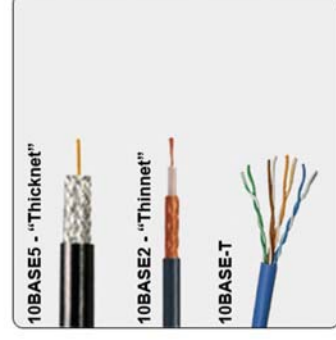
- Unshielded twisted-pair cable (also known as UTP) became popular in the 1990s because it's easier to install, lighter, and more reliable, and it offers more flexibility in how networks are designed.
- 10BaseT networks use a star topology with hubs at the center of each star.



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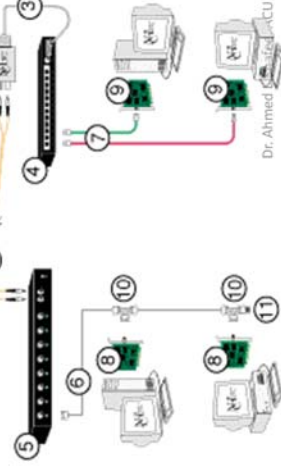
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- Although the maximum length of 10BaseT cable is only 100 meters, hubs can be chained together to extend networks well beyond the 100-meter limit.
- 10BaseT cable has four pairs of wires that are twisted together throughout the entire span of the cable.
- However, 10BaseT uses only two of these wire pairs, so the unused pairs are spares.



• 10BaseFL:

- Fiber-optic cables were originally supported at 10 Mbps by the 10BaseFL standard., up to 40 Km
- However, because faster fiber-optic versions of Ethernet now exist, 10BaseFL is rarely used.



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2. Fast Ethernet

- Fast Ethernet refers to Ethernet that runs at 100 Mbps
- The following are the three varieties of Fast Ethernet:
 - **100BaseT4:**
 - The 100BaseT4 protocol allows transmission speeds of 100 Mbps over the same UTP cable as 10BaseT networks.
 - To do this, it uses all four pairs of wire in the cable.
 - 100BaseT4 simplifies the task of upgrading an existing 10BaseT network to 100 Mbps.

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– 100BaseTX:

- The most commonly used standard for office networks today is 100BaseTX, which transmits at 100 Mbps over just two pairs of a higher grade of UTP cable than the cable used by 10BaseT.
- The higher grade cable is referred to as *Category 5*.
- *Most new networks are wired with Category 5 or better cable.*

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– 100BaseFX:

- The fiber-optic version of Ethernet running at 100 Mbps is called 100BaseFX.
- Because fiber-optic cable is expensive and tricky to install, it isn't used much for individual computers in a network.
- However, it's commonly used as a network *backbone*.
- *For example, a fiber backbone is often used to connect individual workgroup hubs to routers and servers.*

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3. Gigabit Ethernet

- Gigabit Ethernet is Ethernet running at 1,000 Mbps, which is 100 times faster than the original 10 Mbps Ethernet.
- today Gigabit Ethernet is the standard for nearly all desktop and laptop PCs.
- Gigabit Ethernet comes in two flavors:
- **1000BaseT**: Gigabit Ethernet run on a higher grades such as Category 5e or Category 6 are preferred because they're more reliable.
- **1000BaseLX**: Several varieties of fiber cable are used with Gigabit Ethernet, but the most popular is called 1000BaseLX.

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Coaxial cable

- operates only at 10 Mbps and is rarely used for new networks.
- With coaxial cables, you connect your computers point-to-point in a bus topology.
- At each computer, a T connector is used to connect two cables to the network interface card.
- A special plug called a *terminator* is required at each end of a series of coax cables.



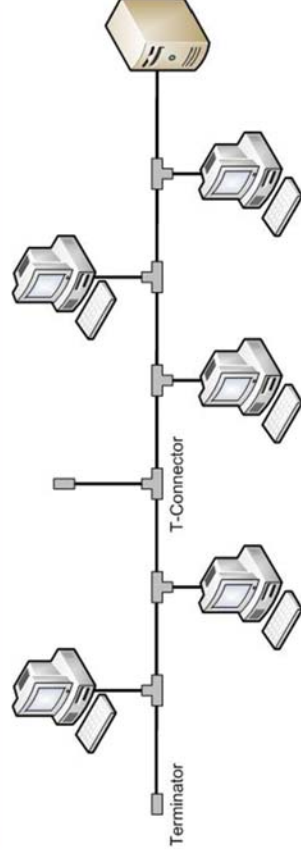
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- The cables end-to-end from one terminator to the other are called a *segment*
- The maximum length of a coax segment is about 200 meters (actually, 185 meters).
- You can connect as many as 30 computers on one segment.
- To span a distance greater than 200 meters or to connect more than 30 computers, you must use two or more segments with a device called a *repeater* to connect each segment.

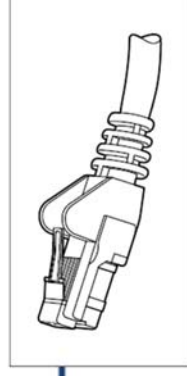


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- **Twisted-pair cable**
- The most popular twisted pair cable is *unshielded twisted pair (UTP)*
- When using UTP cable in Ethernet network, computers arranged in a star topology.
- UTP cable consists of pairs of thin wire twisted around each other; several such pairs are gathered up inside an outer insulating jacket.
- UTP cable comes in various grades called *Categories*
- Most networks are cabled with Category 5 cable, which is fine for 100Mbps networks but isn't rated for Gigabit networks.
- Category 5e cable (the e stands for enhanced) and Category 6 cable will support 1,000 Mbps networks.



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- UTP cable connectors look like modular phone connectors but are a bit larger.
- UTP connectors are officially called *RJ-45 connectors*.
- The maximum allowable cable length between the hub and the computer is 100 meters

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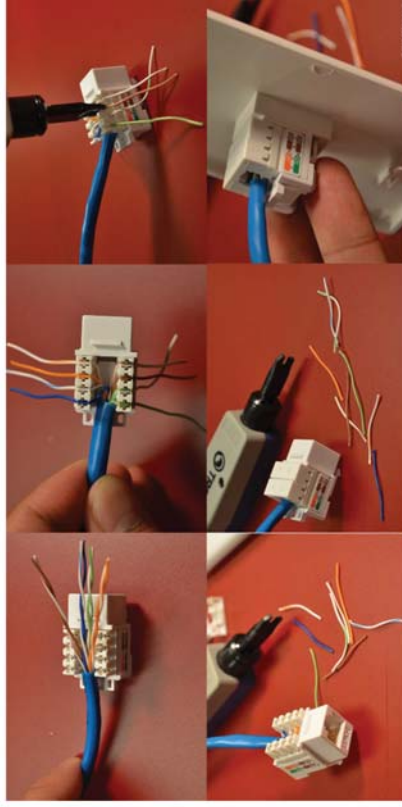
Cat and Data Rate

- **Twisted-Pair Cable Categories**

Category	Maximum Data Rate	Intended Use
1	1 Mbps	Voice only
2	4 Mbps	4 Mbps Token Ring
3	16 Mbps	10BaseT Ethernet
4	20 Mbps	16 Mbps Token Ring
5	100 Mbps (2 pair)	100BaseT Ethernet
	1,000 Mbps (4 pair)	Gigabit Ethernet
5e	1,000 Mbps (2 pair)	Gigabit Ethernet
6	1,000 Mbps (2 pair)	Gigabit Ethernet
6a	10,000 Mbps	10 gigabit (experimental)
7	10,000 Mbps	10 gigabit (experimental)

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- **UTP & STP**

- *Unshielded twisted-pair* cable, or *UTP*, is designed for normal office environments
- In environments that have a lot of electrical interference, such as factories, you may want to use *shielded twisted-pair* cable, also known as *STP*.
- Most STP cable is shielded by a layer of aluminum foil.
- For buildings with unusually high amounts of electrical interference, you can use more expensive, braided copper shielding for even more **protection**.

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- **PVC and Plenum**

- *PVC* cable is the most common and least expensive type.
- *Plenum cable* is a special type of fire-retardant cable that is designed for use in the plenum space of a building.
- Plenum cable has a special Teflon coating that not only resists heat, but also gives off fewer toxic fumes if it does burn.
- a suspended ceiling is *not* a plenum space if both the delivery and return lines of the air-conditioning and heating system are ducted.
- Plenum cable is required only if the air-conditioning and heating system are not ducted.

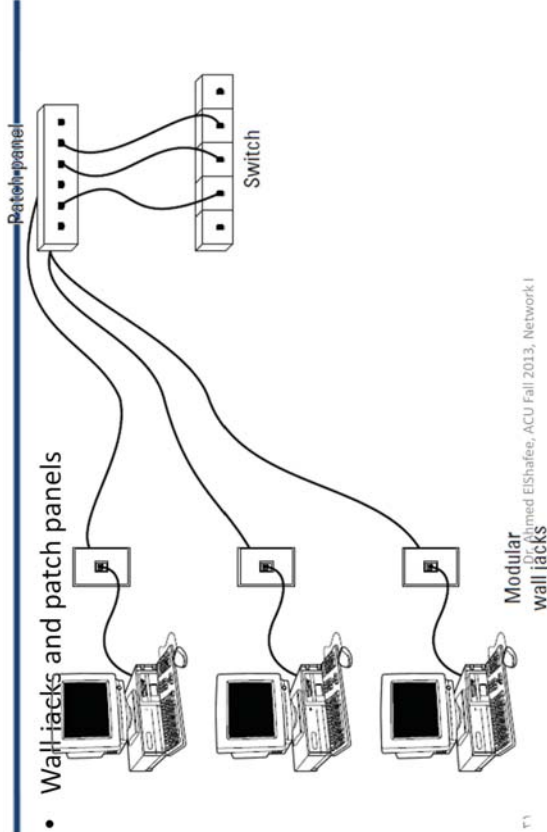
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- **Solid & stranded**
- **stranded cable**, each conductor is made from a bunch of very small wires that are twisted together.
- Stranded cable is more flexible than solid cable, so it doesn't break as easily.
- stranded cable is more expensive than solid cable and isn't very good at transmitting signals over long distances.
- Stranded cable is best used for *station cable and patch cables*, such as the cable used to connect a computer to a wall jack or the cable used to connect patch panels to hubs and switches.

- **solid cable**,
- each conductor is a single solid strand of wire.
- Solid cable is less expensive than stranded cable and carries signals farther,
- it isn't very flexible.
- If you bend it too many times, it will break.
- Solid cable is usually used for permanent wiring within the walls and ceilings of a building.

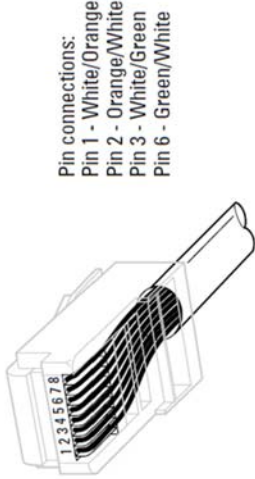


Pin outs for twisted-pair cables

- Each pair of wires in a twisted-pair cable is one of four colors: orange, green, blue, or brown

Pin Connections for Twisted-Pair Cable			
Pin Number	Function	EIA/TIA 568A	EIA/TIA 568B AT&T 258A
Pin 1	Transmit +	White/green	White/orange
Pin 2	Transmit -	Green	Orange
Pin 3	Receive +	White/orange	White/green
Pin 4	Unused	Blue	Blue
Pin 5	Unused	White/blue	White/blue
Pin 6	Receive -	Orange	Green
Pin 7	Unused	White/brown	White/brown
Pin 8	Unused	Brown	Brown

- 10BaseT and 100BaseT actually use only two of the four pairs, connected to pins 1, 2, 3, and 6.



Crossover cables

- A *crossover cable* is a cable that you can use to directly connect two devices without a switch.
- You can use a crossover cable to connect two computers directly to each other, but crossover cables are more often used to daisy chain hubs and switches to each other.

Network Interface Cards

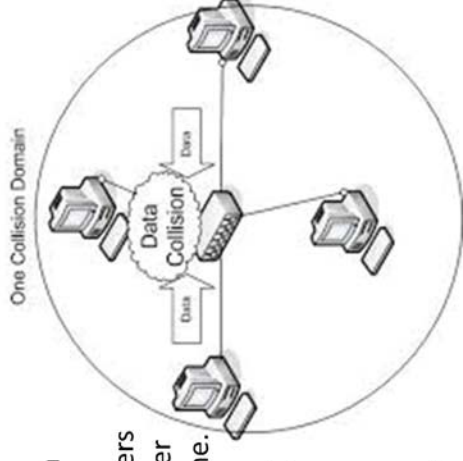
- Every computer on a network, both clients and servers, requires a network interface card (or NIC) in order to access the network.
- Client computers, uses an inexpensive built-in NIC because client computers are used to connect only one user to the network.
- Server NICs are more expensive and have a better quality.
- Most NICs support 1 Gbps, 100 Mbps , and 10 Mbps networks.
- These cards automatically adjust their speed to match the speed of the network
- server computers, may use more than one NIC. That way, the server can handle more network traffic.

Creating a Crossover Cable

Pin	Connector A	Connector B
Pin 1	White/green	White/orange
Pin 2	Green	Orange
Pin 3	White/orange	White/green
Pin 4	Blue	Blue
Pin 5	White/blue	White/blue
Pin 6	Orange	Green
Pin 7	White/brown	White/brown
Pin 8	Brown	Brown

Collision detection algorithm

- **CSMA/CD**
- As mentioned before a main function of data link layer make sure that two computers don't try to send packets over the network at the same time.
- If they do, the signals will collide with each other, and the transmission will fail.
- Ethernet networks use CSMA/CD, and Token Ring networks use token passing.



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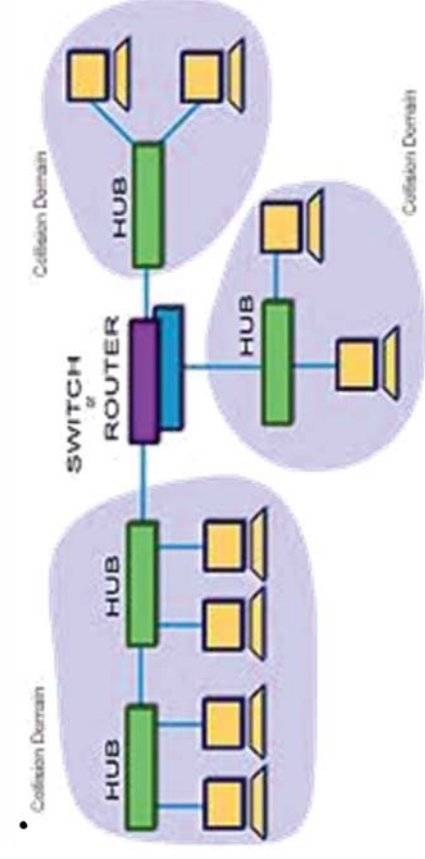
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- Fiber-optic networks also require NICs.
- Fiber-optic NICs are still too expensive for desktop use in most networks.
- Instead, they're used for high-speed backbones.
- If a server connects to a high-speed fiber backbone, it will need a fiber-optic NIC that matches the fiber-optic cable being used.

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- **CSMA/CD & collision domains**
- CSMA/CD works pretty well for smaller networks.
- After a network hits about 30 computers however, packets start to collide, and the network performance degrades radically.
- When that happens, the network should be divided into two or more separate sections that are sometimes called *collision domains*.



T6

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T7

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Network Nodes

- Hub
- Repeater
- Switch
- Bridge
- Router

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- daisy chain no more than three switches together.
- To solve this use stackable switches that have high-speed direct connections that enable two or more switches to be counted as a single switch.
- For large networks, *managed switch should be used*.
- A managed switch allows you to monitor and control various aspects of the switch's operation from a remote computer

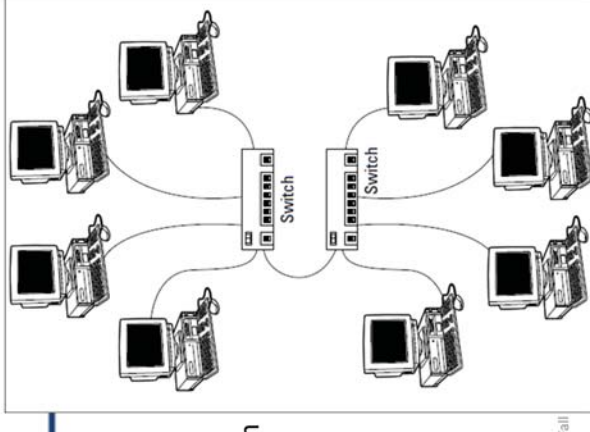
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- **Switches**
- Both hubs and switches let you connect multiple computers to a twisted-pair network.
- Switches are more efficient than hubs,
- User can connect switches to one another; this is called *daisy chaining*
- some switches, have a special designated port for daisy chaining

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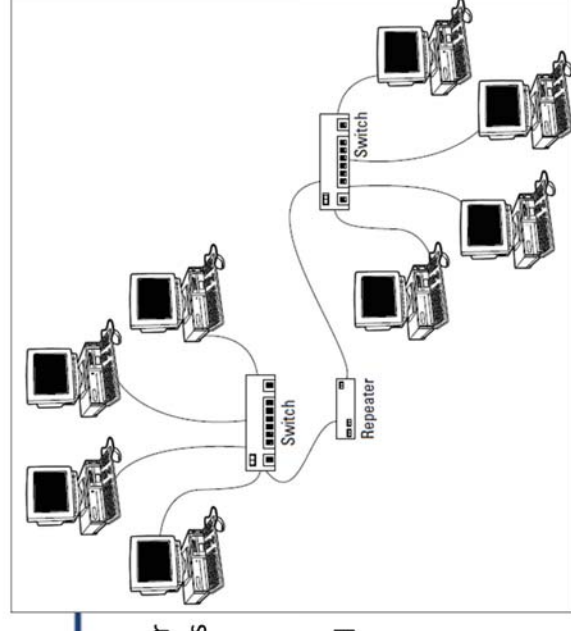
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- **Repeaters**
- Is a physical layer device, that gives the network signals a boost so that the signals can travel farther.

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- User can use a repeater to connect two groups of computers that are too far apart to be strung on a single segment
- Repeaters listen to signals coming down one network cable, amplify them, and send them down the other cable.
- A basic rule of Ethernet life is that a signal can't pass through more than three repeaters on its way from one node to another

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- **Bridges**
- Bridges are Data Link layer, that connects two networks so that they act as if they're one network.
- Bridges are used to partition one large network into two smaller networks for performance reasons
- bridge is a smart repeater.
- bridges listen to the network and automatically figure out the MAC address of each computer on both sides of the bridge.
- Then the bridge can inspect each message that comes from one side of the bridge and broadcast it on the other side of the bridge, but only if the message is intended for a computer that's on the other side.

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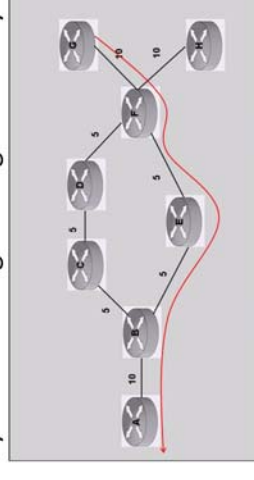
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- **Routers**
- a router is a Network layer device, so it can work with the network packets at a higher level router can examine the IP address of the packets that pass through it.
- And because IP addresses have both a network and a host address, a router can determine what network a message is coming from and going to.
- a router is itself a node on the network, with its own MAC and IP addresses.
- This means that messages can be directed to a router, which can then examine the contents of the message to determine how it should handle the message.

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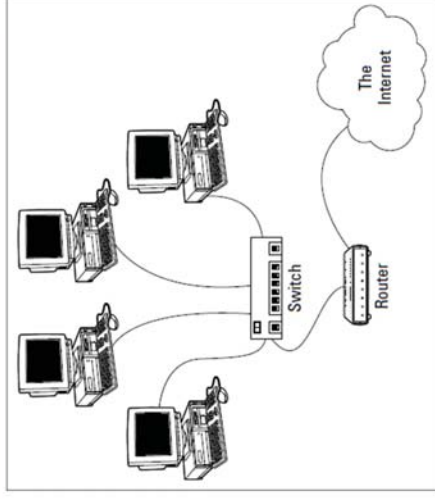
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- User can configure a network with several routers that can work cooperatively together.
- For example, some routers are able to monitor the network to determine the most efficient path for sending a message to its ultimate destination.
- If a part of the network is extremely busy, a router can automatically route messages along a less-busy route.



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- Routers can also connect networks that are geographically distant from each other via a phone line (using modems) or ISDN.
- You can also use a router to join your LAN to the Internet.



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- server computer are similar to the components used in less expensive client computers
- 1. Motherboard:**
 - The major components on the motherboard include the processor (or CPU), supporting circuitry called the *chipset*, memory, expansion slots, a standard IDE hard drive controller, and I/O ports for devices such as keyboards, mice, and printers.
 - Some motherboards also include additional built-in features such as a graphic adapter, SCSI disk controller, or network interface.

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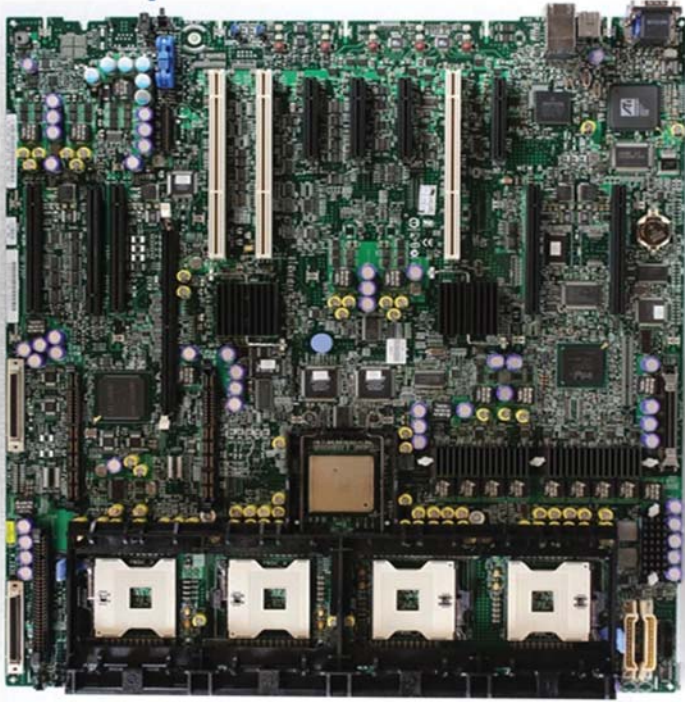
Servers

- Only the smallest networks can operate with out any dedicated server computer.
- Like home network or a small office network with only a few computers, you can get away with true *peer-to-peer networking*.
- That's where each client computer shares its resources such as file storage or printers, and a dedicated server computer isn't needed.
- Servers provide the shared resources that network users crave, such as file storage, databases, e-mail, Web services, and so on.

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Dell power edge 6800

- **Processor:** The processor, or CPU, is the brain of the computer.
- Intel had two processor models specifically designed for use in server computers.

Intel Processors

Processor	Clock Speed	Processor Cores
Itanium 9300	1.60–1.73GHz	4
Xeon	1.83–3.4GHz	2–6

- Itanium processors are faster than Xeon processors at the same clock speed

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• Memory:

- The total memory capacity of the server depends on the motherboard.
- Most new servers can support at least 16GB of memory, and some can handle up to 256GB.

• Hard drives:

- Most desktop computers use inexpensive hard drives called SATA drives
- Servers use another type of drive known as SCSI/
- For the best performance, use the SCSI drives along with a high-performance SCSI controller card.
- SATA drives are often used in inexpensive servers.

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• Network connection

- Gigabit Ethernet builtin card

• Video:

- servers equipped with inexpensive generic video cards and monitors without affecting network performance.

• Power supply:

- larger power supply (typically 300 watts).
- If the server houses a large number of hard drives, it may require an even larger power supply.

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• Server form factors

1. Tower case:

- Most servers are housed in a traditional tower case, similar to the tower cases used for desktop computers.
- A typical server tower case is 18-inches high, 20-inches deep, and 9-inches wide and has room inside for a motherboard, five or more hard drives, and other components.
- Tower cases also come with built-in power supplies.

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• Other features

- redundant power supplies
- hot-swappable fans
- hot-swappable disk drive bays.
- **Rack mount**
- Rack-mount servers are designed to save space when you need more than a few servers in a confined area.
- A rack-mount server is housed in a small chassis that's designed to fit into a standard 19-inch equipment rack.

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Figure 2. Blade server chassis (rear)

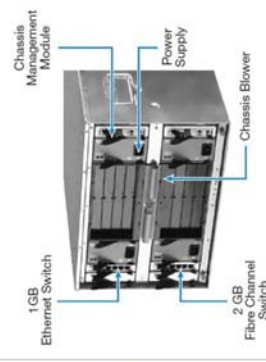


Figure 1. Blade server chassis (front)



• Blade servers

- is a server on a single card that can be mounted alongside other blade servers in a blade chassis, which itself fits into a standard 19-inch equipment rack.
- the blade enclosure provides power for all its blade servers.
- blade enclosure provides KVM switch, so users can control any of the servers in a blade server network from a single keyboard, monitor, and mouse.

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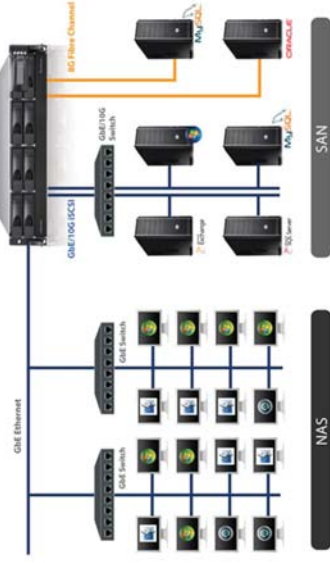
Storage Area Network and Network Attached Storage

- SAN is a complicated and expensive technology that provides huge quantities of data storage for large networks
- A SAN consists of three components:
 - storage devices (perhaps hundreds of them),
 - a separate high-speed network (usually fiber-optic) that directly connects the storage devices to each other,
 - one or more SAN servers that connect the SAN to the local area network.
- The SAN server manages the storage devices attached to the SAN and allows users of the LAN to access the storage.

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- *Network attached storage*, also known as NAS is a network server that provides a disk space to network users.
- A *NAS device* is a self-contained file server that's preconfigured and ready to run.



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- Example of NAS, Dell PowerVault NX300.
- A self-contained file server built into a small rack-mount chassis.
- It supports up to four hard drives with a total capacity up to four terabyte (or 4,000GB).
- The NX300 uses a Xeon processor and two built-in gigabit network ports.



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Network Printers

- Although you can share a printer on a network by attaching the printer to a server computer, many printers have network interfaces built in.

- Note that some NAS devices use customized versions of Linux rather than Windows Storage Server.
- Also, in some systems, the operating system resides on a separate hard drive that's isolated from the shared disks.
- This prevents the user from inadvertently damaging the operating system



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