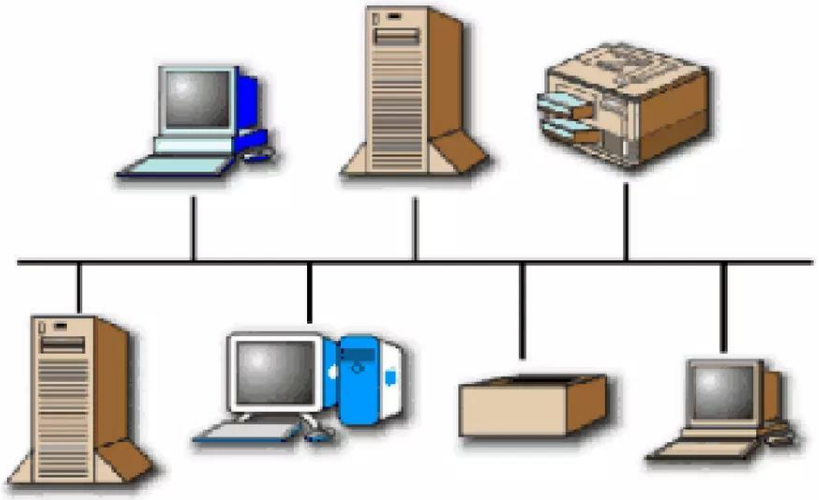
Basics of Computer Networking

What is a Computer Network?

A network is a collection of computers, printers, routers, switches, and other devices that are able to communicate with each other over some transmission media.



Types of Networks

There are two basic types of networks currently in existence:

A *Local Area Network* (LAN)

A *Wide Area Network* (WAN)

Local Area Networks (LAN)

A *Local Area Network* (LAN) is a group of computers and network communication devices within a limited geographic area, such as an office building. No third party involvement here. They are characterized by the following:

- High data transfer speeds
- Generally less expensive technologies
- Limited geographic area

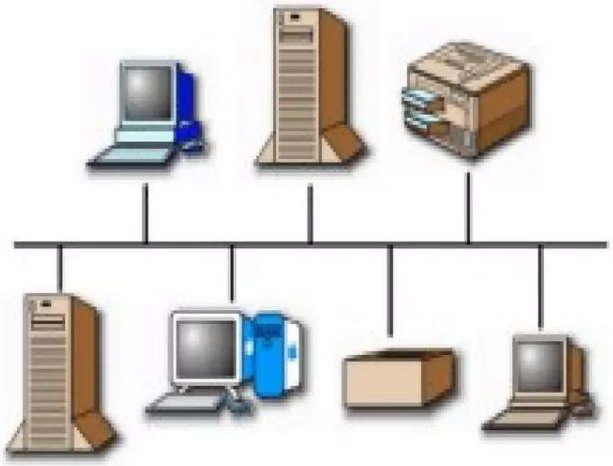
Wide Area Networks (WAN)

A *Wide Area Network* (WAN) interconnects LANs. It is not restricted to a particular geographic area and may be interconnected around the world. Third party network is involved. They are characterized by the following:

- Multiple interconnected LANs
- Generally more expensive technology
- More sophisticated to implement than LANs
- Exist in an unlimited geographic area
- Less error resistance due to transmission travel distances

Common LAN Topologies

Bus Architecture

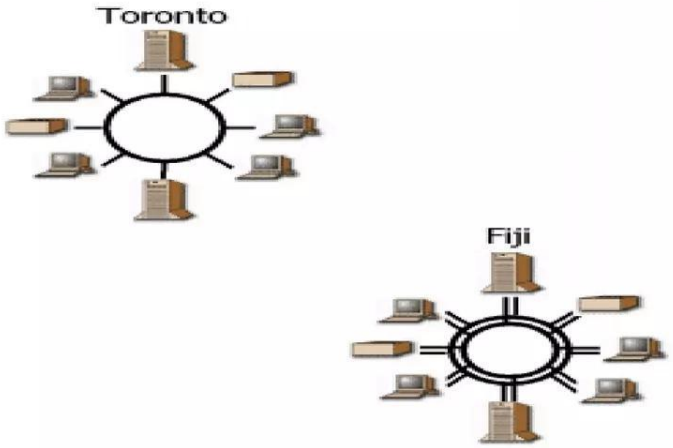


In a bus topology:

- a single cable connects each workstation in a linear, daisy-chained fashion.

- signals are broadcasted to all stations, but stations only act on the frames addressed to them.

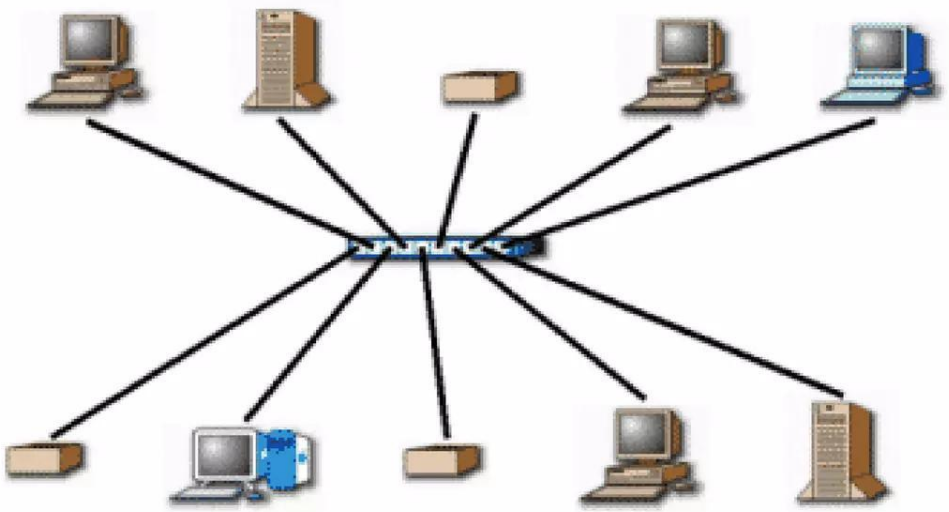
Ring Architecture



- In a ring topology:

- Unidirectional links connect the transmit side of one device to the receive side of another device.
- Devices transmit frames to the next device (downstream member) in the ring.

Star Topology



In a star topology, each station is connected to a central hub or concentrator that functions as a multi-port repeater. Each station broadcasts to all of the devices connected to the hub. Physical LAN topologies are usually characterized as either bus or ring.

LAN Transmission Methods

LAN transmission methods fall into 3 main categories:

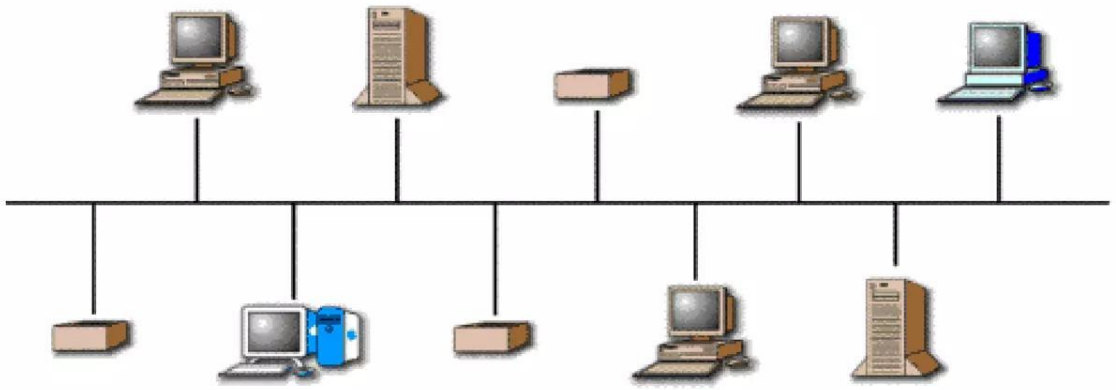
- **Unicast transmission**
- **Multicast transmission**
- **Broadcast transmission**

Unicast Transmission

In unicast transmissions, a single data packet is sent from a source to a single destination on the network.

Unicast Process

- The source addresses the packet with the destination address.
- The packet is sent into the network.
- The network delivers the packet to the destination.

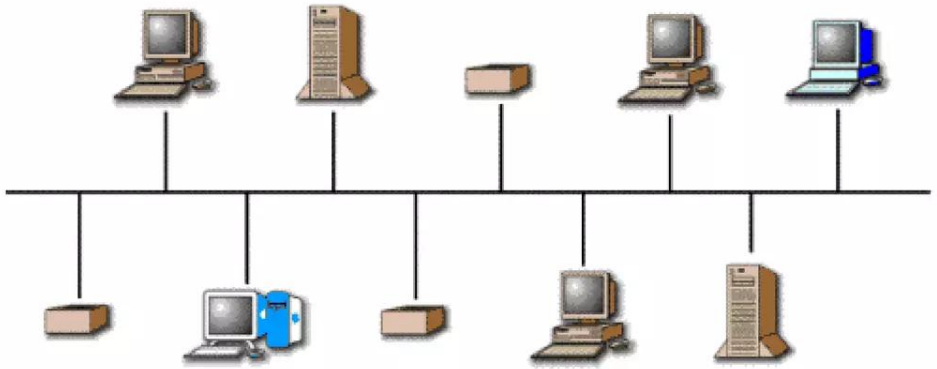


Multicast Transmission

In multicast transmissions, a single data packet is copied and sent to specific destinations on the network

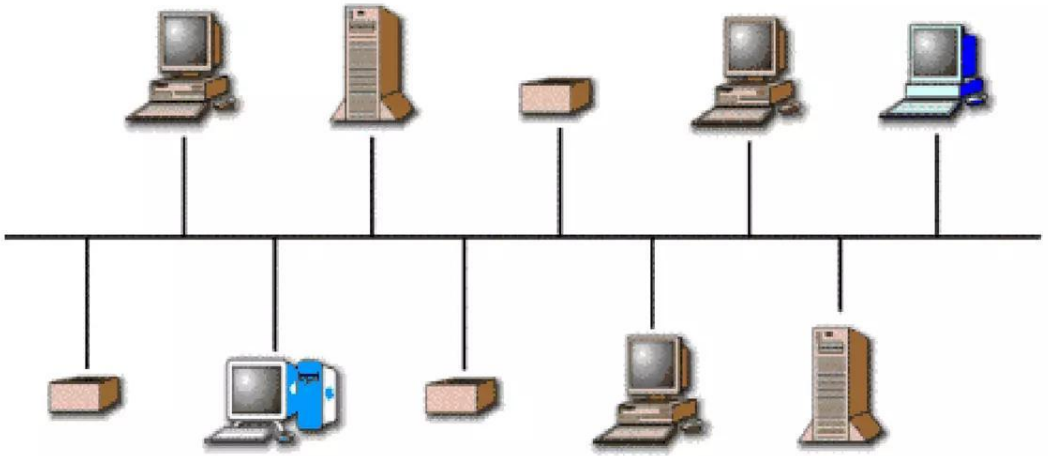
Multicast Process

- The source addresses the packet using a multicast address.
- The packet is sent into the network.
- The network copies the packet.
- A copy is delivered to each destination that is included in the multicast address.



Broadcast Tranmission

In multicast transmissions, a single data packet is copied and sent to specific destinations on the network



Broadcast Process

- The source addresses the packet with the broadcast address.
- The packet is sent into the network.
- The network copies the packet.
- The packet copies are delivered to all destinations on the network.

LAN Infrastructure Devices

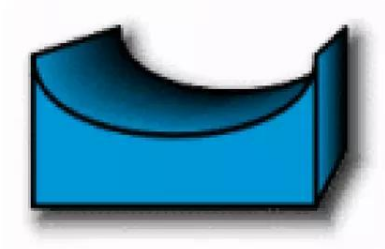
There are numerous devices associated with data information flow across a LAN. When adjoined, they create the infrastructure of a functional LAN. These devices include:

- **Repeaters**
- **Bridges**
- **Hubs**
- **Switches**
- **Routers**

Repeaters

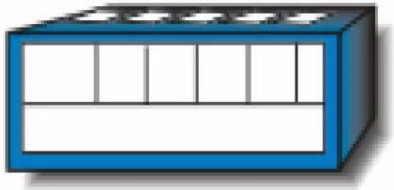
Repeaters, located within the physical layer of a network, regenerate and propagate signals from one to another. They do not change any information being transmitted, and they cannot filter any information. Repeaters help to extend the distances of networks by boosting weak signals.

Bridges



Bridges are intelligent repeaters. They regenerate transmitted signals, but unlike repeaters, they can also determine destinations.

Hubs

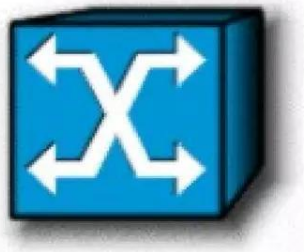


Hubs connect all computer LAN connections into one device. They are nothing more than multiport repeaters. Hubs cannot determine destinations; they merely transmit to every line attached in a half-duplex mode.

Routers

Routers are a step up from bridges. They are able to route and filter information to different networks. Some routers can automatically detect problems and redirect information around the problem area. These are called "intelligent routers."

Switches



Switches connect all computer LAN connections, the same as hubs do. The difference is that switches can run in full-duplex mode and are able to direct and filter information to and from specific destinations.

WAN

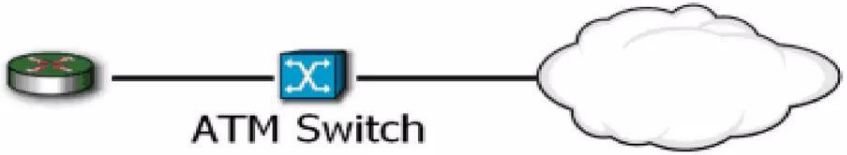
WAN Infrastructure

As with LANs, there are numerous devices associated with data information flow across a WAN. Together, these devices create the infrastructure of a functional WAN. These devices include:

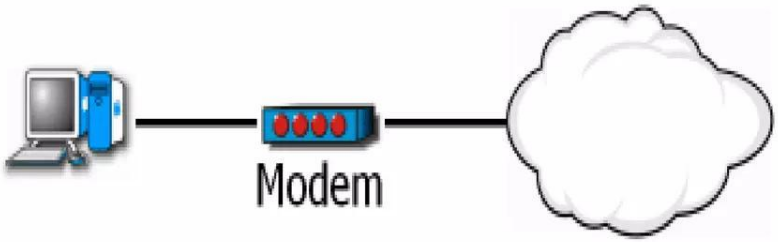
- **Router**
- **ATM Switch**
- **Modem and CSU/DSU**
- **Communication Server**
- **Multiplexer**
- **X.25/Frame Relay Switches**

ATM Switches

ATM Switches provide high-speed transfer between both LANs and WANs.



Modem (modulator / demodulator)



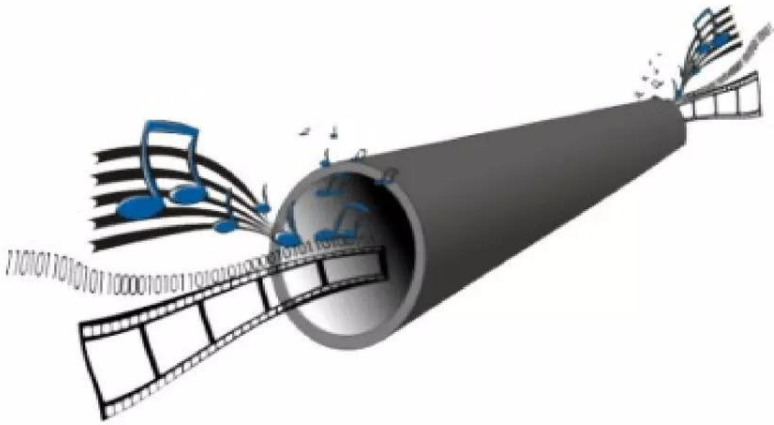
Modems convert digital and analog signals. At the source, modems convert digital signals to a form suitable for transmission over analog communication facilities (public telephone lines). At the destination, modems convert the signal back to a digital format.

CSU/DSU (Channel Service Unit / Data Service Unit)

CSUs/DSUs are similar to modems, however they send data in digital format across digital telephone loops. They are usually in a physical box, but they may come in two separate units: CSUs or DSUs.

Multiplexers

A Multiplexer combines multiple signals for transmission over a single circuit. This allows for the transfer of various data simultaneously, such as video, sound, text, etc.



Communication Servers

Communication Servers are typically dial in/out servers that allow users to dial in from remote locations and attach to the LAN.

X.25 / Frame Relay Switches

X.25 and Frame Relay Switches connect private data over public data circuits using digital signal. These units are very similar to ATM switches, but the transfer rate of data is not comparable.

Local Area Network Cabling

The earliest LANs used coaxial cables. Over time, the twisted pair cables used in telephone systems were improved to carry higher frequencies and support LAN traffic. More recently, fiber optic cables have emerged as a high-speed cabling option.
Local Area Networks use four types of cables:

- **Coaxial**
- **Unshielded Twisted Pair (UTP)**
- **Shielded Twisted Pair (STP)**
- **Fiber Optic**

Coaxial Cables

A coaxial cable consists of:
- a single copper conductor
- a layer of shielding with a ground wire
- an outer jacket

Coaxial cables are sometimes used for bus topologies, but many LAN products are dropping support of coaxial cable connectivity.

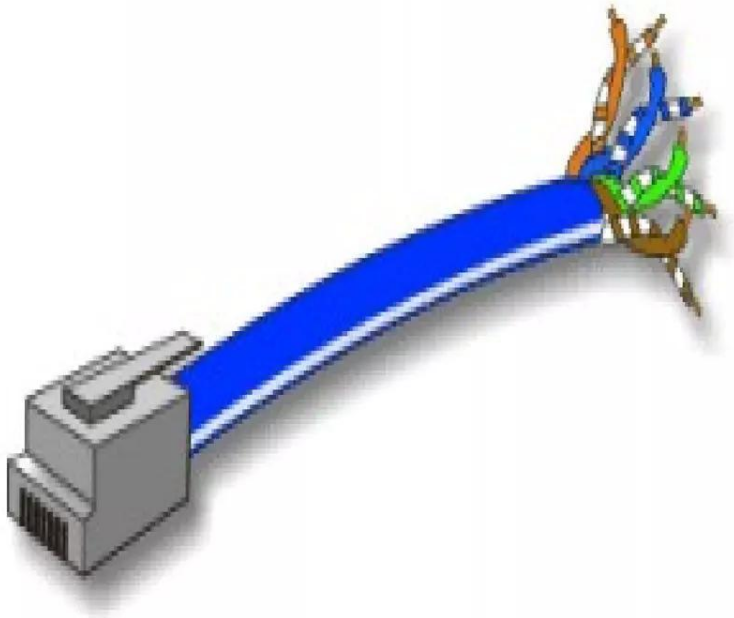
The Ethernet LAN protocol was originally developed to operate over coaxial cables.

10Base5 / Thicknet cable:
- was the original Ethernet cable.
- is no longer in use in modern LANs.

10Base2 / Thinnet cable:

has a smaller diameter than Thicknet.
- replaced Thicknet.
- is no longer recommended, but is still used in some very small LANs.

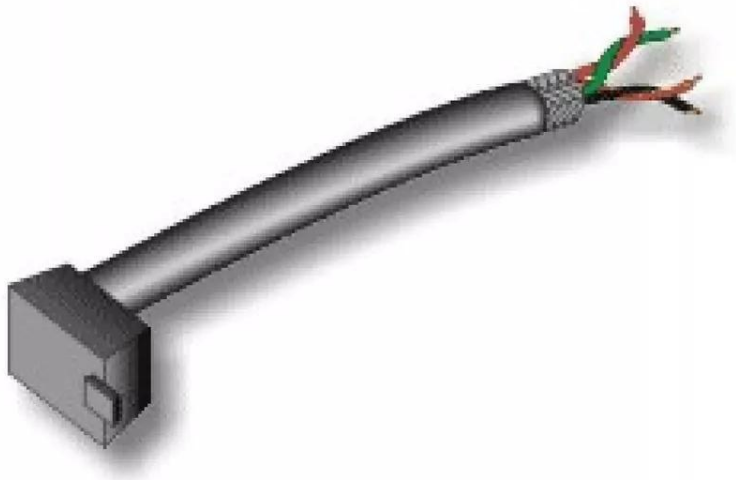
Unshielded Twisted Pair



Unshielded twisted pair (UTP) cable is used for both LANs and telephone systems. UTP cables are composed of four color-coded pairs of copper conductors twisted around each other. An outer jacket provides protection and keeps the pairs in alignment. UTP cable connects to devices via 8 pin modular connectors called RJ-45 plugs. All LAN protocols can operate over UTP. Most modern LAN devices are equipped with RJ-45 jacks.

Shielded Twisted Pair

STP cable is also used for Data Networks. It originated with IBM's Token-Ring networks. Its shielding allows greater tolerances for protection from EMI interference, such as from flourescent light fixtures and electric motors.



Fiber Optic Cable

Fiber Optic cables are the latest development in cabling technology. They are constructed from optical glass. There is a central glass filament, called the core, and surrounding layers of cladding, buffer coatings, strengthening materials, and an outer jacket.

Information is transmitted by wavelengths of light. This is accomplished through devices that convert electrical signals into rapid pulses of either LED or Laser light.

Fiber optic cables offer several advantages, including:

- high bandwidth capacity (many gigabits per second).
- longer distances between devices (from 2 to over 60 kilometers).
- immunity to electromagnetic interferences

Fiber optic cables are widely used in WANs for both voice and data communications. The primary barrier to their widespread use in LANs is the cost of electronics.

Ethernet

Ethernet was developed by Xerox in 1970. It was implemented through thicknet cable running at 10 Mbps.

Ethernet is a connection media access method that allows all hosts on a network to share the same bandwidth of a link.

Ethernet actually just refers to the LAN implementations that includes three principal categories.

- Ethernet / IEEE 802.3---operates at 10 Mbps on coaxial cable and twisted pair cable.
- 100-Mbps Ethernet---(also known as Fast Ethernet) operates at 100 Mbps over twisted-pair cable.
- 1000-Mbps Ethernet---(also known as Gigabit Ethernet) operates at 1000 Mbps (1 Gbps) over fiber and twisted-pair cables.

Ethernet and IEEE 802.3 operation involves three basic components:

- **Transmission**
- **Media access**
- **Collision handling**

Media Access

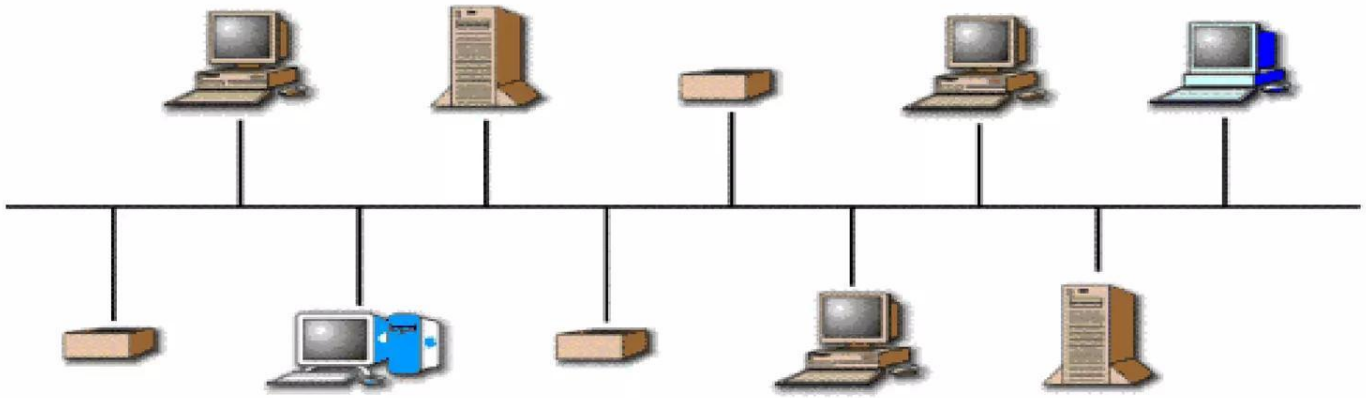
The Ethernet media access uses the following process:

- Any station on a LAN can access the network at any time.
- Before sending data, stations listen for traffic on the network.
- A station waits until it detects no traffic before it transmits data.

Collision handling

Ethernet is a "first come, first serve" environment. In such an environment, any station on the network can transmit whenever the network is quiet. A collision occurs when two stations listen for traffic, hear none, and then transmit data at the same time. Both transmissions are damaged, and the stations must retransmit at a later time.

CSMA / CD

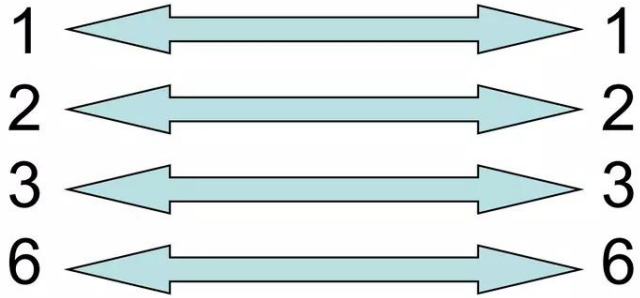


Ehernet Cabling

Striaght Through cable: used to connect

- Host to switch or hub
- Router to switch or hub

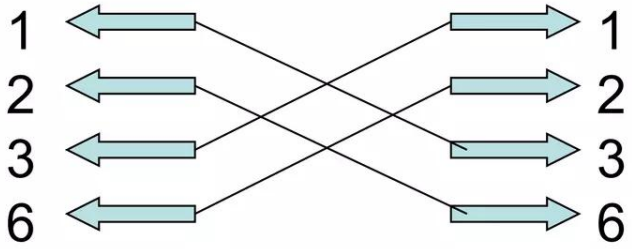
Four wires are used in straight-through cable to connect Ethernet devices.



Cross Through cable: used to connect

- switch to switch
- Router direct to host
- hub to hub
- Host to host

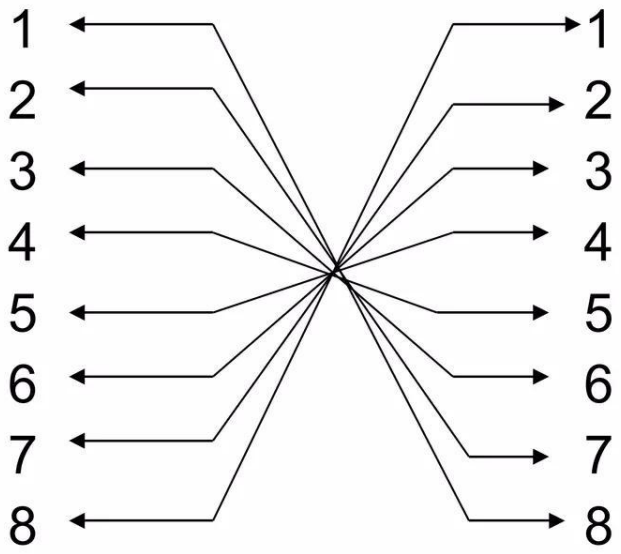
Four wires are used as in straight-through cable to connect Ethernet devices.



Rolled cable

Although rolled cable is not used to connect any Ethernet connections together, we use this cable to connect a host to a router console serial communication (com) port.

Eight wires are used in this cable to connect serial devices.



Start HyperTerminal to create a console connection and configure the device.

Start → Programs → accessories → communications → HyperTerminal

Provide the default settings for com1 port

Network Model Overview

In order for a computer to send information to another computer, and for that computer to receive and understand the information, there has to exist a set of rules or standards for this communication process. These standards ensure that varying devices and products can communicate with each other over any network. This set of standards is called a model.

Network Model Advantages

This division provides advantages for the network design, architecture and implementation. These include:

- **Reduces complexity** - by dividing the processes into groups, or layers, implementation of network architecture is less complex
- **Provides compatibility** - standardized interfaces allow for "plug-and-play" compatibility and multi-vendor integration
- **Facilitates modularization** - developers "swap" out new technologies at each layer keeping the integrity of the network architecture
- **Accelerates evolution of technology** - developers focus on technology at one layer while preventing the changes from affecting another layer
- **Simplifies learning** - processes broken up into groups divides the complexities into smaller, manageable chunks