Ch. 2 - LAN

The history of local area networks, LAN

Mid 70`s	Experiments	Robert Metcalf and David Boggs on Xerox
1982	Ethernet ver 2	Digital Intel Xerox
Mid 80`s	PC-networks	
Today Tomorrow	10 Mbps 100-1000 Mbps	

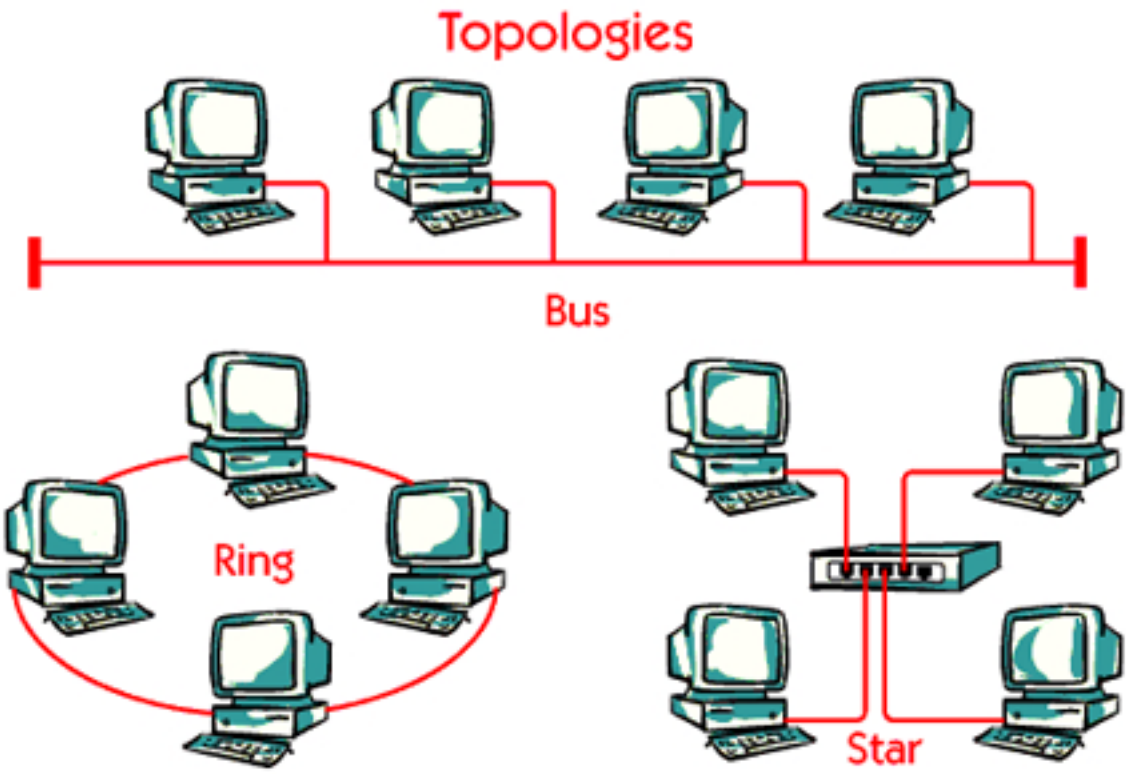
In the mid 70's Robert Metcalf and David Boggs at Xerox experimented with communication between the computers. This became the first implementation of Ethernet.

In 1982, the second version of Ethernet was implemented by Digital, Intel and Xerox. This is the version of Ethernet that is still in use today.

In the mid 80's the first PC-networks started to appear. Network components such as bridges and routers were now available on the market.

The normal bandwidth of the Local Area Network today is 10 Mbps.

In the near future we will see higher bandwidths, such as 100 to 1000 Mbps.



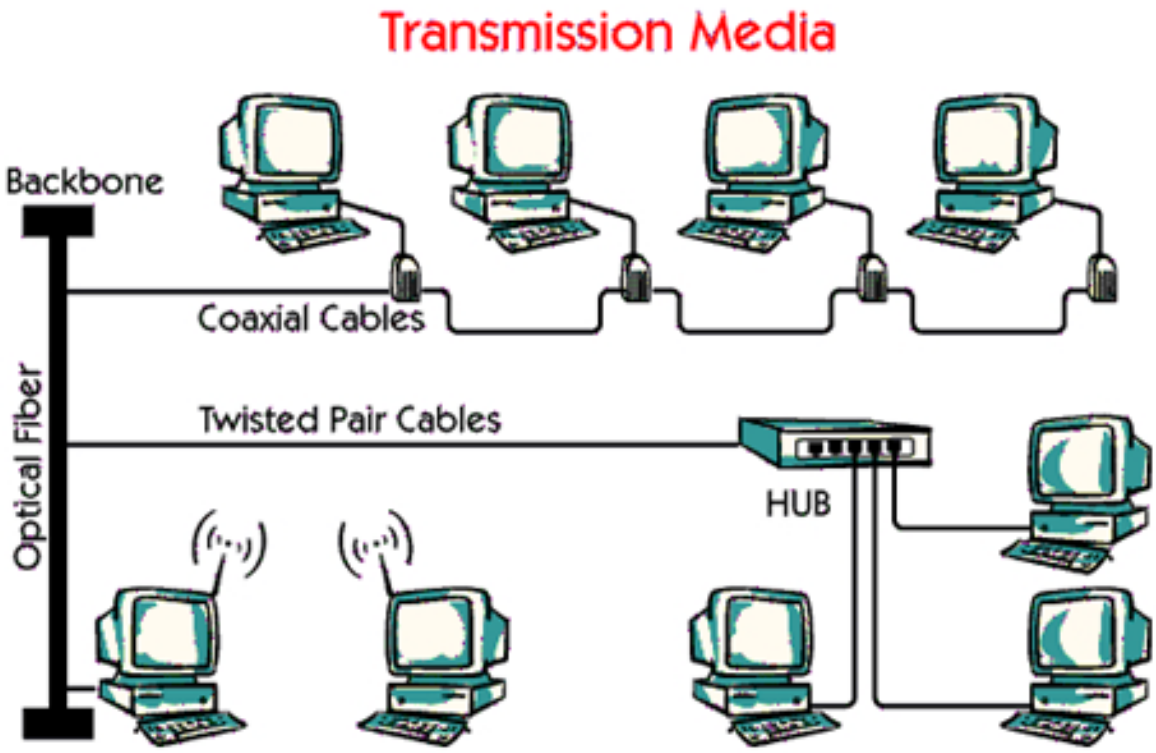
The topology of a network concerns the physical configuration of the devices and the cables that connect them.

Three principle topologies are used for local area networks:

1. Bus network
On the bus network all connected hosts are sharing the same cable. All the hosts must use the same communication speed and every host ”hears” all traffic on the cable.

2. Ring network
In the ring topology all hosts are connected into a ring. Every host in the ring receives all data that is passing. If the data has another destination address, the host will re-transmit the data into the ring. The data will continue to travel in this way until it reaches the destination host.

3. Star network
A star configuration includes a central controller which could be a hub or a switch. Every host is directly connected to a port on the central controller.



IEEE standards for LANs describe different types of transmission media. It could be cable, fiber or wireless.

Cables:
Cables typically come in two flavors: twisted pair cables or coaxial cables.

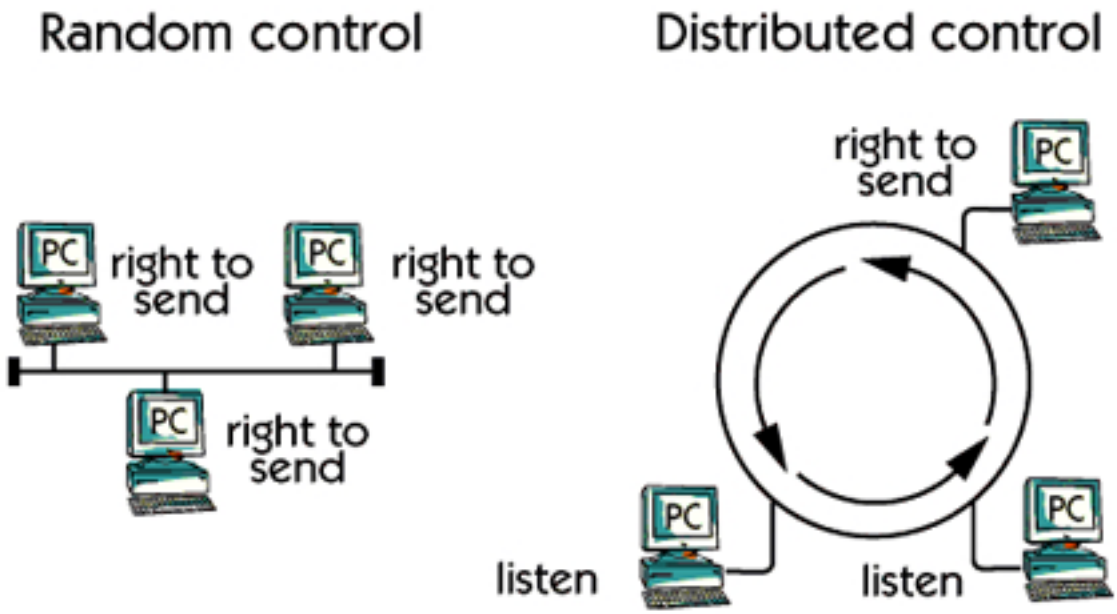
Twisted pair cables
A twisted-wire consists of two insulated strands of copper wire that have been braided. Often a number of twisted-wire pairs are grouped together into a twisted pair cable. Twisted pair cables are used both for data communication and telephony.
In the picture the twisted pair cables would typically be used in the star topology in the middle, that is between the hub and the connected hosts.

Coaxial cables
Coaxial cables consist of a central conducting copper core that is surrounded by insulating material. The insulation is surrounded by a second conducting layer, which can consist of either a braided wire mesh or a solid sleeve. In the picture, the coaxial cable would typically be used for the bus network seen on the top.

Optical fiber:
Optical fibers can be used to carry data signals in the form of modulated light beams with high bandwidth. An optical fiber consists of an extremely thin cylinder of glass, called the core, surrounded by a concentric layer of glass. In the picture, the optical fiber would typically be used for the backbone network.

Wireless:
Different types of radio LANs are available on the market. This is an expensive type of LAN technique. In the picture, wireless connection is used between the two hosts with antennas. Wireless LAN connections are often used in old historical buildings where you are not allowed to install cables.

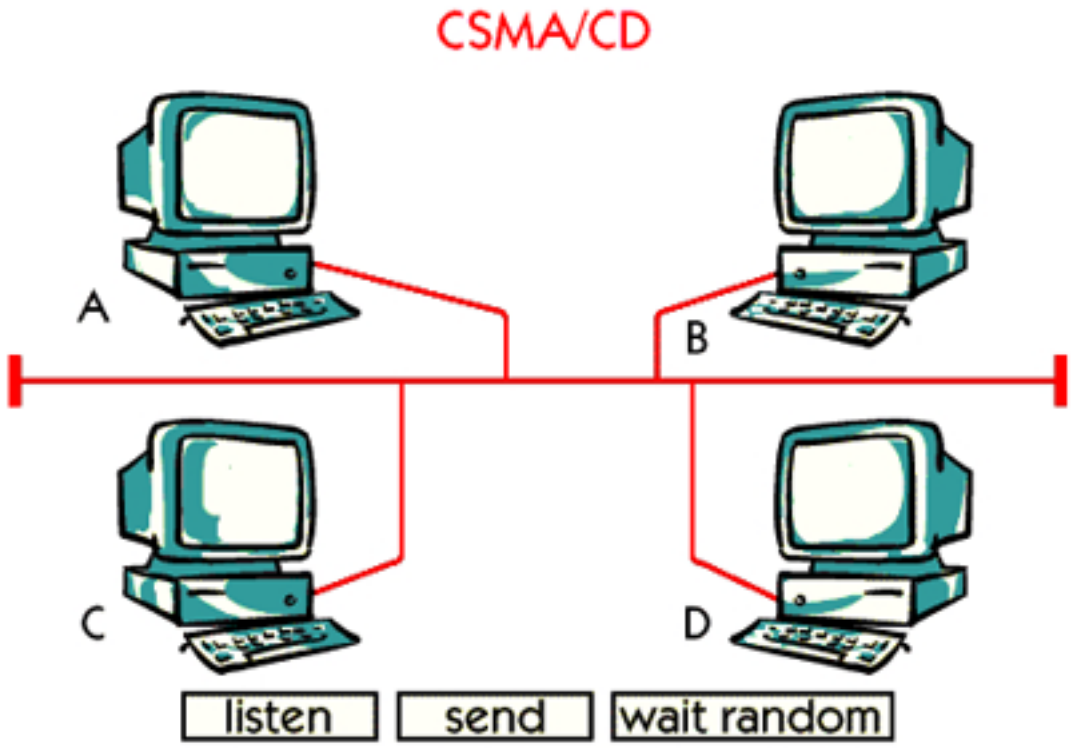
Access methods



A characteristic common to all Local Area Networks is that multiple hosts have to share access to a single physical transmission medium. Several methods can be employed to control the sharing of access to the transmission medium.
The various access control methods can be characterized by where in the network the transmission control function is performed. An access method can use following forms of transmission control:

1. Random control
With random control any host can transmit and permission is not required. A host may check the medium to see if it is free before beginning to transmit.

2. Distributed control
With distributed control only one host at a time has the right to transmit and that right is passed from host to host. This is usually done by passing on a small piece of data called a token. The host that has the token, is the one that has the right to transmit.



CSMA/CD stands for "Carrier Sense Multiple Access with Collision Detect". **CSMA/CD** is a random control access method.

The CSMA/CD access method is used as the access control method in Ethernet and is defined in a standard from IEEE. The CSMA/CD algorithm is quite simple and the efficiency for an ordinary Ethernet is about 65%. This means that the effective bandwidth for a 10 Mbps Ethernet is about 6.5 Mbps. The rest is lost, mainly due to collisions.

Before one host will transmit it must ”listen” on the medium whether or not another host is transmitting. If the medium is ”quiet” the host can send its data. The term "Carrier Sense" indicates that a host listens before it transmits.

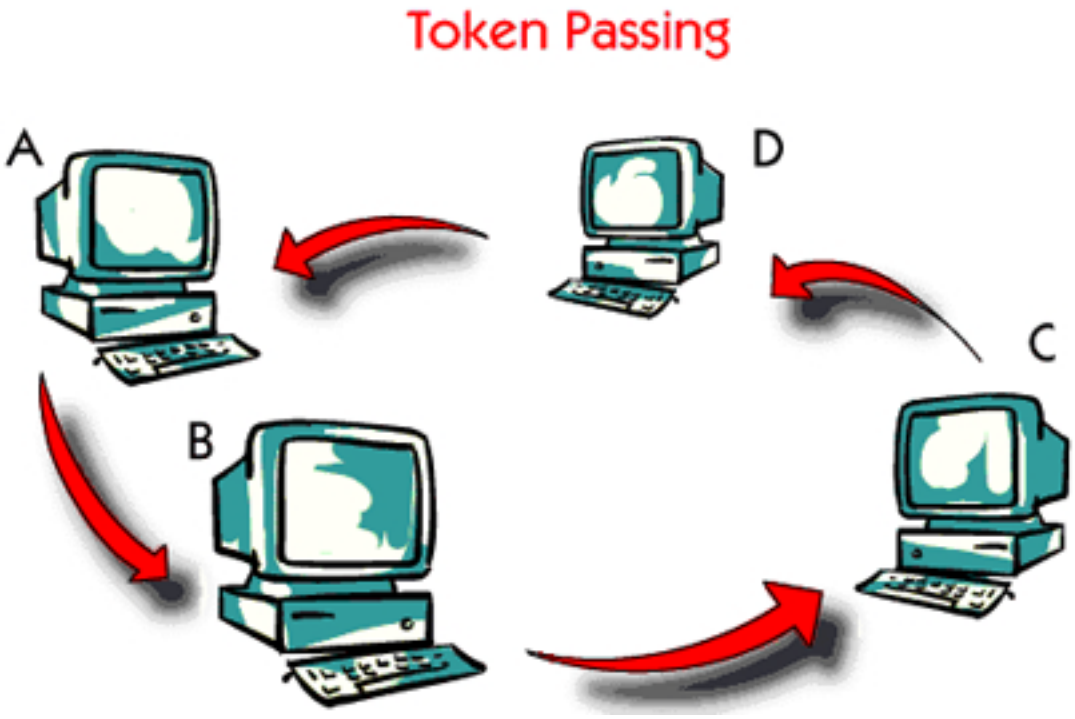
"Multiple Access" means that many hosts can be connected to the network and all hosts have the same right to transmit.

With CSMA/CD, it occasionally happens that two hosts send their packets at the same time. This will make a collision on the network. The information about the collision is detected by all the other hosts on the network. This is called "Collision Detect". If a host detects a collision it will wait a random period of time before it tries to transmit again.

Development of the most popular LAN technologies

Type:	Standard:	Bandwidth:
Ethernet	IEEE 802.3 / ver II (DIX)	10 Mbit/s
Fast Ethernet	IEEE 802.3u	100 Mbit/s
Gigabit Ethernet	IEEE 802.3z (over fiber)	1000 Mbit/s
Gigabit Ethernet	IEEE 802.3ab (over tp cable)	1000 Mbit/s
Token Ring	IEEE 802.5	4 Mbit/s
Token Ring	IEEE 802.5	16 Mbit/s
High Speed Token Ring	IEEE 802.5	100 Mbit/s

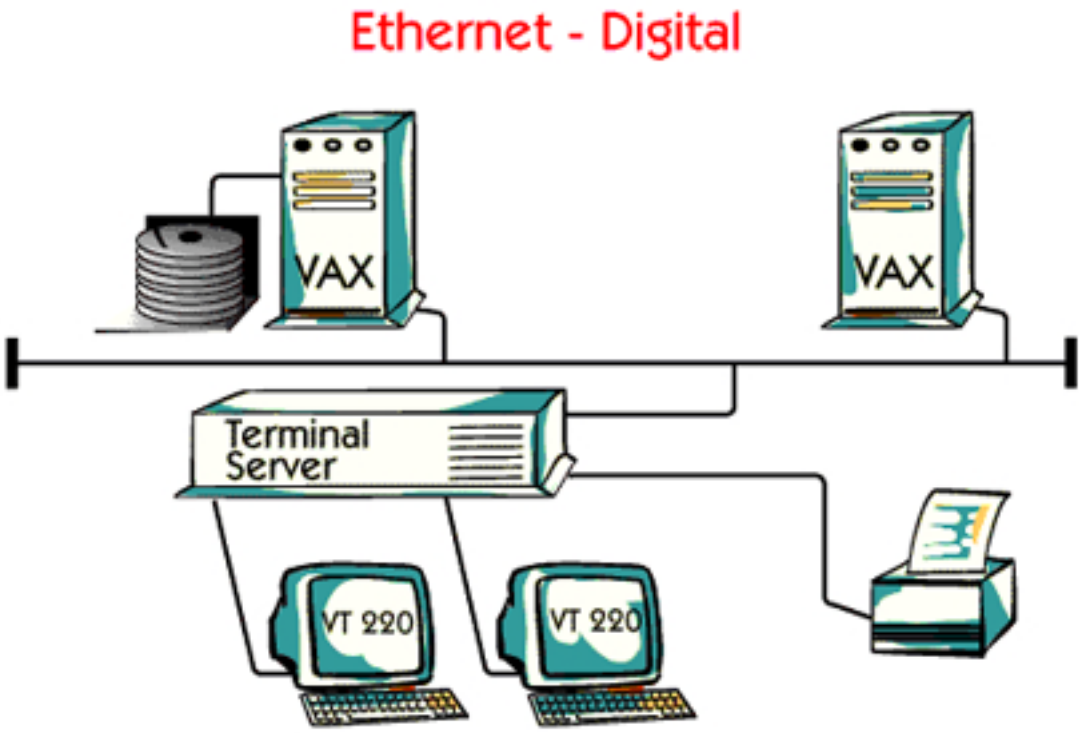
This diagram shows what has happened to the development of the two most used LAN technologies today, Ethernet and Token ring. 10 Megabits Ethernet exists in two versions. Version two as specified by Digital. Intel and Xerox, is the most commonly used version and IEEE standard 802.3 which is not so commonly used. These two versions are not compatible, because the frame format differs.
Fast Ethernet, which is specified in IEEE 802.3u, offers 100 Mbps. Fast Ethernet is a modern version of Ethernet and is often used in LAN backbone networks today (that is 1999), but is still not so commonly used for clients.
Gigabit Ethernet over fiber, is specified in IEEE 802.3z, offers 1000 Mbps. Gigabit Ethernet is not so common today (that is 1999). Gigabit Ethernet is only used in LAN backbone networks because it is expensive and there is not any need today for so high bandwidth to clients.
Gigabit Ethernet over twisted pair cable, is specified in IEEE 802.3ab, offers 1000 Mbps. This standard is not fully specified today, that is in the spring 1999.
Gigabit Ethernet is the future of LAN development, because Ethernet is simple, reliable and will become cheap.
Token ring as specified in IEEE 802.5 offers 4 and 16 Mbps. The use of token ring technology is diminishing even though a new standard, called high speed token ring, offering 100 Mbps, has been specified.



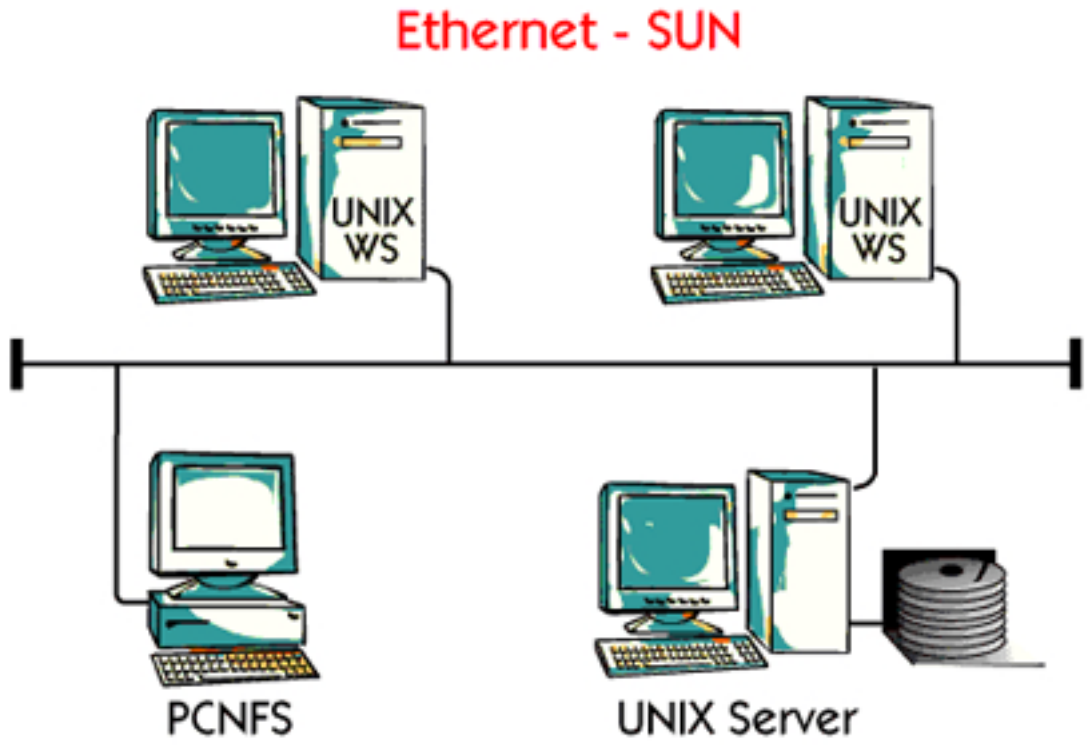
In Token Ring another access method is used, called Token Passing.

With Token Passing, a small message, called a token, constantly circulates around the ring. If the token is marked as free, the host that receives the ”free” token can transmit its data and mark the token as busy. All the hosts along the ring receive the data and the busy token, until the host that sent the original message sets the token free again.

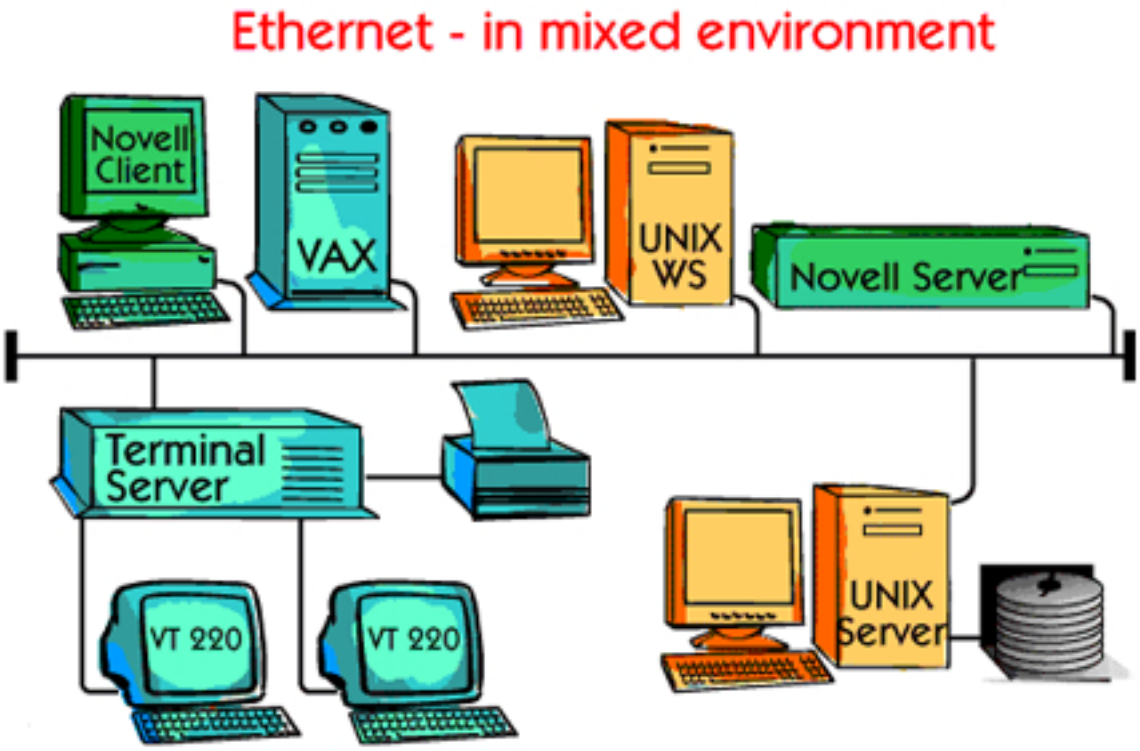
Right now the token is with host B, and it is marked free. Let’s say that host B wants to send data to host D. B sets the token to busy and adds its data.
The host C has now received the token and the data, but since C is not the receiver it just passes on the token and the data into the ring.
The host D receives the data and sets the token to copied. The token and the data are then passed on into the ring.
The host A just passes on the token and the data.
The host B sees that the data has been received in a proper way by D. B therefore deletes the data and sets the token free again.



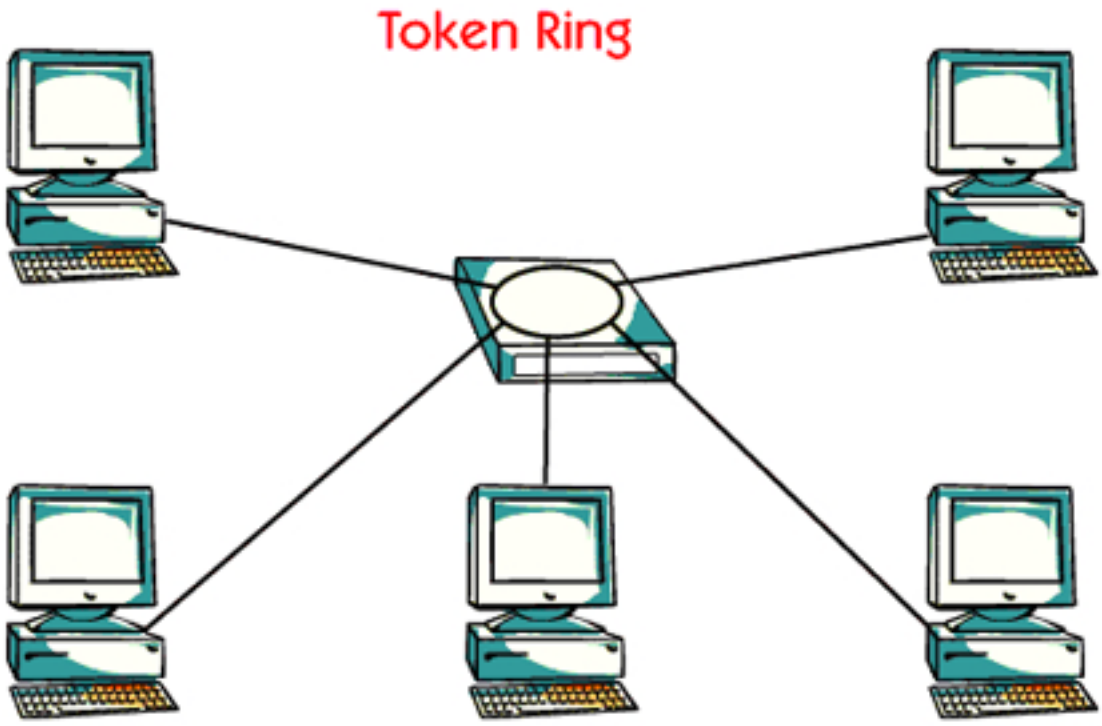
Ethernet, as defined in IEEE 802.3 standard, can use both star and bus topology with bandwidths between 10 and 100 Mbps. Ethernet is today the most common technique used in Local Area Networks.
Digital uses Ethernet for communication between their products. This picture represents an early implementation by Digital. You can see that Vax computers can be accessed by VT220 terminals, through a terminal server.



Sun microsystems was one of the earliest manufacturers of UNIX workstations. Sun had an early vision that ”The network is the computer”. SUN is using Ethernet and TCP/IP as a strategic platform. Since every UNIX workstation and UNIX server comes with an Ethernet card and TCP/IP software, it is ready for direct connection to the network.
For the PC market, SUN has developed PCNFS software, so that a PC can communicate with SUN equipment.



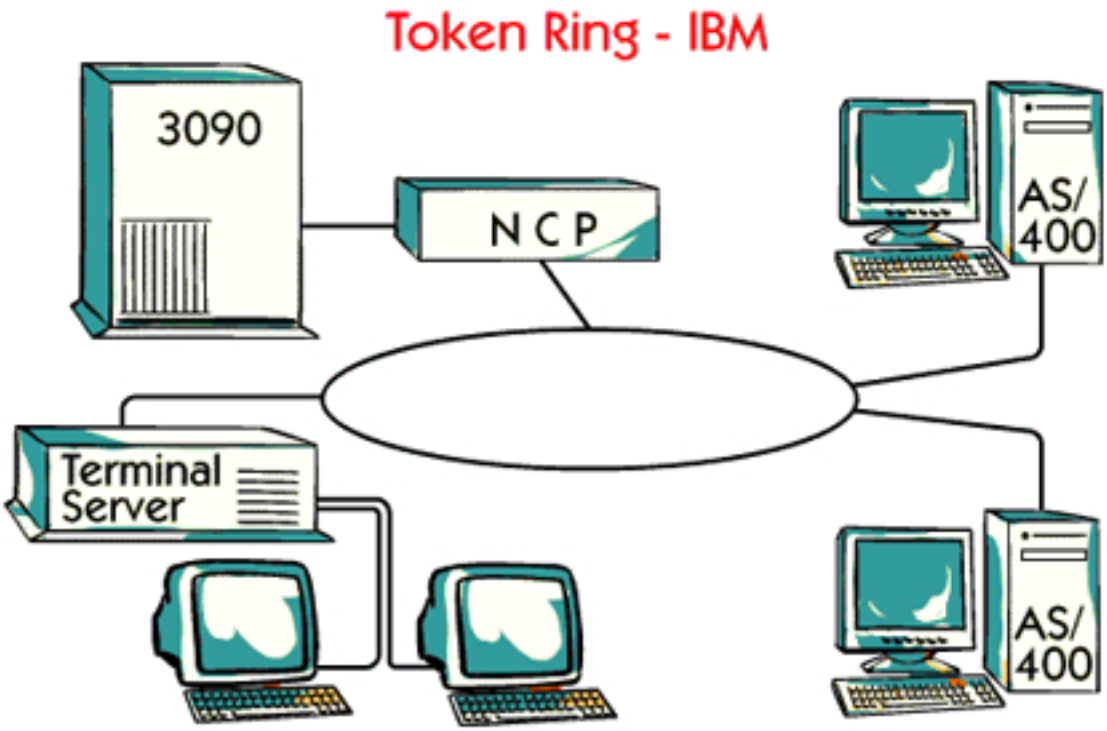
Ethernet can be used to connect equipment from different vendors. Different protocols can also be used at the same time on Ethernet. For example Novell's IPX/SPX can be used together with TCP/IP. Almost all modern computers, printers and network components can connect to Ethernet.
In this picture you have three environments, Novell, SUN and Digital, co-existing at the same time on a single Ethernet. Although these three environments cannot communicate with each other in this configuration, they can still use the same Ethernet.



Token Ring was introduced by IBM in 1987 and became their main architecture. The standard for Token Ring from IEEE came in 1989.

Token Ring is physical star and logical ring topology. This means that you connect the computers physically in a star configuration to the hub, but the computers still pass the access rights with help of a token in a ring.

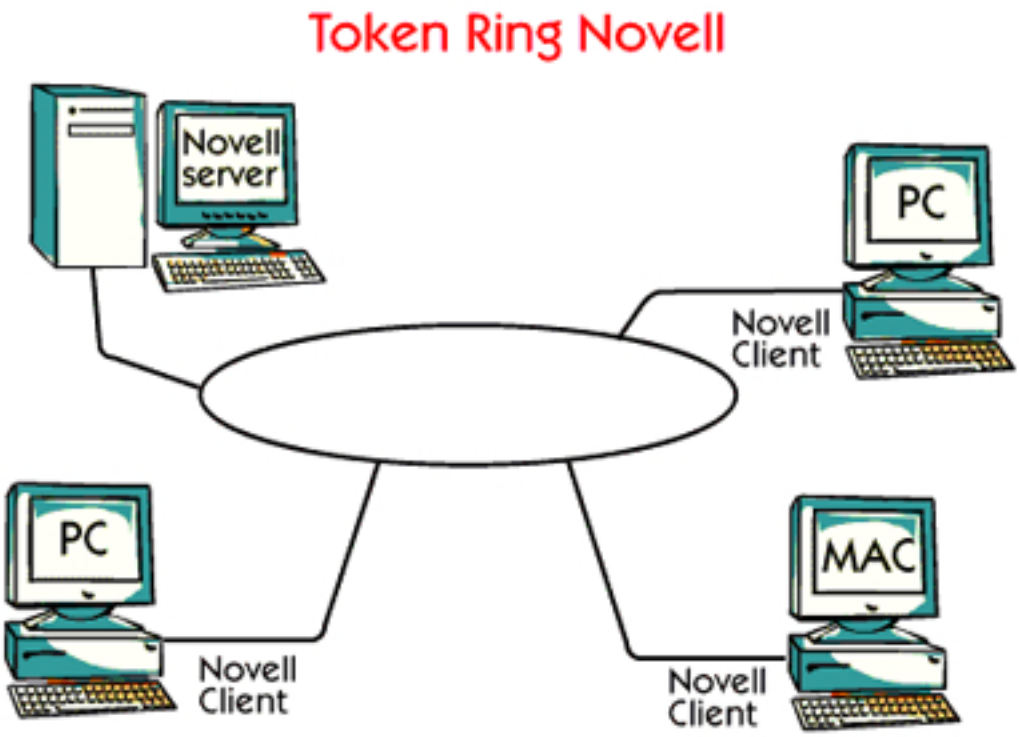
The bandwidths used in Token Ring are 4 or 16 Mbps.



In this picture we see an IBM implementation of Token Ring. An IBM mainframe 3090 cannot directly communicate with the Token Ring. To do that it needs an NCP which is a dedicated computer that only handles the communication between the mainframe and the Token Ring network.

The users sitting on terminals can access the data from the mainframe through a terminal server. There can be several thousand terminals connected to a mainframe.

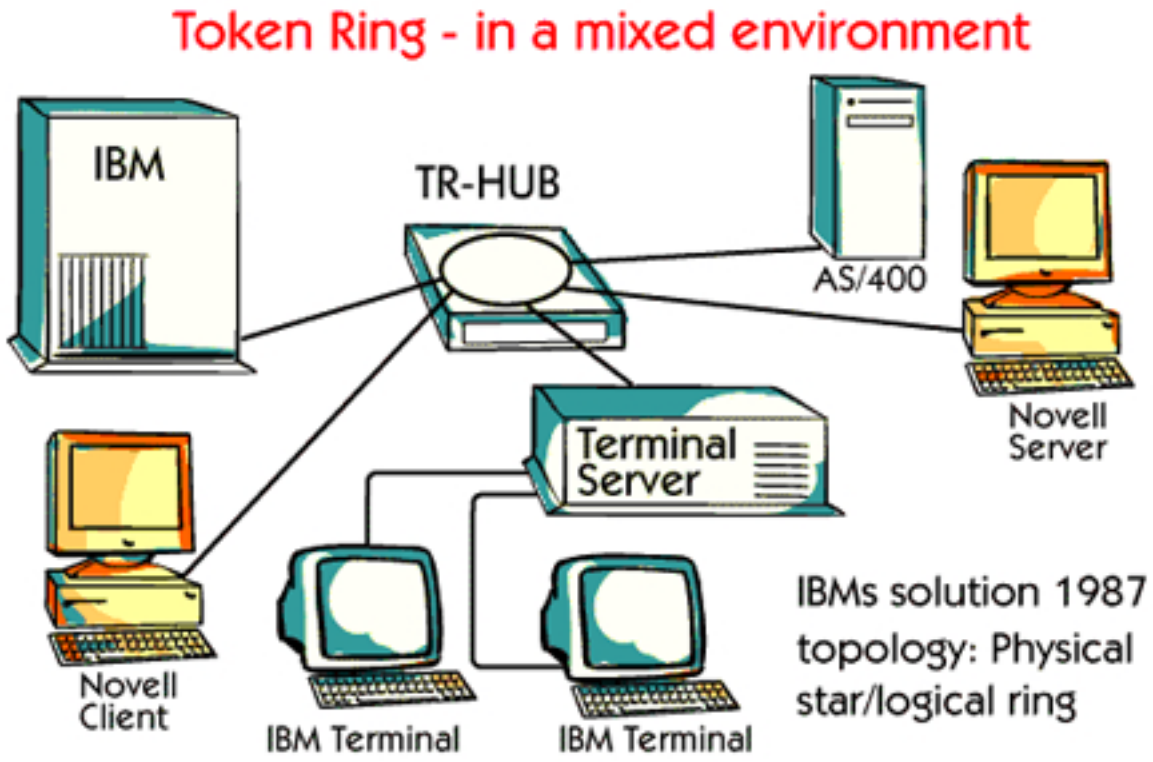
Another possibility is to use mini computers such as AS/400. These mini computers can be accessed by directly connected terminals as in the picture, or from a terminal server.



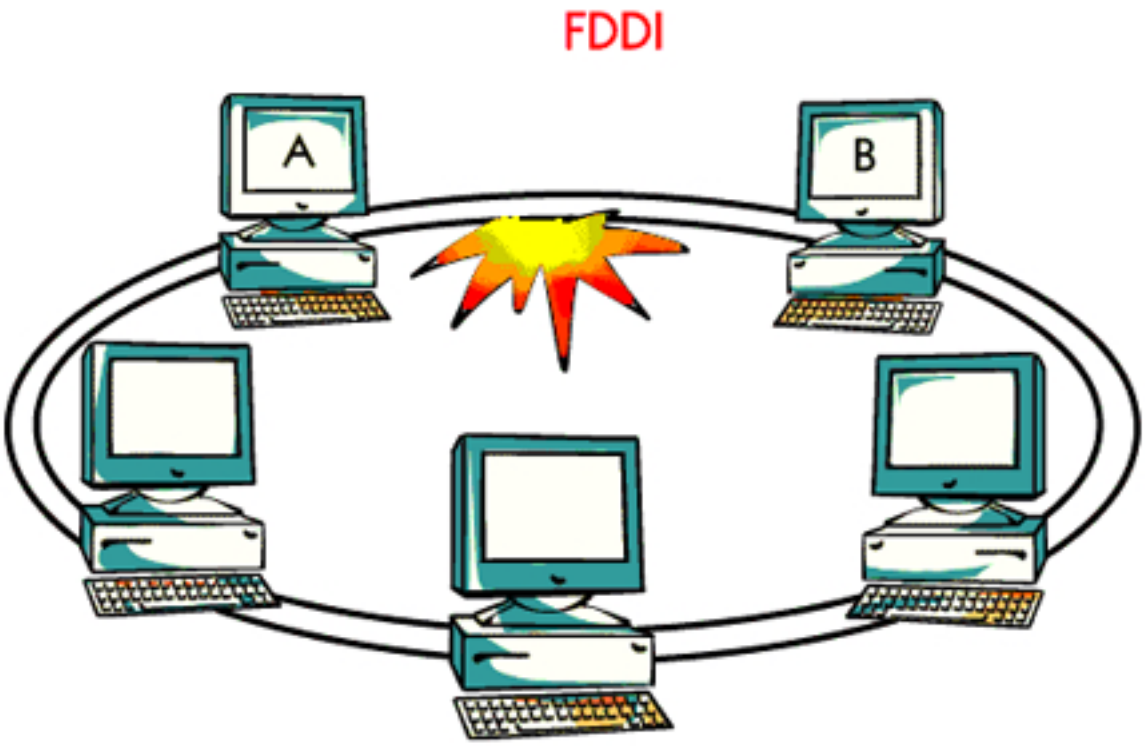
A normal way for an organization to go from mainframes to more modern computers is to use the existing Token Ring network but to change the earlier IBM devices to personal computers.

Novell was one of the first to see this market and they are using Token Ring to connect their servers and clients together.

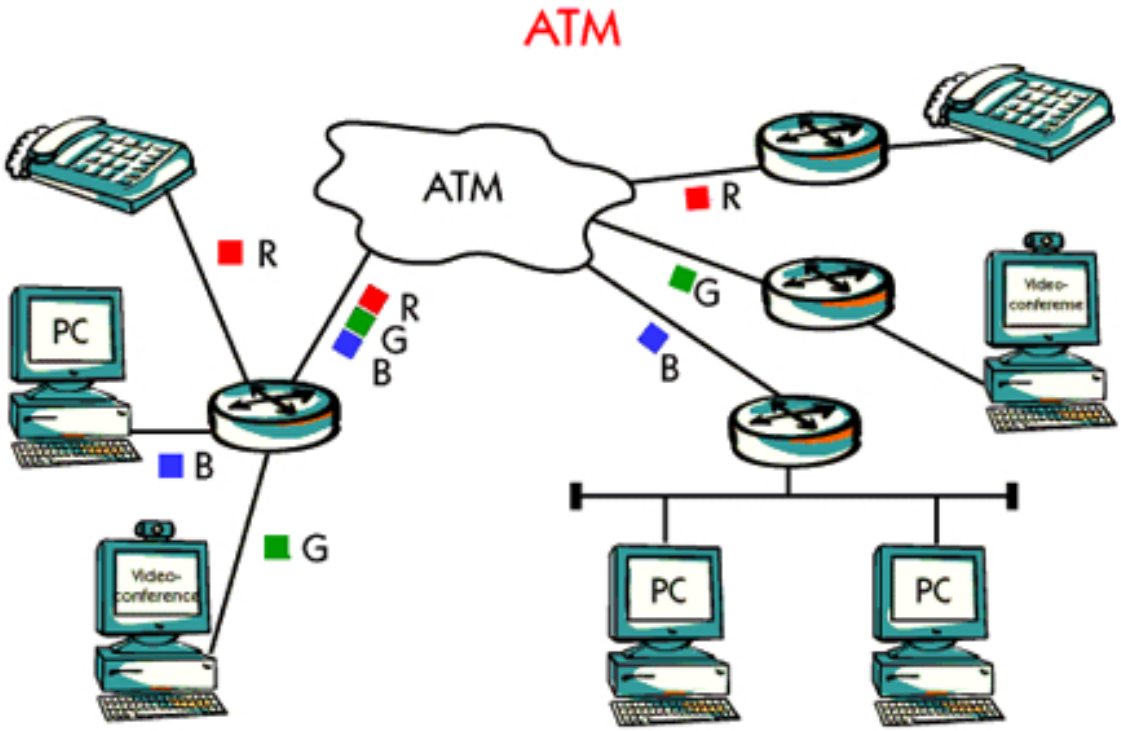
In the picture you can see a typical configuration with different types of personal computers working as Novell clients and servers.



Token Ring is mainly used to connect equipment from IBM and Novell.
In this picture you have two environments, IBM and Novell, co-existing on a single Token Ring. Although these two environments cannot communicate with each other in this configuration, they can still use the same Token Ring.



FDDI stands for Fiber Distributed Data Interface. FDDI standard was developed by ANSI, the American National Standards Institute. It is based on the use of double optical fiber cable and provides for a token-passing ring configuration, operating at 100 Mbps.
FDDI is being developed to deal with the requirements of high-speed LANs, MANs and backbone networks. Since FDDI consists of two fiber rings, primary and secondary ring, there is good redundancy and high availability. Normally traffic only flows on the primary ring, but if the primary ring is broken then the secondary ring is used.



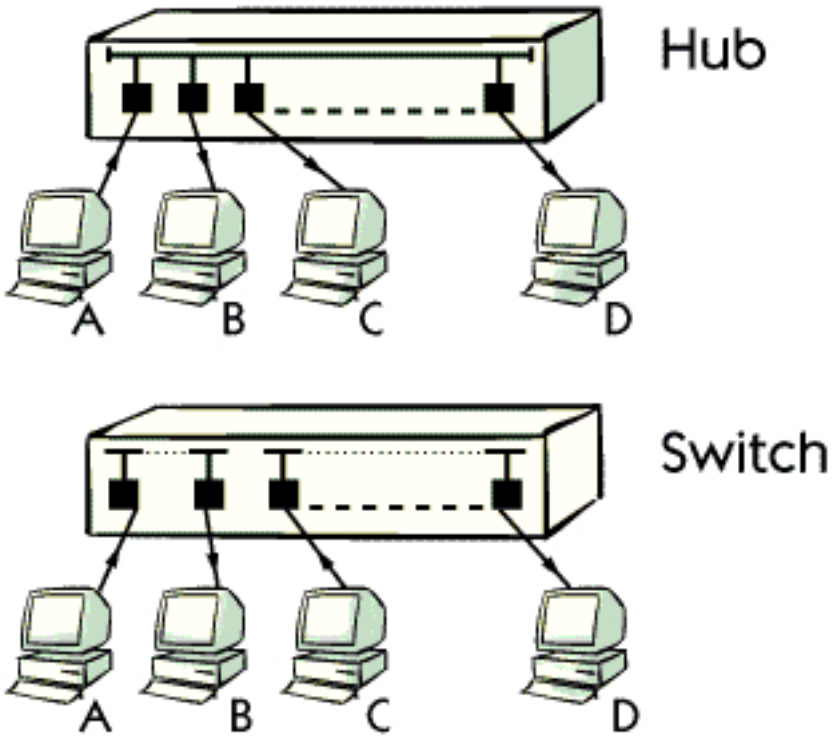
ATM, which stands for Asynchronous Transfer Mode is a ”de facto standard” developed by the ATM Forum and is a switching method of communication, which can be used in both LANs and WANs.

ATM specifications are being written to ensure that ATM smoothly integrates numerous existing network technologies.

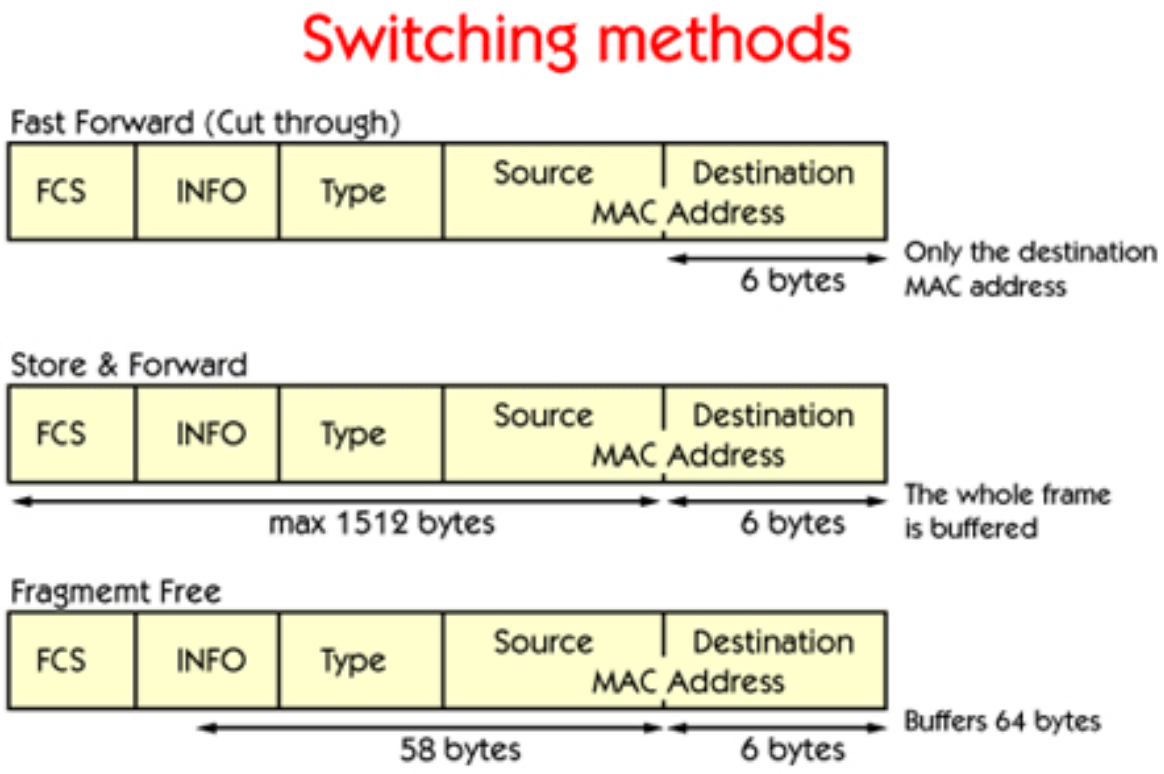
Today, in many instances, separate networks are used to carry voice, data and video information, mostly because these traffic types have different characteristics. For instance, data traffic tends to be "bursty" while voice and video tend to be more "continuous". With ATM, separate networks will not be required. ATM is the only technology which from the beginning, was designed to accommodate the simultaneous transmission of data, voice and video.

ATM is available at various speeds but the most commonly used are 25, 155 and 622 Mbps.

LAN Components



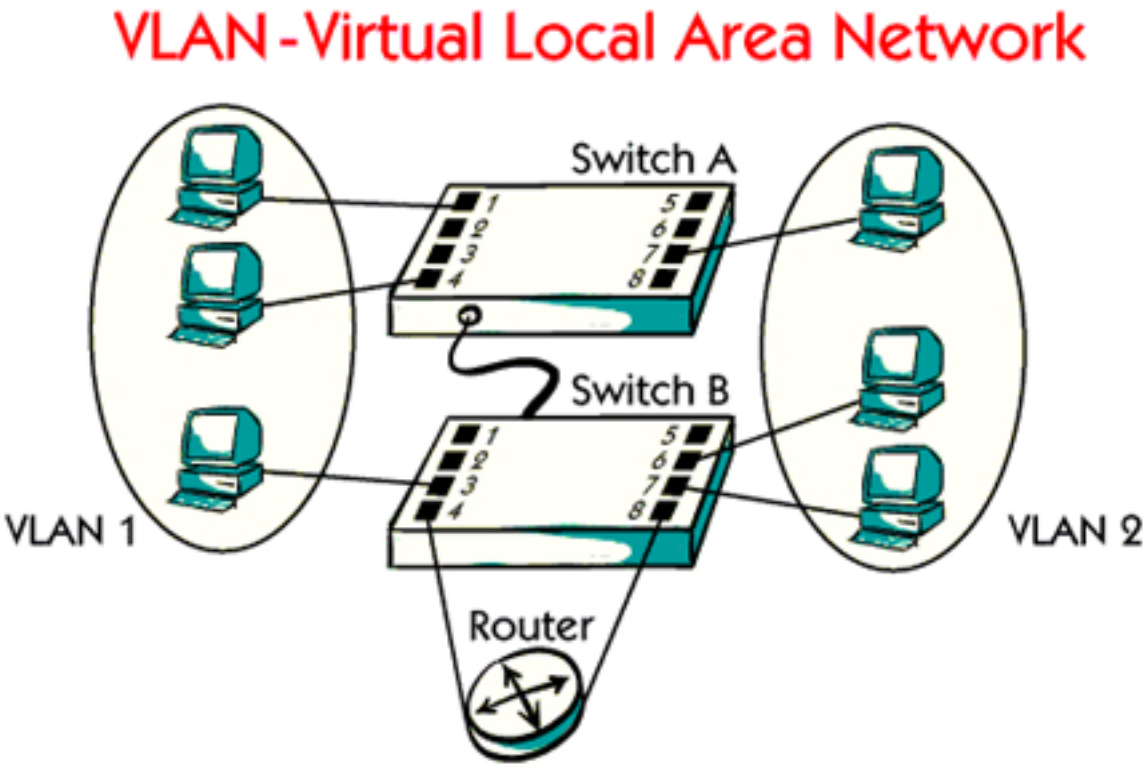
A hub is a commonly used device for connecting hosts to each other, using bus or ring topology. Each host is attached to a hub via a port. When a hub receives a signal on one port it transmits that signal to all other ports. Many hubs also regenerate and amplify weak signals before re-transmitting them.
A switch is a multiport device that handles routing between different hosts based on their MAC addresses. A switch ”learns” MAC addresses from the hosts that are connected to the switch, and stores them in an internal table. When two hosts communicate with each other, the switch creates a temporary connection path between them. This means that only two hosts will hear each other and not like the hub where everyone hears everything. For example if host A and host B have a conversation with each other, then host C and D can also communicate at the same time without any disturbance from host A or B. There is also possibility for one host to broadcast, which means that the packets will be transmitted on all ports in the switch.
Switches improve the performance of a LAN in two ways. First they increase the available bandwidth for each host, since the collisions are avoided.The second improvement is the security. A user on a host connected via a hub, can by using a sniffer software, hear other conversations. This is not possible in a switched network.



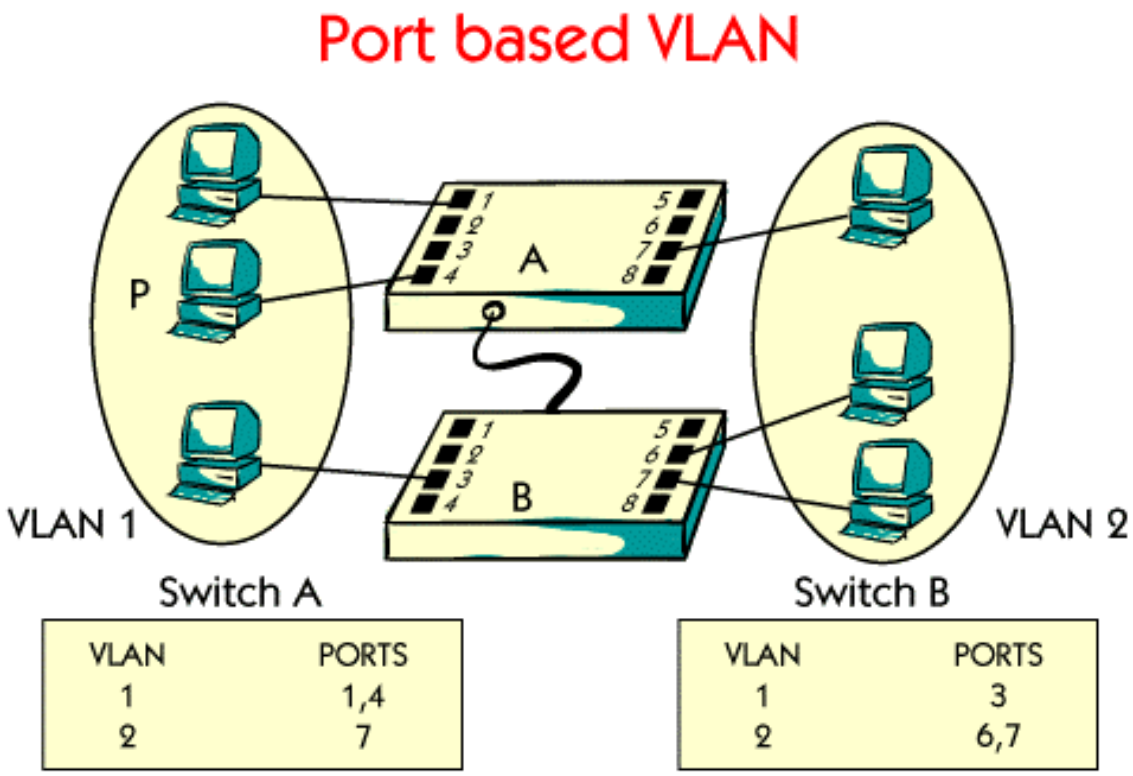
Fast Forward
Fast forward or cut-through switching is the fastest way of forwarding packets thorough a switch. The switch forwards the packets as soon as the switch is able to determine the destination MAC address. Although this generally reduces network latency, fast forward switching doesn't verify the checksum and consequently allows bad packets to pass, which can reduce the available bandwidth. In fast forward switching the sending direction is never established which means that two hosts can send to each other simultaneously which will lead to a collision.

Store and Forward
In Store and forward switching the switch waits until the entire packet is received before sending it to the destination. This lets the switch verify the packet's checksum and eliminate the possibility of forwarding bad packets. While the packet is stored in the buffer of the switch, the transmission direction is established, which means that no collisions can occur. A disadvantage with store and forward switching is that a delay occurs because the switch needs time to buffer and analyze the packet.

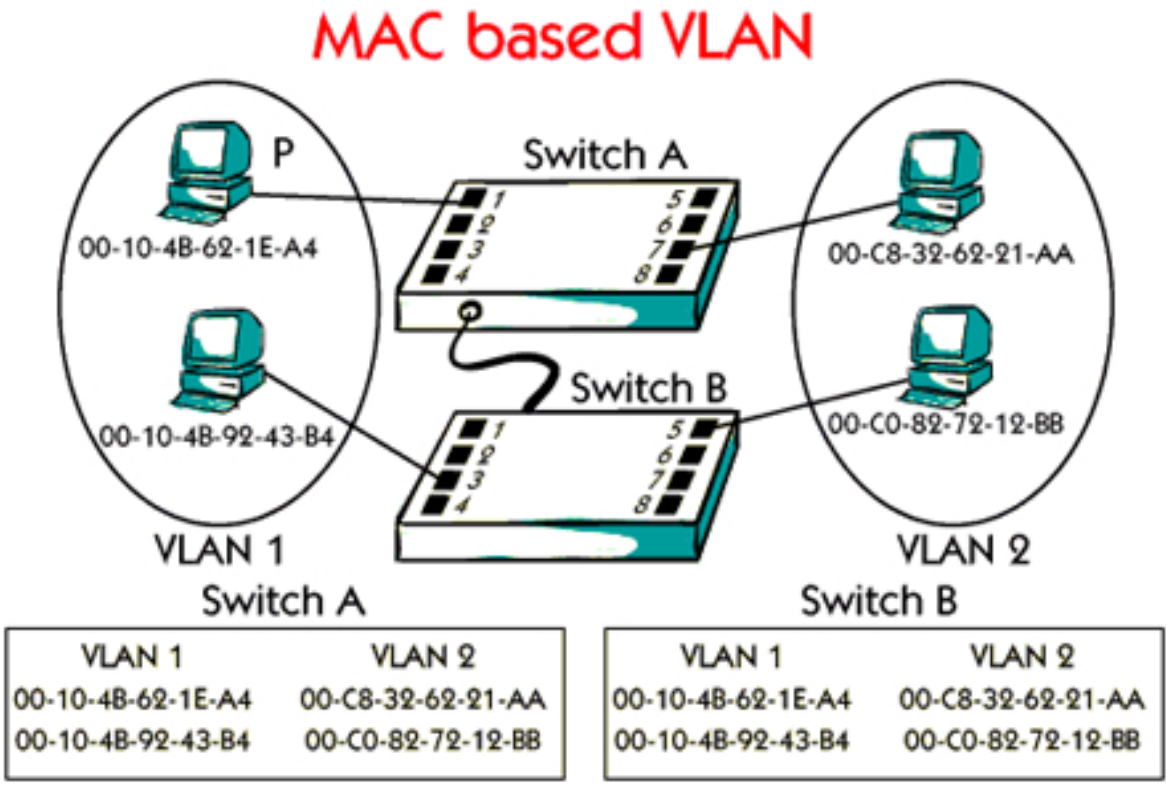
Fragment Free
The fragment free switch works just like fast forward, but it buffers 64 bytes of every packet in order to avoid collisions.



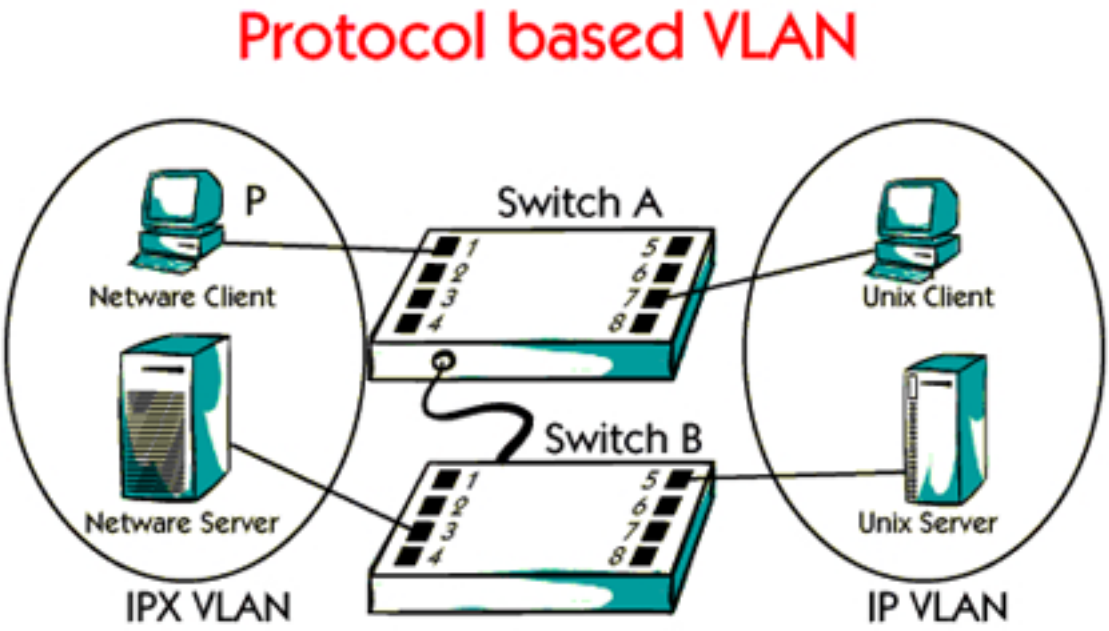
A switch makes it possible to configure something called VLAN. A VLAN, which stands for Virtual Local Area Network, is a logical LAN consisting of a group of hosts. One physical LAN can be divided into several VLANs. A VLAN can be configured by one or several switches, which makes it possible to be geographically distributed but having a logical presence. Users of the same VLAN can communicate with each other at LAN speeds and with no router latency.
There are different solutions for communication between VLANs, but the most common way is to use a router. The router is sometimes integrated in the switch.



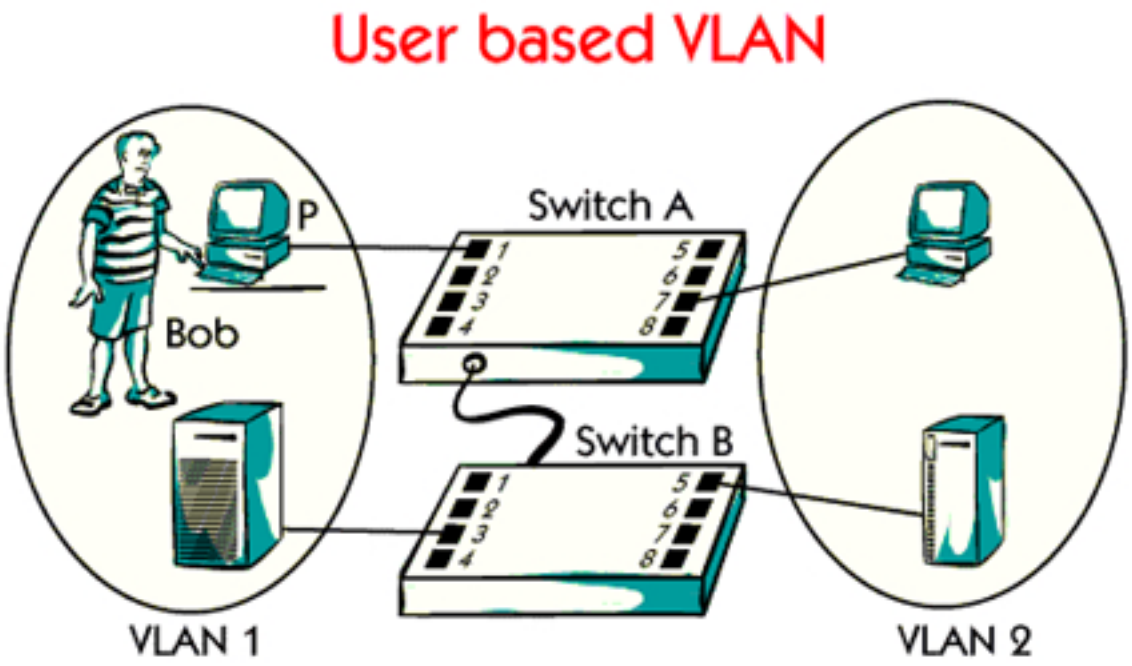
There are a number of different sollutions to create VLAN. Port based solution means that a host belongs to a particular VLAN based on which physical port in the switch the host is connected to. For example, the host P in the picture is connected to port 4 of switch A, which means that host P belongs to VLAN 1, as can be seen in the left table.



Mac based VLAN means that a host belongs to a particular VLAN based on which MAC address the host has. MAC based VLAN is independent of which physical switch port the host is connected to. For example, the host P in the picture has the MAC address 00-10-4-B-62-1E-A4, which means that host P belongs to VLAN 1, as can be seen in the left table. As you can see the same MAC address of the host P is also in the table for switch B. This means that if we connect host P to any port of switch B, the host P will still belong to VLAN 1.



Protocol based VLAN means that a host belongs to a particular VLAN based on which protocol it uses for communication. For example, the host P in the picture is a Netware client which normally uses IPX protocol, which means that it belongs to IPX VLAN.



In the future there will be other VLAN solutions. One promissing solution, that many poeple wait for, is user based VLAN. When a user logs on a particular host, the user identity is anylized by the switch and then the host becomes a part of a particular VLAN. For example, the user Bob logs on the host P in the picture with his own user ID and password. The switch A decides that Bob belongs to VLAN 1.