Chapter
2

TRANSMISSION TECHNIQUES AND CABLING

SYS-ED/
COMPUTER
EDUCATION
TECHNIQUES, INC.

Objectives:

You will learn:

- Network transport protocols.
- Implementing concurrent multiple protocols.
- NWLINK.
- NWLINK configuration options.
- TCP/IP.
- TCP/IP configuration options.
- TCP/IP diagnostic commands and utilities.

1 Transmission Techniques

There are two main transmission techniques that might be used in a LAN.

C Analog Technology	C Digital Technology

Within this framework, networks can classified as baseband or broadband.

Baseband LANs, such as Ethernet, Arcnet, and Token Ring, are much more common in the office environment.

Broadband LANs are popular where multiple services are required such as environments utilizing voice and interactive multimedia applications.

Analog Technology

Analog signals are continuous waves of either voltage or current amplitude. Information is transmitted by varying either the amplitude or the frequency of the waves.

C When the amplitude of the signal is varied, the technique is called Amplitude Modulation (AM).

C When the frequency of the signal is varied, the technique is called Frequency Modulation (FM).

2 Broadband System

A "broadband" system has the capability for transmitting a broad range of analog frequencies over a single cable,

Broadband LANs work in much the same way that cable television works.

Broadband LANs transmit multiple radio frequency signals on the same cable, usually coaxial but sometimes fiber. This ability to send many types of communication simultaneously over the same cable, including voice, video, and data, distinguishes broadband LANs from the far more common baseband LANs.

To accomplish this feat, broadband LANs use a technique called frequency division multiplexing.

Frequency Division Multiplexing

Frequency division multiplexing is used to put several channels on the same cable simultaneously. To understand frequency division multiplexing, think of the cable as a highway. A highway has a width, which determines how many lanes are possible; the cable has bandwidth, which also determines its capacity. Highway width is measured in feet; LAN bandwidth is measured in cycles per second (Hertz) or frequency.

Each "lane" or channel on a cable uses a different set of frequencies. Just as cars traveling on different lanes of a highway do not collide, information traveling at different frequencies on the same cable do not interfere with one another. Thus, frequency division multiplexing sends its different types of information at unique frequencies.

Frequencies are sent in analog, not digital, form. Digital signals are discrete--one or zero. Analog is continuous, like a wave. To reconcile this difference, digital computer data must be converted into analog form for transmission over a broadband cable. This converter device is called a broadband modem. Once it converts the data to an analog form, the broadband modem puts the data on the correct frequency and channel.

The following factors affect the performance of a broadband system.

- Coaxial cable can reliably support communication over a wide range of frequencies. The broader the bandwidth, the higher quality of cable required.

- All but the smallest broadband systems require analog amplifiers to force the signal down the length of the cable.

  These amplifiers must have a flat output over a range of frequencies. The broader the frequency range, the more expensive these amplifiers become.

- The broader the bandwidth, the larger the number of assigned frequencies available, and the larger the number of devices and communication paths that can be accommodated.

C Each device on the network requires an analog radio frequency modulator/demodulator (RF modem) to allow it to send or receive on its assigned frequency; it is often built into the NIC.

C By means of a switchable or multifrequency RF modem, devices on different frequencies can communicate. Some control logic must be incorporated into the modem to control the switching from one frequency to another.

C Devices on different assigned frequencies cannot communicate with each other without additional frequency translation equipment.

Each channel in a broadband system is separated from the adjacent channel by a guard band, a frequency range over which no data will be transmitted.

For example, consider your cable TV. If you turn into one channel and turn the fine-tuning knob until you begin to bring in another station, you will see a pattern of snow between the two. This is the guard band.

The simplest broadband LAN will be split into two channels, one for inbound data, one for outbound. Each of these gross channels may be split into two or many more channels.

The total bandwidth in a single commercially available cable is 400 megahertz (400 million cycles per second). In a midsplit system, frequencies from 5 to 108 MHz are reserved for inbound signals, frequencies from 162 to 395 are reserved for outbound signals.

Broadband frequencies need not be split down the middle. A system may be sub-split. For example, frequencies from 5 to 30 MHz could be reserved for inbound traffic, and frequencies from 54 to 395 MHz reserved for outbound. These systems are most often used to accommodate heavy video traffic.

Full-motion video is the only LAN application that requires an exclusive channel and therefore a broadband system.

2.1 Broadband Tree and Branch Topology

Broadband LANs use a tree-and-branch topology. The root of the tree is the headend, or central retransmission facility. The trunk cable is attached to this root.

Various branch cables are attached to the truck cable. From there, user devices may be connected. Although most broadband networks use a single cable, some use a dual cable system, one for each direction to and from the headend. A dual cabling system has twice the bandwith of a single cable system.

A headend is essential. All transmissions must pass though the headend, because each device transits on one frequency and receives on another. The headend is responsible for translating the device's transmit frequency to the receive frequency of another device. This frequency translation is called remodulation.

When transferring a file, from one PC to another PC, the PC sends the file to its broadband modem, where it is modulated into analog form. The modem sends data at one frequency, called the return frequency and receives at another called the forward frequency. These terms sound reversed because they are named from the headend's point of view.

Before getting to the headend, the signal probably passes through several splitters and couplers, where the signal loses strength. It also passes through amplifiers, where the signal gains strength. According to the principle of unity gain, the signal must arrive at the headend with the correct strength, usually at a level lower than the transmission strength.

At the headend, the packet is translated from the return frequency to the forward frequency then sent back onto the cable to the receiving PC. The trip to the receiving PC is just like the trip to the headend, except in reverse. Once at the receiving PC, the receiving modem translates the file back to digital form so the PC can understand it.

Forward and return frequencies make a pair. The headend can handle more than one pair of frequencies, although it cannot mix and match them.

One complex part of designing a broadband LAN is deciding which information will travel on which frequecies. In many designs, the bandwidth is divided into 6MHz slices, which a television channel uses. Each type of communication takes one or more slices.

In general, higher speed communication services, such as Ethernet and data services, take up larger chunks of bandwidth than slower services, such as security and voice communications.

2.2 Broadband Tree and Branch Topology Unity Principle

All components of a broadband system either amplify or weaken the signal strength.

As radio frequency signal travel down a cable, they deteriorate or experience signal loss. Devices on the broadband network, such as splitters, couplers, power inserters, and equalizers, also cause loss.

The amount of loss experienced by a particular signal depends on many factors:

- Diameter of the cable.
- Components it encounters.
- Distance it has traveled.
- Frequency.

Broadband LANs are equipped with devices called amplifiers to counter act this unavoidable loss. Amplifiers attach to the cable in certain places and regenerate signals to a level determined by the system design. Any distortion the signal has picked up is also amplified.

The goal in designing a broadband system is to reach unity gain.

Unity gain means that the amount of loss caused by the components in the system is equal to the amount of gain caused by amplifiers in the system. Achieving unity gain is complicated since the amount of loss imposed by a component depends on the signal frequency. Thus, amplifiers and other components are placed strategically to keep signal conditions uniform as signals move from device to device.

Since different frequencies are affected differently by various components on the network, achieving and maintaining unity gain is an arduous task. Consequently, broadband LANs--far more so than baseband LANs--require trained professionals for design and installation.

Broadband systems are best suited for large installations with large staffs of networking professionals, although smaller installations that require multiple service types can also benefit from broadband.

2.3 Broadband Standards

Supported US access rates to a public WAN supporting cell relay service include:

• DS3	• STS-1	• STS-3c	• STS-12c

The physical access channel can be a T3/DS3 or SONET-BASED (STS-3c or STS-12c) facility.

ATM cells must conform to ITU-T Recommendation I.361. Cells are transported to their destination(s) with a level of assurance consistent with the selected quality of service, of which a number of classes may be available.

3 Digital Technology

Digital signals do not continuously vary as do analog signals. They have only two conditions, on or off, corresponding to two known levels of voltage or current. The pulses produced by turning the voltage or current on or off are known as bits.

Individual bits are sent at a known rate, and the presence or absence of either a high or low level on the line signifies either an on or off condition. Patterns of bits are used to represent numerals, characters, system commands, or other information.

Systems that use digital technology are called "baseband" systems.

4 Baseband System

Baseband technology allows several devices to share a cable by means of a time-sharing technique.

Each device is assigned a specific time slot some thousandths or millionths of a second in length in which to transmit. Only one device can transmit in a given time interval.

This technique is called time division multiplexing.

Baseband transmission is associated with specific network and performance characteristics.

- Many types of media can be used, such as twisted pair, coaxial cable, and fiber optics.
- There must be a protocol included in the network to assign time slots and provide access to the network.
- Modems are not required to connect devices to the cable when communicating digital information.
- Any number of devices can be used for transmission or reception of information, without complex added equipment, as long as there are enough slots available.

5 Analog vs Digital: A Comparison

Broadband (analog) transmission is generally regarded as a higher throughput technique because of the ability to simultaneously transmit multiple signals over a single cable.

Transmission Rate

Baseband is a highly efficient way of moving data from one piece of digital equipment to another. Hundreds of millions of data bits per second can move along the cable, with no slowdowns for analog conversion. These data bits, however, must move single file, and there is a finite limit to the total number of bits that can be transmitted during any given time period.

The transmission rate advantage of broadband transmission is rapidly disappearing, however, with recent advances in digital technology, particularly in fiber optics, allowing digital baseband transmissions to rival, and even exceed broadband analog transmission speed.

Cost

Baseband technology has benefitted substantially from continuing advances in integrated circuit technology. Installation, device connection, and control of communication traffic are all less expensive for digital networks than for analog networks.

Broadband cable per foot is less expensive than baseband. The additional hardware needed (modems and directional couplers) to modulate the data signal for analog transmission from point to point and the more complex design engineering required will however raise the cost of installing broadband.

5.1 Which Transmission to Choose

There are two critical variables.

1. Will you be running full-motion video as well as other applications?

   If yes, you need broadband.

2. What volume of data do you expect to transmit along the LAN?

   If a single high-speed channel will be adequate to meet your needs for the next five years, you don't need broadband.

You might also consider broadband if you will be installing the network in a high noise environment. However, baseband coaxial media such as Ethernet can conquer most noise problems. The cable can also be shielded.

In order to implement either of these transmission techniques, you will require a specific type of cable.

6 Terrestrial and Free-Space Media

LAN media are of two types: terrestrial and free-space

- Terrestrial

  Include twisted-pair wiring, coaxial cable, and fiber optic cable.

- Free-space

  Utilized in highly specialized situations, includes digital microwave and infrared light beam transmission.

If you were going to build a private road for vehicles to travel in and around your organization's site, you would think about how much traffic that road would need to accommodate and what kind of traffic - 18-wheelers, commercial vans, passenger cars, bicycles. You wouldn't spend the money to build a superhighway for a small amount of lightweight traffic. Under certain circumstances, you might decide that a combination of roads is the most cost efficient solution.

6.1 Terrestrial Media: Twisted Pair

The twist provides isolation from other conductors in the same cable and improves the immunity to electromagnetic interference.

1. Varying the twist length reduces the coupling between pairs.

2. Flat cable is more susceptible to electrical interference.

Common gauges range from #19 to #26, with conductor size decreasing with higher gauges.

1. Larger conductors transmit current more efficiently.

2. Larger insulation improves high frequency response.

Insulation on early cable was primarily paper or pulp, but PIC (polyethylene insulated conductor) is now most prevalent.

Foamed insulation in low capacity cable provides improved high frequency response.

Bandwidth capabilities vary widely with distance:

C To 13 Mbps with 6000 ft. repeater spacings over conventional twisted pair.

C To 63 Mbps with 15,000 ft. repeater spacings over low capacity cable.

C Higher digital rates achievable over shorter distances.

C LANs on twisted pairs run at various speeds - up to 100 Mbps.

Shielding reduces interference in high frequency data transmission applications:

C Also reduces cable bandwidth by increasing capacitance.

C Locap thick shielded twisted pair reduces the capacitance and allows very high bandwidth.

6.2 Terrestrial Media: Copper Wire

Unshielded Copper Wire

- Unshielded Twisted Pair (UTP)

Unshielded twisted pair is the most widely used form of copper wire cable. It is suitable for voice frequency and low frequency data communication. Because of its disadvantages (lack of speed and low noise immunity), it does not lend itself to use in high performance Local Area Networks. Transmission rates for unshielded twisted pair are typically implemented at 64 thousand bits per second, and in most cases are limited to 512 thousand bits per second or less.

Twisted pair is comprised of two copper wires, usually 22, 24, or 26 gauge, wound around one another so each wire receives the same exposure to interfering signals.

Shielded Copper Wire

- Shielded Twisted Pair (STP)

There are several variations of shielded copper wire cable, but most common are two basic types, shielded twisted pair and coaxial. Shielded twisted pair maintains much of the economy and simplicity of use as common twisted pair wiring, it reduces noise and interference with the added shielding.

The freedom from electrical interference and cross talk allows shielded twisted pair to be used at transmission speeds of up to 10 million bits per second. Line losses are less than for unshielded wiring, but line amplifiers are required for extended runs and add to your costs.

A twisted pair LAN can theoretically support up to 1,000 devices spread over a distance of up to 15 miles.

- Coaxial Cable

Coaxial cable is available in a variety of forms, the most common being a flexible, single conductor type for general use. Higher grade cable is required for broad bandwidth applications, such as high speed data transmission. In addition to standard coaxial cable, there are several other types used in LAN applications.

Cable designed for cable television (CATV) provides greater bandwidth, about 350 million bits per second, and lower losses than other grades of coaxial. CATV has some limitations because of its rigidity and thickness. Over long distances, signal amplifiers must be used.

Twin-axial and tri-axial cables house more than one conductor in a single cable. Twin-axial cable is easier to install than two separate cables.

A center conductor wire carries the transmission signal in coaxial cable. It is insulated by nonconducting materials, such as PVC or teflon. This material is then surrounded by another conducting material - usually solid copper or a woven mesh of fine copper wire - all encased in another layer of insulation, sometimes called a sleeve. The outer sleeve may be extruded aluminum.

Coax costs three to four times as much as twisted pair. Maximum speeds achievable on coax range are about 10 million bits per second. Bandwidth and traffic are deciding factors. Coax is not as easy to tap as twisted pair. Tapping coax requires piercing and coring the cable, then clamping on a tap. Coax offers much more potential for expansion than twisted pair. But, it is easy to end up paying for a lot of unused potential.

6.3 Terrestrial Media: Optical Fibers

Optical Fibers:

- First proposed for communications in the late 1960's.

- Steady improvements in the attenuation of glass and the lifetime of lasers made fiber communications commercially feasible in the late 1970's.

- Several advantages over conventional communications.

  1. Low attenuation allows for long repeater spacings:
     - 200 km between repeaters in laboratory systems.
     - Up to 50 km in commercial systems.

  2. Very large bandwidth capability for digital systems:
     - Information capacity increases as carrier frequency gets higher.
     - Up to 1.2 Gbps in commercial service.
     - Laboratory systems to 20 Gbps.
     - Future may bring 100's of Gbps.
     - Larger bandwidth does not demand larger fiber.

  3. Small and lightweight:
     - Allows efficient use of ducts.
     - Minimal loading on bridges and poles.
     - Many alternative cable designs.

  4. No emitted radiation:
     - Good security characteristics.
     - Minimal crosstalk.

- Immune to electromagnetic interference.

Disadvantages:

- Requires electro-optic transducers to convert from electrical to optical energy.

- More precise alignment in splices and connectors.

- No pure optical repeaters, at present.

- Cannot power repeaters over same conductor.

- Uncoated fiber is susceptible to breakage.

Light Sources and Detectors

C Sources:
- Surface-emitting LED (Light Emitting Diode).
- Edge-emitting LED.
- Laser diodes.

C Detectors:
- PIN diode (Positive-Intrinsic-Negative).
- Avalanche photo diode.

Fiber Propagation

C Fiber consists of two layers, core and cladding.

• Speed of light is slower in core since core has a higher refractive index than cladding.

• Leads to total internal reflection.

6.4 Terrestrial Media: Fiber Optics

Fiber Optics:

- Fiber optic cable is a lightweight, rugged, high-security medium that provides very high speed and high capacity, along with freedom from noise and electrical interference.

- Fiber optic cable transmits light over glass or plastic fibers. Each highly refractive fiber is surrounded by cladding with slightly lower refractive properties to isolate one fiber from its neighbors.

  One or more clad fibers make up the core of the cable.

  A plastic jacket surrounds the core to protect the cable from environmental damage.

- Fiber optic cabling's prices are falling quickly.

  Most experts expect fiber optic to be the media of choice before the next century.

- Fiber optic is difficult to tap into, but is unparalleled as a backbone media, tapped by coax and twisted pair.

7 Centralized Premises Wiring Schemes

Centralized premises wiring plans specify cable, topology, connectors, signaling equipment, and wire closet termination methods for entire installations.

7.1 IBM Cabling System

The IBM cabling system was introduced in 1984 and intended as the backbone for its Token Ring network. The first such cables to be manufactured by third-party companies were tested by IBM, verified to IBM specifications, and given IBM part numbers.

At present, however, cable manufacturers have to rely on the ETL and UL independent testing laboratories or industry-standard manufacturers such as AMP, to verify compliance with the specifications by IBM.

Type 1 Data Cable	Is copper-based for data connections only. IBM terminology for a two-pair shielded twisted-pair, 22-gauge, data communications cable. It typically is used between a distribution panel or multi station access unit and a workstation.
Type 2 Data and Telephone Cable	The same as Type 1 cable, except it contains four additional twisted-pairs of unshielded, 22-gauge wire. It is used for voice, data and telephone transmissions.
Type 3 Cable Voice-Grade Cabling	A four-pair unshielded 24-gauge twisted-pair wire in polyvinyl-chlorided plastic. This is common telephone wire and is usually used with RG-11 connectors.
Type 4 Not Used	Reserved for future use.
Type 5 Fiber-Optic Cabling	A data communications fiber-optic cable containing two 100/140-micron (100 micron core surrounded by 140-micron cladding layer) multimode optical fibers. This cable is not defined by IBM.
Type 6 Patch Panel Cable	Provides for connecting a workstation to a wall faceplate or making connections within a wiring closet. The cable consists of two pairs of 26-gauge solid conductors in a flat sheath.
Type 7 Not Used	Reserved for future use.
Type 8 Cable (Under-Carpet Cable)	A cable containing two shielded, flat, parallel pairs of 26-gauge solid conductors. Its flat, tapered jacket makes it suitable for use under carpeting, but it suffers twice the loss characteristics of Type 1 or 2 cable.
Type 9 Cable (Plenum Cable)	A communications cable resembling Type 6, but its two twisted pairs of 26-gauge can be solid or standard conductors. It is a low-cost alternative to Type 1 cable when high performance or long distances are not needed. This cable is not defined by IBM.

7.2 Other Cabling Systems

AT&T Premises Distribution System (PDS)

Similar to IBM, but relies more heavily on unshielded telephone twisted pair.

PDS also integrates voice and data wiring. Connections are based on modular jacks/plugs and cross-connect techniques originally designed for voice PBX to telephone-set wiring, which use multipair cable.

AT&T is generally lower in parts cost than the IBM system, but is more labor-intensive to install.

DECconnect

The DECconnect system is based upon the use of ThinNet 50-ohm thin coaxial cable, commonly used on EtherNet networks. The system standardizes much of the connecting cable used in major DEC installations of VAX systems.

DECconnect also defines a line of protocol converters, line drivers, and satellite closet rack and termination hardware.

A significant number of DECconnect installations consist of an Ethernet backbone (central cable to which other cables connect) wired throughout a building, with taps (connection points) provided at VAX computer sites and satellite closets (a small room set aside just for communications equipment).

8 IEEE Baseband Cable Standards

10Base2	Specifications for running Ethernet over thin coaxial cable.
10Base5	IEEE's specifications for running Ethernet over thick coaxial cable.
10BaseT	IEEE's specifications for running Ethernet over unshielded twisted-pair wiring. A major advantage is that 10BASET wiring installation can be implemented as a star wiring scheme.
Thick Ethernet	A cabling system using relatively stiff, large-diameter cable to connect transceivers. The transceivers connect to the nodes through flexible multi wire cable.
Thin Ethernet	A cabling system using a thin and flexible coaxial cable to connect each node to the next node in line.

9 Free-Space Media

Free-space media is used in special situations. One situation is when an appropriate right of way cannot be obtained between two locations, such as two buildings.

Digital Microwave Radio

This media relies on radio technology to send the LAN signal from one station to another along a line of sight. This means there can be no trees or buildings in the way.

This type of network requires an FCC license.

Infrared Light Beam Transmission

This sort of transmission is done with mirrors. A laser or a light emitting diode produces light pulses, which are received and/or relayed by mirrors.

This medium also requires line-of-sight transmission, but is less vulnerable to weather.

9.1 Infrared

C Free space optical transmission may be useful in metropolitan or campus environments.

C Sources and detectors are similar to those used with fiber optics.

Lasers have greater directionality, but also may present eye hazards.

Most systems are classified as non-hazardous.

Narrower beam provides somewhat greater security than microwave.

C Primarily for digital signals.

C Point-to-point rather than multi-drop.

C FCC license not needed.

C Distances up to 5 miles, dependent on bit rate and weather conditions.

C Speeds of 1.56 and 4.5 Mbps depending on light source.

9.2 Microwave Radio

C Long distance communications typically use 2, 4, 6, 11 and 18 GHz carrier frequencies.

C 23 GHz systems becoming popular for short haul (GEMLINK, M/A-Com).

The T1 transmission rate common, 48 operating channels available.

It uses digital transmission.

C Requires line-of-sight.

C Up to 20 mile hops.

C Small antennas: 15 inches diameter, 10 lb. weight.

10 Summary: Baseband vs. Broadband

CARRIER	**DIGITAL BASEBAND**	**ANALOG BROADBAND**
MEDIA	TWISTED PAIR COAXIAL CABLES OPTICAL FIBERS	COAXIAL CABLE
SIMULTANEOUS CHANNELS	ONE	MANY
BANDWIDTH	TO 50 Mbps	TO 500 Mbps
DISTANCES	0.4 TO 4 MILES	1 TO 3 MILES
TOPOLOGIES	STAR, BUS, RING	TREE
ANALOG VIDEO	NO	YES
EFFORT TO DESIGN, IMPLEMENT, MANAGE	EASIER	HARDER
REQUIRES MODEM	NO	YES

This leads us to the physical configuration and connection of the hardware and cables.

11 LAN Topology

Topology refers to the physical layout of the medium that connects devices in the network.

- It is the spatial pattern formed by the physical links of a network.
- The points where devices connect to the medium are called nodes.
- Each topology has distinct characteristics that distinguish it from others.
- It's important to recognize the important implications of both the physical topology and logical topology of a LAN.

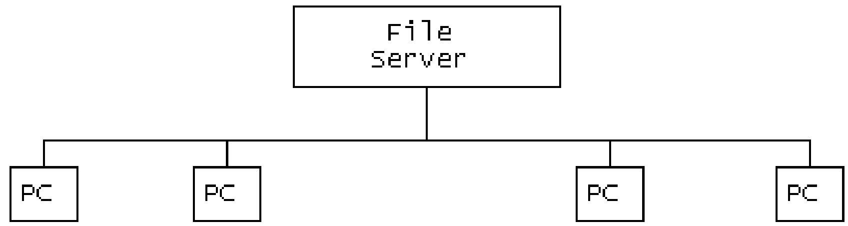
11.1 Choosing an Appropriate Topology

In some buildings, it may be impossible or prohibitively expensive to run cable or conduit along any pathway but one possibility would be to plan for a duct to be installed during construction to accommodate future needs for additional wiring.

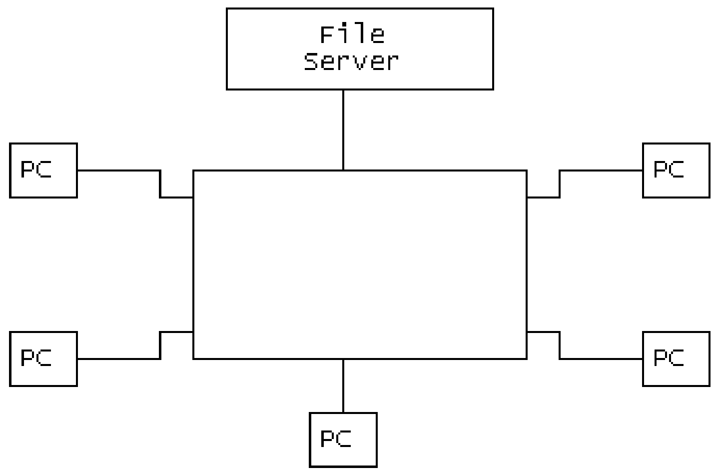
If so, the scope and placement of that duct will have a strong influence on your choice of topology.

Usually, it will point the way to a bus network as the least costly topology for at least that segment of the LAN.

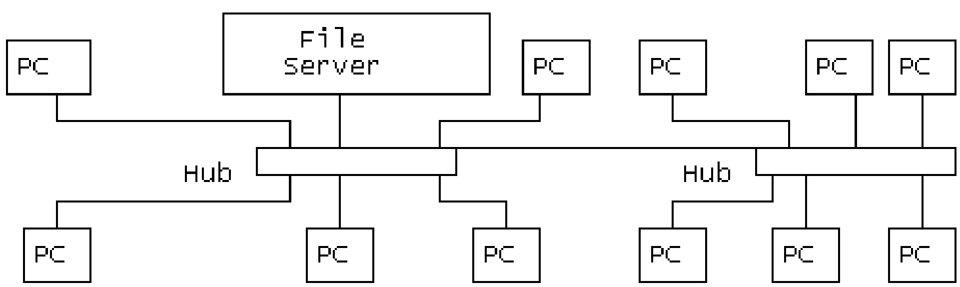
12 Cable Topologies



Bus Network



Token Ring Network



Distributed
Star

13 Star Topology

- The star topology is characterized by a number of nodes, each connected directly to a central controller.
- The connecting links can be bi-directional communication paths.
- All transmissions pass from the transmitting node through the controller to the receiving node.
- The central controller (server) manages and controls all communication.
- Failure of a particular node is easy to detect and remove.
- Failure of the server disables the network.
- All nodes are joined at a single centralized point.
- Routing is typically controlled at this centralized location, relieving the outlying nodes of control functions.
- Dedicated links to each outlying node simplifies the link control requirements.
- Network operation is dependent on the central node, suggesting the use of redundancy at this critical location.
- Inherently greater network security than other topologies, because the signal to each outlying node is transmitted only to that node, not to the entire network.
- Requires extensive wiring since each station has a dedicated physical path to a central location.
- Usually used with twisted pair cabling, but optical fibers are receiving increased attention.
- Most common examples are the voice and data PBXs.

13.1 Star Considerations

- A star topology relies on point-to-point transmission in either direction between a central host and each station.

- Since the network software is stored and operates in the host, that machine most likely will be "dedicated" to network tasks.

- The host is frequently part of a PBX system.

  Upgrading your PBX to handle intra-organization data could cut installation costs dramatically.

- Star networks are not unlike the old mainframe-terminal relationship, but with a virtual pathway among terminals.

  Communications between nodes will be much slower than from host to node because all inter-node traffic has to deal with "detours," plus host "bottlenecks".

- The capacity of the host is the largest single cost factor in installing a star network. Bottlenecks occur at the host, so the bigger and faster the better.

- Initial installation costs are normally higher for star networks, but lower cost medium can be used since the traffic between the host and node will be a fraction of the total network load.

- Expansion costs are also relatively low.

14 Bus Topology

- The bus can be a bidirectional communication path with defined end points terminators.

- All nodes are connected directly to the bus.

- A signal originating at a node propagates away from that node in both directions along the bus.

  Each node listens for its address on the bus. Recognizing its address, it accepts the data transmitted. Otherwise, it ignores the transmitted data.

- Control can be centralized or distributed. In other words, it does not reside in a central server, but in individual nodes.

- A break in the bus renders the bus inoperative.

  Breaks can be difficult to identify and operate.

- Structurally like a multi-point private line.

- Single transmission path shared by all users.

- Nodes do not intervene with passing signals, such that the network operation is not dependent on any single node.

  Taps can be inserted into an active system.

- Signal balancing is a critical issue, as the same output should be detectable in the adjacent station and at the network boundaries.

  Networks are usually divided into segments to help solve this problem.

- Access points are typically active amplifiers to minimize impact on the passing signal.

- All nodes on the network must examine the address of each message, so broadcast is easy to implement.

C No inherent security or privacy.

C Implemented primarily with twisted pair and coaxial cable. Coupler and power limitations restrict the use of optical fibers.

C Examples include Ethernet, Corvus Omninet, and Ungermann-Bass Net/ One.

14.1 Bus Considerations

Bus topology always seems to come in second when compared to star and ring cost, reliability, flexibility, ease of expansion, maximum scope - which is probably why it is the most popular choice.

C Information on a bus travels two ways, simultaneously.

C Each station broadcasts its transmission to both of its neighbors.

C A node grabs any transmission sent to it, then rebroadcasts any transmission not intended for it.

C To speed up transmission, broadband coaxial cable allows a single cable to be divided into separate channels.

C This will increase the cost of the installation.

C If one station dies on the bus, it will not affect other nodes.

C By setting up trees, many traffic or contention problems can be averted.

15 Tree Topology

- Tree topology offers an expanded version of the bus topology.
- By turning the bus to a vertical position and extending its branches, we now have a tree.
- Tree topologies are often called hybrid networks.

15.1 Tree Considerations

- Similar to bus, but greater flexibility in branching.
- Most common example is Cable Television networks, and all CATV compatible LANS.
- All signals are routed through a central point, known as the root of the tree, or the head-end.
- Taps are passive and directional and cannot be inserted into an active cable.
- Transmission medium is coaxial cable.

  75 ohm cable is used with the main line typically of higher quality than the branches.
- Broadband transmission.
- Single or dual cable operation.
- No inherent security or privacy.
- Examples include Wangnet, Sytek's LocalNet and 3M.

16 Ring Topology

C Nodes are connected in an unbroken circular configuration.

C Ring topology is characterized as a logically circular, unidirectional transmission path without defined ends.

Control can be distributed or centralized.

C Each node acts as a repeater, regenerating the signal as it travels around the network.

As in the bus topology, each node listens for its address, and, recognizing it, accepts the data transmitted with it.

C A break in the ring can be readily identified when the sender does not receive confirmation of receipt from the recipient.

The exact location of the fault can be identified through timing or interrogation of the status of nodes.

C Implemented with twisted pair, coaxial cable, and optical fibers.

C Baseband transmission is used exclusively.

C Node must be able to recognize its address.

C Routing is fixed; every signal travels along the same path.

C Network operation is dependent on the operation of every repeater, unless additional design features are implemented to improve reliability.

- Bidirectional ring.
- Bypass failed nodes.

C Rings with centralized control are often referred to as loops. Failure of the central node causes the network to fail.

- In a simple ring, adding a station requires that the network be shut down or at least interrupted.

- In many buildings, wiring paths are not available to directly connect different device locations, leading to creative wiring solutions.

- Broadcast transmission is easy to implement on a ring.

- Not inherently secure since every message passes through each node on the network.

16.1 Ring Considerations

- As the circumference of a ring increases, signal attenuation - the signal fades out - may become a problem.

  You can either add repeaters and amplifiers, or break the ring into interconnected, smaller rings.

- As the number of stations on a ring increases, response time increases also.

  In some cases, access time of 2 seconds will be too slow.

  In other cases, 4.5 seconds is fine.

- Ring topology would seem most appropriate for relatively small, stable-size networks or for small branches of a hybrid LAN.

- Its relatively low cost make rings attractive for those who want to "tiptoe" into LANs, one department at a time.

- Rings are not great choices for a network that will encompass hundreds of stations, extended over a great distance, or need frequent expansion.

17 Star Wired Ring Topology

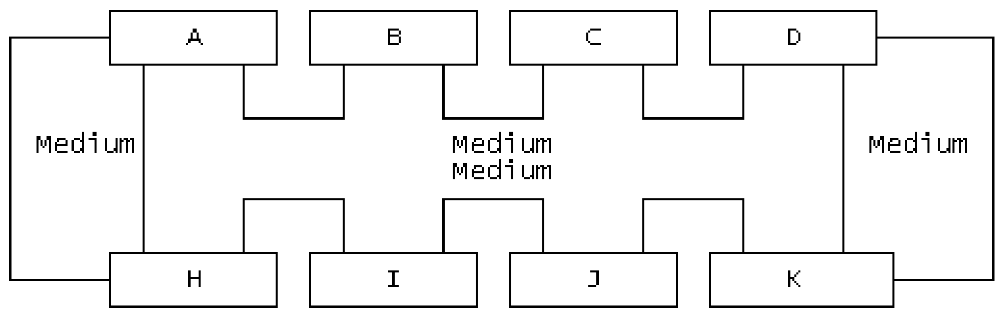
- A combination of the physical wiring of a star network and the logical flow of data as in a ring.

- This topology offers all the fault detection capabilities of the ring, while also providing the flexibility in installing, maintaining, and reconfiguring of a star.

- The logical operation of this hybrid topology is the same as described for a ring.

18 Physical Topology and Logical Path

Logical Path on a Token-Passing Ring Network



Logical
Path on a Token-Passing Bus Network