Workshop in PDF Format

This Online workshop has been created to assist schools in Imperial County with planning and implementing their computer networks. Much of the information, resources, and images contained in this workshop were borrowed from the Florida Center for Instructional Technology, College of Education, University of South Florida, Tampa, FL © 1997

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Networking Overview

What is a Network?

A network consists of two or more computers that are linked in order to share resources (such as printers and CD-ROMs), exchange files, or allow electronic communications. The computers on a network may be linked through cables, telephone lines, radio waves, satellites, or infrared light beams.

The three basic types of networks include:

- Local Area Network (LAN)
- Metropolitan Area Network (MAN)
- Wide Area Network (WAN)

Local Area Network

A Local Area Network (LAN) is a network that is confined to a relatively small area. It is generally limited to a geographic area such as a writing lab, school, or building. Rarely are LAN computers more

than a mile apart.

In a typical LAN configuration, one computer is designated as the file server. It stores all of the software that controls the network, as well as the software that can be shared by the computers attached to the network. Computers connected to the file server are called workstations. The workstations can be less powerful than the file server, and they may have additional software on their hard drives. On most LANs, cables are used to connect the network interface cards in each computer. See the Topology, Cabling, and Hardware sections of this tutorial for more information on the configuration of a LAN.

Metropolitan Area Network

A Metropolitan Area Network (MAN) covers larger geographic areas, such as cities or school districts. By interconnecting smaller networks within a large geographic area, information is easily disseminated throughout the network. Local libraries and government agencies often use a MAN to connect to citizens and private industries.

One example of a MAN is the El Centro School District. It connects all of the schools in the district to a centralized mainframe at the district office by using dedicated phone lines.

Wide Area Network

Wide Area Networks (WANs) connect larger geographic areas, such as Imperial County, the United States, or the world. Dedicated transoceanic cabling or satellite uplinks may be used to connect this type of network.

Using a WAN, schools in Imperial County can communicate with places like Tokyo in a matter of minutes, without paying enormous phone bills. A WAN can be complicated. It uses multiplexers to connect local and metropolitan networks to global communications networks like the Internet. To users, however, a WAN will not appear to be much different than a LAN or a MAN.

Advantages of Installing a School Network

- **Speed**. Networks provide a very rapid method for sharing and transferring files. Without a network, files are shared by copying them to floppy disks, then carrying or sending the disks from one computer to another. This method of transferring files (referred to as sneaker-net) is very time-consuming.
- **Cost**. Networkable versions of many popular software programs are available at considerable savings when compared to buying individually licensed copies. Besides monetary savings, sharing a program on a network allows for easier upgrading of the program. The changes have to be done only once, on the file server, instead of on all the individual workstations.
- **Security**. Files and programs on a network can be designated as "copy inhibit," so that you do not have to worry about illegal copying of programs. Also, passwords can be established for specific directories to restrict access to authorized users.
- **Centralized Software Management**. One of the greatest benefits of installing a network at a school is the fact that all of the software can be loaded on one computer (the file server). This eliminates that need to spend time and energy installing updates and tracking files on independent computers throughout the building.
- **Resource Sharing**. Sharing resources is another area in which a network exceeds stand-alone

computers. Most schools cannot afford enough laser printers, fax machines, modems, scanners, and CD-ROM players for each computer. However, if these or similar peripherals are added to a network, they can be shared by many users.

- **Electronic Mail**. The presence of a network provides the hardware necessary to install an e-mail system. E-mail aids in personal and professional communication for all school personnel, and it facilitates the dissemination of general information to the entire school staff. Electronic mail on a LAN can enable students to communicate with teachers and peers at their own school. If the LAN is connected to the Internet, students can communicate with others throughout the world.
- **Flexible Access**. School networks allow students to access their files from computers throughout the school. Students can begin an assignment in their classroom, save part of it on a public access area of the network, then go to the media center after school to finish their work. Students can also work cooperatively through the network.
- **Workgroup Computing**. Workgroup software (such as Lotus Notes) allows many users to work on a document or project concurrently. For example, educators located at various schools within a county could simultaneously contribute their ideas about new curriculum standards to the same document and spreadsheets.

Disadvantages of Installing a School Network

- **Expensive to Install**. Although a network will generally save money over time, the initial costs of installation can be prohibitive. Cables, network cards, and software are expensive, and the installation may require the services of a technician.
- **Requires Administrative Time**. Proper maintenance of a network requires considerable time and expertise. Many schools have installed a network, only to find that they did not budget for the necessary administrative support.
- **File Server May Fail**. Although a file server is no more susceptible to failure than any other computer, when the files server "goes down," the entire network may come to a halt. When this happens, the entire school may lose access to necessary programs and files.
- **Cables May Break**. The Topology section of this tutorial presents information about the various configurations of cables. Some of the configurations are designed to minimize the inconvenience of a broken cable; with other configurations, one broken cable can stop the entire network.

Network Topologies

There are two types of topology: physical and logical. The physical topology of a network refers to the configuration of cables, computers, and other peripherals. Logical topology is the method used to pass the information between workstations. Issues involving logical topologies are discussed in the section on protocols.

Main Types of Physical Topologies

The following sections discuss the physical topologies used in networks and other related topics.

- Linear Bus
- Star

Linear Bus

A linear bus topology consists of a main run of cable with a terminator at each end (See fig. 1). All nodes (file server, workstations, and peripherals) are connected to the linear cable. Ethernet and LocalTalk networks can use a linear bus topology.

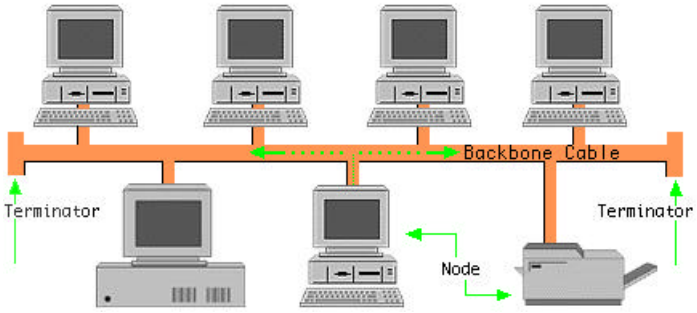


Fig. 1. Linear Bus topology

Advantages of a Linear Bus Topology

- Easy to connect a computer or peripheral to a linear bus.
- Requires less cable length than a star topology.

Disadvantages of a Linear Bus Topology

- Entire network shuts down if there is a break in the main cable.
- Terminators are required at both ends of the backbone cable.
- Difficult to identify the problem if the entire network shuts down.
- Not meant to be used as a stand-alone solution in a large building.

Star

A star topology is designed with each node (file server, workstations, and peripherals) connected directly to a central network hub or concentrator (See fig. 2).

Data on a star network passes through the hub or concentrator before continuing to its destination. The hub or concentrator manages and controls all functions of the network. It also acts as a repeater for the data flow. This configuration is common with twisted pair cable; however, it can also be used with coaxial cable or fiber optic cable.

The protocols used with star configurations are usually Ethernet or LocalTalk. Token Ring uses a similar topology, called the star-wired ring.

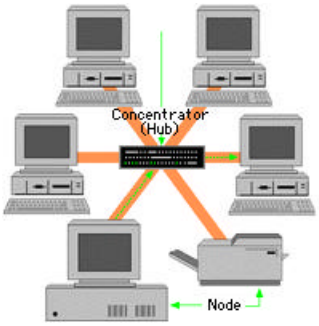


Fig.2. Star topology

Advantages of a Star Topology

- Easy to install and wire.
- No disruptions to the network when connecting or removing devices.
- Easy to detect faults and to remove parts.

Disadvantages of a Star Topology

- Requires more cable length than a linear topology.
- If the hub or concentrator fails, nodes attached are disabled.
- More expensive than linear bus topologies because of the cost of the concentrators.

Star-Wired Ring

A star-wired ring topology may appear (externally) to be the same as a star topology. Internally, the MAU (multistation access unit) of a star-wired ring contains wiring that allows information to pass from one device to another in a circle or ring (See fig. 3). The Token Ring protocol uses a star-wired ring topology.

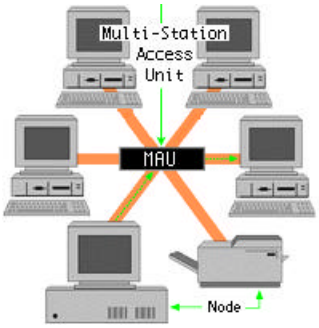


Fig.3. Star-wired ring topology

Tree

A tree topology combines characteristics of linear bus and star topologies. It consists of groups of star-configured workstations connected to a linear bus backbone cable (See fig. 4). Tree topologies allow for the expansion of an existing network, and enable schools to configure a network to meet their needs.

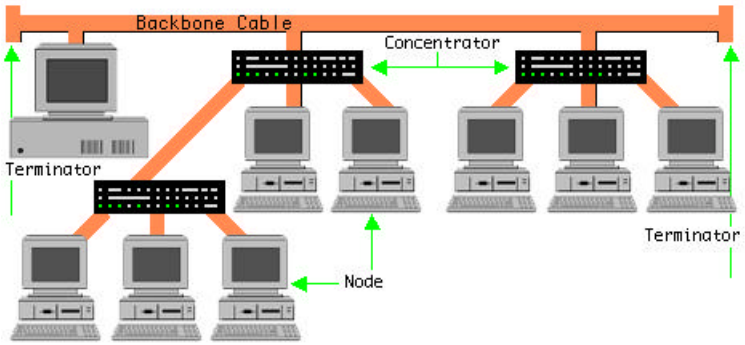


Fig.4. Tree topology

Advantages of a Tree Topology

- Point-to-point wiring for individual segments.
- Supported by several hardware and software venders.

Disadvantages of a Tree Topology

- Overall length of each segment is limited by the type of cabling used.
- If the backbone line breaks, the entire segment goes down.
- More difficult to configure and wire than other topologies.

5-4-3 Rule (Ethernet)

A consideration in setting up a tree topology using Ethernet protocol is the 5-4-3 rule. One aspect of the Ethernet protocol requires that a signal sent out on the network cable reach every part of the network within a specified length of time. Each concentrator or repeater that a signal goes through adds a small amount of time. This leads to the rule that between any two nodes on the network there can only be a maximum of 5 segments, connected through 4 repeaters/concentrators. In addition, only 3 of the segments may be populated (trunk) segments if they are made of coaxial cable. A populated segment is one which has one or more nodes attached to it . In Figure 4, the 5-4-3 rule is adhered to. The furthest two nodes on the network have 4 segments and 3 repeaters/concentrators between them.

This rule does not apply to other network protocols or Ethernet networks where all fiber optic cabling is used.

(Activity 6.5)

Considerations When Choosing a Topology:

- **Money**. A linear bus network may be the least expensive way to install a network; you do not have to purchase concentrators.
- **Length of cable needed**. The linear bus network uses shorter lengths of cable.
- **Future growth**. With a star topology, expanding a network is easily done by adding another concentrator.
- **Cable type**. The most common cable in schools is unshielded twisted pair (Cat. 5), which is most often used with star topologies.

Summary Chart:

Physical Topology	Common Cable	Common Protocol
Linear Bus	Coax Twisted Pair Fiber	Ethernet LocalTalk
Star	Twisted Pair Fiber	Ethernet LocalTalk
Star-Wired Ring	Twisted Pair	Token Ring
Tree	Coax Twisted Pair Fiber	Ethernet

(Activity 1.5)

Networking Protocols

A protocol is a set of rules that governs the communications between computers on a network. These rules include guidelines that regulate the following characteristics of a network: access method, allowed physical topologies, types of cabling, and speed of data transfer. See the Topology and Cabling sections of this tutorial for more information.

The most common protocols are:

- Ethernet
- LocalTalk
- Token Ring
- FDDI

Ethernet

The Ethernet protocol is by far the most widely used. Ethernet uses an access method called CSMA/CD (Carrier Sense Multiple Access/Collision Detection). This is a system where each computer listens to the cable before sending anything through the network. If the network is clear, the computer will transmit. If some other node is already transmitting on the cable, the computer will wait and try again when the line is clear. Sometimes, two computers attempt to transmit at the same instant. When this happens a collision occurs. Each computer then backs off and waits a random amount of time before attempting to retransmit. With this access method, it is normal to have collisions. However, the delay caused by collisions and retransmitting is very small and does not normally effect the speed of transmission on the network.

The Ethernet protocol allows for linear bus, star, or tree topologies. Data can be transmitted over twisted pair, coaxial, or fiber optic cable at a speed of 10 Mbps.

Fast Ethernet

To allow for an increased speed of transmission, the Ethernet protocol has developed a new standard that supports 100 Mbps. This is commonly called Fast Ethernet. Fast Ethernet requires the use of different, more expensive network concentrators/hubs and network interface cards. In addition, category 5 twisted pair or fiber optic cable is necessary.

(Activity 1.7)

LocalTalk

LocalTalk is a network protocol that was developed by Apple Computer, Inc. for Macintosh computers. The method used by LocalTalk is called CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance). It is similar to CSMA/CD except that a computer signals its intent to transmit before it actually does so. LocalTalk adapters and special twisted pair cable can be used to connect a series of computers through the serial port. The Macintosh operating system allows the establishment of a peer-to-peer network without the need for additional software. With the addition of the server version of AppleShare software, a client/server network can be established.

The LocalTalk protocol allows for linear bus, star, or tree topologies using twisted pair cable. A primary disadvantage of LocalTalk is speed. Its speed of transmission is only 230 Kbps.

Token Ring

The Token Ring protocol was developed by IBM in the mid-1980s. The access method used involves token-passing. In Token Ring, the computers are connected so that the signal travels around the network from one computer to another in a logical ring. A single electronic token moves around the ring from one computer to the next. If a computer does not have information to transmit, it simply passes the token on to the next workstation. If a computer wishes to transmit and receives an empty token, it attaches data to the token. The token then proceeds around the ring until it comes to the computer for which the data is meant. At this point, the data is captured by the receiving computer. The Token Ring protocol requires a star-wired ring using twisted pair or fiber optic cable. It can operate at transmission speeds of 4 Mbps or 16 Mbps. Due to the increasing popularity of Ethernet, the use of Token Ring in school environments has decreased.

FDDI

Fiber Distributed Data Interface (FDDI) is a network protocol that is used primarily to interconnect two or more local area networks, often over large distances. The access method used by FDDI involves token-passing. FDDI uses a dual ring physical topology. Transmission normally occurs on one of the rings; however, if a break occurs, the system keeps information moving by automatically using portions of the second ring to create a new complete ring. A major advantage of FDDI is speed. It operates over fiber optic cable at 100 Mbps.

Protocol Summary

Protocol	Cable	Speed	Topology
Ethernet	Twisted Pair, Coaxial, Fiber	10 Mbps	Linear Bus, Star, Tree
Fast Ethernet	Twisted Pair, Fiber	100 Mbps	Star
LocalTalk	Twisted Pair	.23 Mbps	Linear Bus or Star
Token Ring	Twisted Pair	4 Mbps - 16 Mbps	Star-Wired Ring
FDDI	Fiber	100 Mbps	Dual ring

Network Operating Systems

Network operating systems (NOS) coordinate the activities of multiple computers across a network. The network operating system acts as a director to keep the network running smoothly.

The two major types of network operating systems are:

- Peer-to-Peer
- Client/Server

Peer-to-Peer

Peer-to-peer network operating systems allow users to share resources and files located on their computers and to access shared resources found on other computers. However, they do not have a file server or a centralized management source (See fig. 1). In a peer-to-peer network, all computers are considered equal; they all have the same abilities to use the resources available on the network. Peer-to-peer networks are designed primarily for small to medium local area networks. AppleShare, Windows for Workgroups, and Windows 95 are examples of systems that can function as peer-to-peer network operating systems.

Fig.1. Peer-to-peer network

Advantages of a peer-to-peer network:

- Less initial expense - No need for a dedicated server.
- Setup - An operating system (such as Windows 95) already in place may only need to be reconfigured for peer-to-peer operations.

Disadvantages of a peer-to-peer network:

- Decentralized - No central repository for files and applications.
- Security - Does not provide the security available on a client/server network.

Client/Server

Client/server network operating systems allow the network to centralize functions and applications in one or more dedicated file servers (See fig. 2). The file servers become the heart of the system, providing access to resources and providing security. Individual workstations (clients) have access to the resources available on the file servers. The network operating system provides the mechanism to integrate all the components of the network and allow multiple users to simultaneously share the same resources irrespective of physical location. Novell Netware and Windows NT Server are examples of client/server network operating systems.

Fig.2. Client/server network

Advantages of a client/server network:

- Centralized - Resources and data security are controlled through the server.
- Scalability - Any or all elements can be replaced individually as needs increase.
- Flexibility - New technology can be easily integrated into system.
- Interoperability - All components (client/network/server) work together.
- Accessibility - Server can be accessed remotely and across multiple platforms.

Disadvantages of a client/server network:

- Expense - Requires initial investment in dedicated server.
- Maintenance - Large networks will require staff to ensure efficient operation.
- Dependence - When server goes down, operations will cease across the network.

Networking Hardware

Networking hardware includes all computers, peripherals, interface cards and other equipment needed to perform data-processing and communications within the network.

This section provides information on the following components:

File Servers

A file server stands at the heart of most networks. It is a very fast computer with a large amount of RAM and storage space, along with a fast network interface card. The network operating system software resides on this computer, along with any software applications and data files that need to be shared.

The file server controls the communication of information between the nodes on a network. For example, it may be asked to send a word processor program to one workstation, receive a database file from another workstation, and store an e-mail message during the same time period. This requires a computer that can store a lot of information and share it very quickly.

Workstations

All of the computers connected to the file server on a network are called workstations. A typical workstation is a computer that is configured with a network interface card, networking software, and the appropriate cables. Workstations do not necessarily need floppy disk drives or hard drives because files can be saved on the file server. Almost any computer can serve as a network workstation.

Network Interface Cards

The network interface card (NIC) provides the physical connection between the network and the computer workstation. Most NICs are internal, with the card fitting into an expansion slot inside the computer. Some computers, such as Mac Classics, use external boxes which are attached to a serial port or a SCSI port. Laptop computers generally use external LAN adapters connected to the parallel port or network cards that slip into a PCMCIA slot.

Network interface cards are a major factor in determining the speed and performance of a network. It is a good idea to use the fastest network card available for the type of workstation you are using.

The three most common network interface connections are Ethernet cards, LocalTalk connectors, and Token Ring cards. According to a International Data Corporation study, Ethernet is the most popular,

followed by Token Ring and LocalTalk (Sant'Angelo, R. (1995). *NetWare Unleashed*, Indianapolis, IN: Sams Publishing).

Ethernet Cards

Ethernet cards are usually purchased separately from a computer, although many computers (such as the Macintosh) now include an option for a pre-installed Ethernet card. Ethernet cards contain connections for either coaxial or twisted pair cables (or both) (See fig. 1). If it is designed for coaxial cable, the connection will be BNC. If it is designed for twisted pair, it will have a RJ-45 connection. Some Ethernet cards also contain an AUI connector. This can be used to attach coaxial, twisted pair, or fiber optics cable to an Ethernet card. When this method is used there is always an external transceiver attached to the workstation. (See the Cabling section for more information on connectors.)

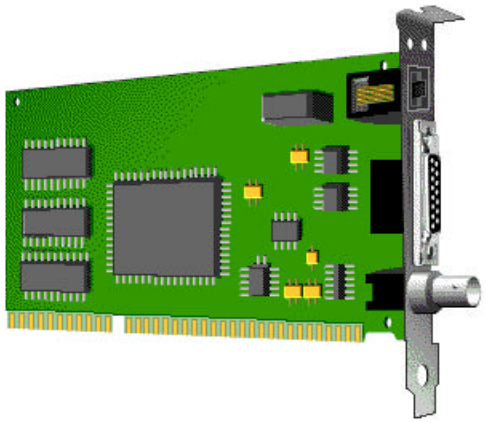


Fig. 1. Ethernet card.
From top to bottom:
RJ-45, AUI, and BNC connectors

LocalTalk Connectors

LocalTalk is Apple's built-in solution for networking Macintosh computers. It utilizes a special adapter box and a cable that plugs into the printer port of a Macintosh (See fig. 2). A major disadvantage of LocalTalk is that it is slow in comparison to Ethernet. Most Ethernet connections operate at 10 Mbps (Megabits per second). In contrast, LocalTalk operates at only 230 Kbps (or .23 Mbps).

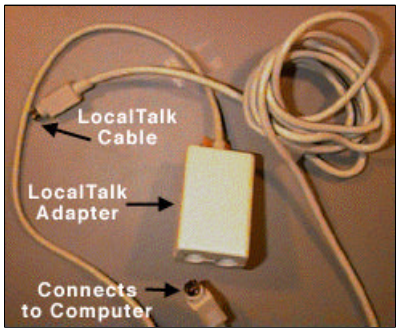


Fig.2. LocalTalk connectors

Ethernet Cards vs. LocalTalk Connections	
Ethernet	**LocalTalk**
Fast data transfer (10 Mbps)	Slow data transfer (.23 Mbps)
Purchased separately	Built into Macintosh computers
Requires computer slot	No computer slot necessary
Available for most computers	Works only on Macintosh computers

Token Ring Cards

Token Ring network cards look similar to Ethernet cards. One visible difference is the type of connector on the back end of the card. Token Ring cards generally have a nine pin DIN type connector to attach the card to the network cable.

Concentrators/Hubs

A concentrator is a device that provides a central connection point for cables from workstations, servers, and peripherals. In a star topology, twisted-pair wire is run from each workstation to a central concentrator. Hubs are multislot concentrators into which can be plugged a number of multi-port cards to provide additional access as the network grows in size. Some concentrators are passive, that is they allow the signal to pass from one computer to another without any change. Most concentrators are active, that is they electrically amplify the signal as it moves from one device to another. Active concentrators are used like repeaters to extend the length of a network. Concentrators/Hubs are:

- Usually configured with 8, 12, or 24 RJ-45 ports
- Often used in a star or star-wired ring topology
- Sold with specialized software for port management

(Activity 4.5)

Repeaters

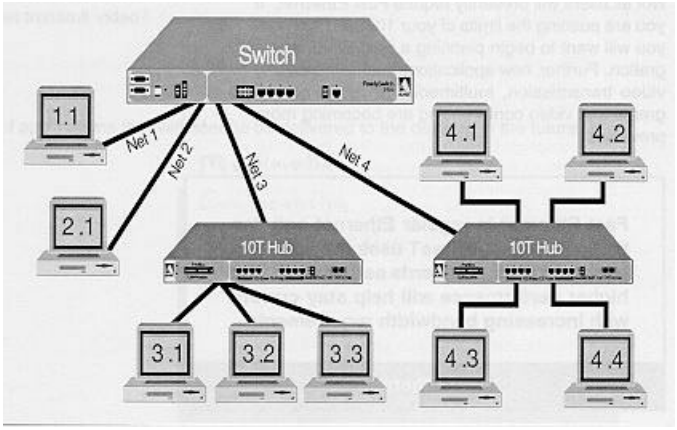
When a signal travels along a cable, it tends to lose strength. A repeater is a device that boosts a network's signal as it passes through. The repeater does this by electrically amplifying the signal it receives and rebroadcasting it. Repeaters can be separate devices or they can be incorporated into a concentrator. They are used when the total length of your network cable exceeds the standards set for the type of cable being used.

A good example of the use of repeaters would be in a local area network using a star topology with unshielded twisted-pair cabling. The length limit for unshielded twisted-pair cable is 100 meters. The most common configuration is for each workstation to be connected by twisted-pair cable to a multi-port active concentrator. The concentrator regenerates all the signals that pass through it allowing for the total length of cable on the network to exceed the 100 meter limit.

Switches

Switches allow you to avoid the congestion of a shared Ethernet network by permitting you to create individual segments. The improvement in network performance can be dramatic. In the illustration below (A), the switch is being fed a 100Mbps signal. The switch is then creating four segmented networks, each with its own 10Mbps path. Net 3 and Net 4 are then connecting to a hub, creating two shared 10Mbps networks.

Switches come in a variety of configurations.



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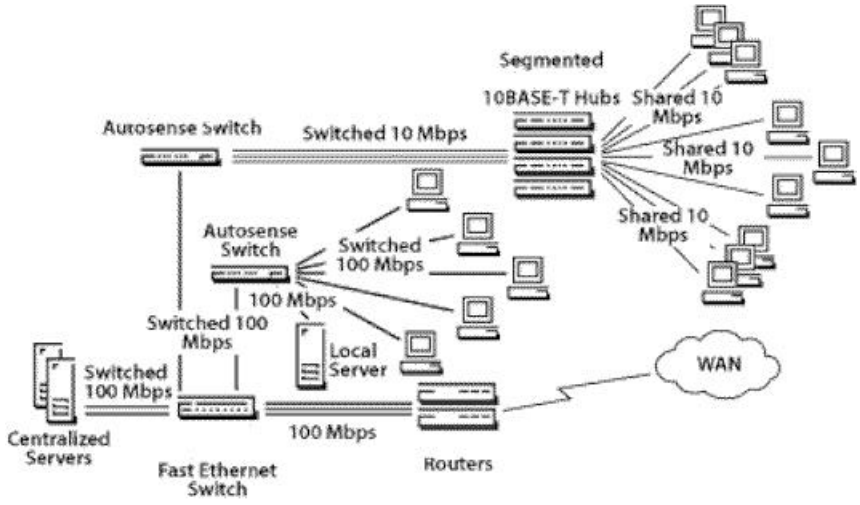


(B)

(Activity 4.9)

Bridges

A bridge is a device that allows you to segment a large network into two smaller, more efficient networks. If you are adding to an older wiring scheme and want the new network to be up-to-date, a bridge can connect the two.

A bridge monitors the information traffic on both sides of the network so that it can pass packets of information to the correct location. Most bridges can "listen" to the network and automatically figure out

the address of each computer on both sides of the bridge. The bridge can inspect each message and, if necessary, broadcast it on the other side of the network.

The bridge manages the traffic to maintain optimum performance on both sides of the network. You might say that the bridge is like a traffic cop at a busy intersection during rush hour. It keeps information flowing on both sides of the network, but it does not allow unnecessary traffic through. Bridges can be used to connect different types of cabling, or physical topologies. They must, however, be used between networks with the same protocol.

Routers

A router translates information from one network to another; it is similar to a superintelligent bridge. Routers select the best path to route a message, based on the destination address and origin. The router can direct traffic to prevent head-on collisions, and is smart enough to know when to direct traffic along back roads and shortcuts.

While bridges know the addresses of all computers on each side of the network, routers know the addresses of computers, bridges, and other routers on the network. Routers can even "listen" to the entire network to determine which sections are busiest -- they can then redirect data around those sections until they clear up.

If you have a school LAN that you want to connect to the Internet, you will need to purchase a router. In this case, the router serves as the translator between the information on your LAN and the Internet. It also determines the best route to send the data over the Internet. Routers can:

- Direct signal traffic efficiently
- Route messages between any two protocols
- Route messages between linear bus, star, and star-wired ring topologies
- Route messages across fiber optic, coaxial, and twisted-pair cabling

(Activity 6.7)

Network Cabling

Cable is the medium through which information usually moves from one network device to another. There are several types of cable which are commonly used with LANs. In some cases, a network will utilize only one type of cable, other networks will use a variety of cable types. The type of cable chosen for a network is related to the network's topology, protocol, and size. Understanding the characteristics of different types of cable and how they relate to other aspects of a network is necessary for the development of a successful network.

The following sections discuss the types of cables used in networks and other related topics.

Unshielded Twisted Pair (UTP) Cable

Twisted pair cabling comes in two varieties: shielded and unshielded. Unshielded twisted pair (UTP) is the most popular and is generally the best option for school networks (See fig. 1).

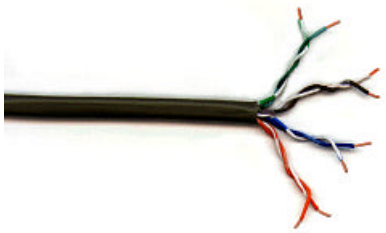


Fig.1. Unshielded twisted pair

The quality of UTP may vary from telephone-grade wire to extremely high-speed cable. The cable has four pairs of wires inside the jacket. Each pair is twisted with a different number of twists per inch to help eliminate interference from adjacent pairs and other electrical devices. The EIA/TIA (Electronic Industry Association/Telecommunication Industry Association) has established standards of UTP and rated five categories of wire.

Categories of Unshielded Twisted Pair

Type	Use
Category 1	Voice Only (Telephone Wire)
Category 2	Data to 4 Mbps (LocalTalk)
Category 3	Data to 10 Mbps (Ethernet)
Category 4	Data to 20 Mbps (16 Mbps Token Ring)
Category 5	Data to 100 Mbps (Fast Ethernet)

One difference between the different categories of UTP is the tightness of the twisting of the copper pairs. The tighter the twisting, the higher the supported transmission rate and the greater the cost per foot. Buy the best cable you can afford; most schools purchase Category 3 or Category 5. Category 5 cable is highly recommended.

If you are designing a 10 Mbps Ethernet network and are considering the cost savings of buying Category 3 wire instead of Category 5, remember that the Category 5 cable will provide more "room to grow" as transmission technologies increase. Both category 3 and category 5 UTP have a maximum segment length of 100 meters. 10BaseT refers to the specifications for unshielded twisted pair cable (category 3, 4, or 5) carrying Ethernet signals.

Unshielded Twisted Pair Connector

The standard connector for unshielded twisted pair cabling is an RJ-45 connector. This is a plastic connector that looks like a large telephone-style connector (See fig. 2). A slot allows the RJ-45 to be inserted only one way. RJ stands for Registered Jack, implying that the connector follows a standard borrowed from the telephone industry. This standard designates which wire goes with each pin inside the connector.

Fig.2. RJ-45 connector

Shielded Twisted Pair (STP) Cable

A disadvantage of UTP is that it may be susceptible to radio and electrical frequency interference. Shielded twisted pair (STP) is suitable for environments with electrical interference; however, the extra shielding can make the cables quite bulky. Shielded twisted pair is often used on networks using Token Ring topology.

Coaxial Cable

Coaxial cabling has a single copper conductor at its center. A plastic layer provides insulation between the center conductor and a braided metal shield (See fig. 3). The metal shield helps to block any outside interference from fluorescent lights, motors, and other computers.

Fig.3. Coaxial cable

Although coaxial cabling is difficult to install, it is highly resistant to signal interference. In addition, it can support greater cable lengths between network devices than twisted pair cable. The two types of coaxial cabling are: thick coaxial and thin coaxial.

Thin coaxial cable is also referred to as thinnet. 10Base2 refers to the specifications for thin coaxial cable carrying Ethernet signals. The 2 refers to the approximate maximum segment length being 200 meters. In actual fact the maximum segment length is 185 meters. Thin coaxial cable is popular in school networks, especially linear bus networks.

Thick coaxial cable is also referred to as thicknet. 10Base5 refers to the specifications for thick coaxial cable carrying Ethernet signals. The 5 refers to the maximum segment length being 500 meters. Thick coaxial cable has an extra protective plastic cover that helps keep moisture away from the center conductor. This makes thick coaxial a great choice when running longer lengths in a linear bus network. One disadvantage of thick coaxial is that it does not bend easily and is difficult to install.

Coaxial Cable Connectors

The most common type of connector used with coaxial cables is the Bayone-Neill-Concelman (BNC) connector (See fig. 4). Different types of adapters are available for BNC connectors, including a T-connector, barrel connector, and terminator. Connectors on the cable are the weakest points in any network. To help avoid problems with your network, always use the BNC connectors that crimp, rather than screw, onto the cable.

Fig.4. BNC connector

Fiber Optic Cable

Fiber optic cabling consists of a center glass core surrounded by several layers of protective materials (See fig. 5). It transmits light rather than electronic signals, eliminating the problem of electrical interference. This makes it ideal for certain environments that contain a large amount of electrical interference. It has also made it the standard for connecting networks between buildings, due to its immunity to the effects of moisture and lighting.

Fiber optic cable has the ability to transmit signals over much longer distances than coaxial and twisted pair. It also has the capability to carry information at vastly greater speeds. This capacity broadens communication possibilities to include services such as video conferencing and interactive services. The cost of fiber optic cabling is comparable to copper cabling; however, it is more difficult to install and modify. 10BaseF refers to the specifications for fiber optic cable carrying Ethernet signals.

Fig.5. Fiber optic cable

Facts about fiber optic cables:

- Outer insulating jacket is made of Teflon or PVC.
- Kevlar fiber helps to strengthen the cable and prevent breakage.
- A plastic coating is used to cushion the fiber center.
- Center (core) is made of glass or plastic fibers.

Fiber Optic Connector

The most common connector used with fiber optic cable is an ST connector. It is barrel shaped, similar to a BNC connector. A newer connector, the SC, is becoming more popular. It has a squared face and is easier to connect in a confined space.

Ethernet Cable Summary

Specification	Cable Type	Maximum length
10BaseT	Unshielded Twisted Pair	100 meters
10Base2	Thin Coaxial	185 meters
10Base5	Thick Coaxial	500 meters
10BaseF	Fiber Optic	2000 meters

Wireless LANs

Not all networks are connected with cabling; some networks are wireless. Wireless LANs use high frequency radio signals or infrared light beams to communicate between the workstations and the file server. Each workstation and file server on a wireless network has some sort of transceiver/antenna to send and receive the data. Information is relayed between transceivers as if they were physically connected. For longer distance, wireless communications can also take place through cellular telephone technology or by satellite.

Wireless networks are great for allowing laptop computers or remote computers to connect to the LAN. Wireless networks are also beneficial in older buildings where it may be difficult or impossible to install cables.

Wireless LANs also have some disadvantages. They can be very expensive, provide poor security, and are susceptible to electrical interference from lights and radios.

Installing Cable - Some Guidelines

When running cable, it is best to follow a few simple rules:

- Always use more cable than you need. Leave plenty of slack.
- Test every part of a network as you install it. Even if it is brand new, it may have problems that will be difficult to isolate later.
- Stay at least 3 feet away from fluorescent light boxes and other sources of electrical interference.
- If it is necessary to run cable across the floor, cover the cable with cable protectors.
- Label both ends of each cable.
- Use cable ties (not tape) to keep cables in the same location together.

Windows 95 LAN Configuration

What You Need to Get Started:

- A network adapter card connected to a Local Area Network (LAN)
- For Internet Access, you will need an Internet connection to your LAN (see your LAN administrator for information)
- Permission and information from your LAN administrator to connect your workstation to the

LAN's Internet connection

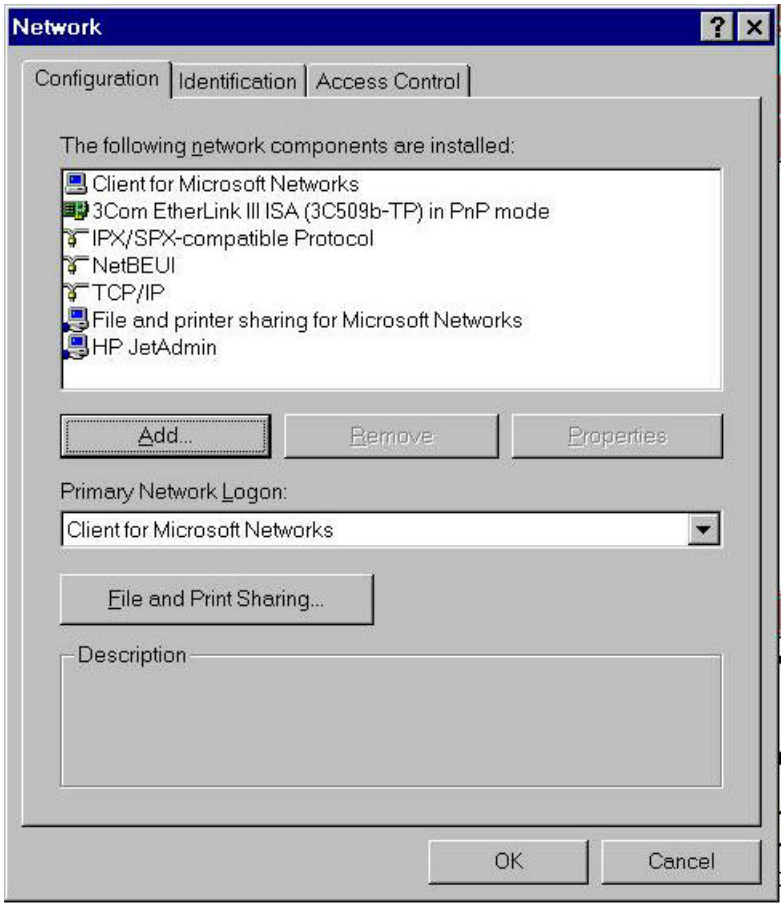
- Your LAN administrator should be aware of any network connections and/or changes you are planning to make. Please contact him or her regarding your Windows 95 Internet connection *before* making any changes to your configuration

Step 1: Install the Network Adapter Driver and TCP/IP Protocol (if not already installed)

Press the button , select Settiengs..., then Control Panel.

Double click the Network icon. Make sure the Configuration Tab is selected. Both your Network Adapter (not the Dial-Up Adapter) and TCP/IP should be present. If there are, you're ready to proceed to step 2.

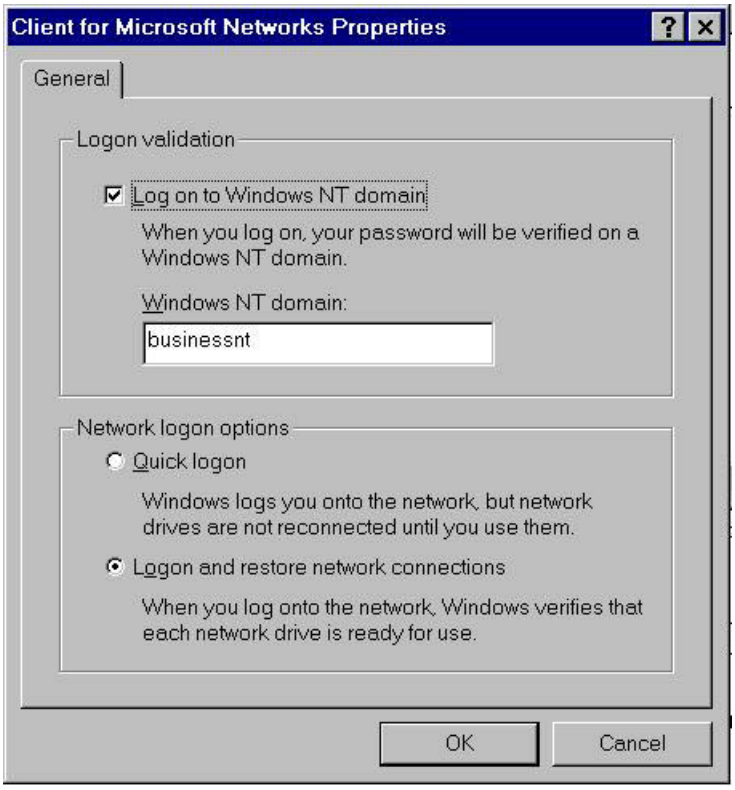
If you need to install **TCP/IP**, hit the **Add...** button, double-click **Protocol**, then select **Microsoft**, then **TCP/IP**, and hit **OK**. To add your adapter, hit the **Add...** button, double-click **Adapter**, then scroll down the list until you see your card's vendor on the list. Choose the correct adapter and hit **OK**. Now your **Network** dialog box should contain both your Adapter and **TCP/IP**. Select the adapter, click **Properties...**, **Bindings**, and make sure the **TCP/IP** and **NetBEUI** boxes are checked (as well as any other protocols you are using--check with your LAN administrator). You're now ready to proceed to step 2.



Step 2: Configure your Network Client and TCP/IP Protocol

Now that the drivers are installed, you need to configure them to work with Windows 95. Go to the **Control Panel** and double-click the **Network** icon.

Click on the **Client for Microsoft Networks**, then click on **Properties**.



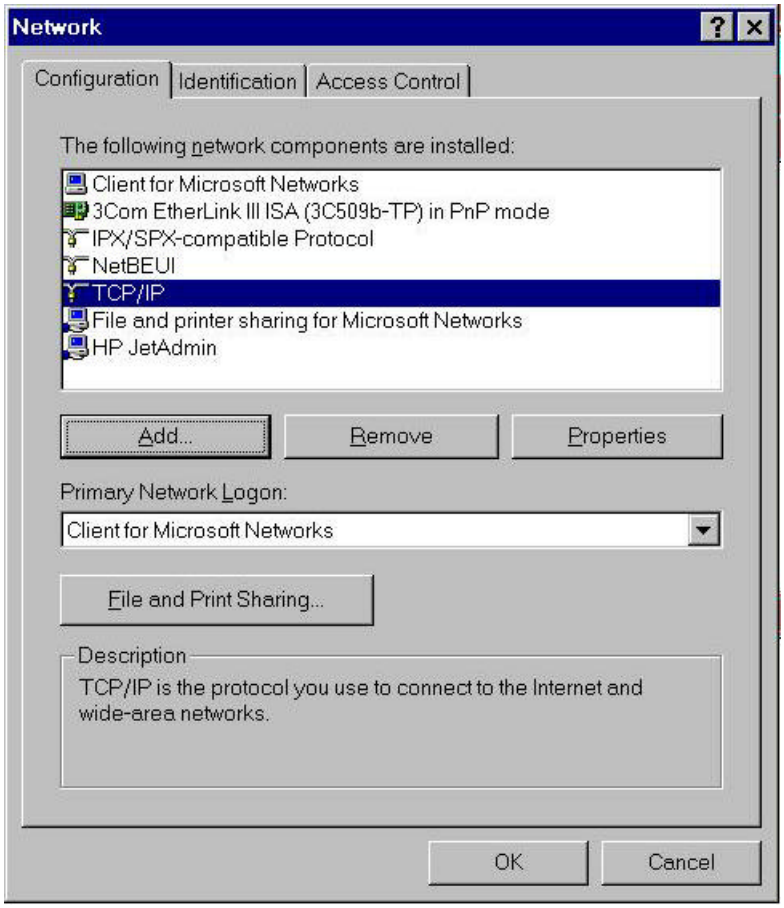
If you plan to log onto an NT server, make sure the **Log on to Windows NT domain** box is checked. Otherwise, you can leave it unchecked. If you are connecting to an NT server you can also select **Quick Login** or **Logon and Restore Network Connections**. **Quick Login** assumes that the connections you usually make when you log on are actually there, and **Logon and Restore Network Connections** verifies the integrity of all assigned network connections. When you are done with these settings, press the **OK** button.

You should now get the following screen:

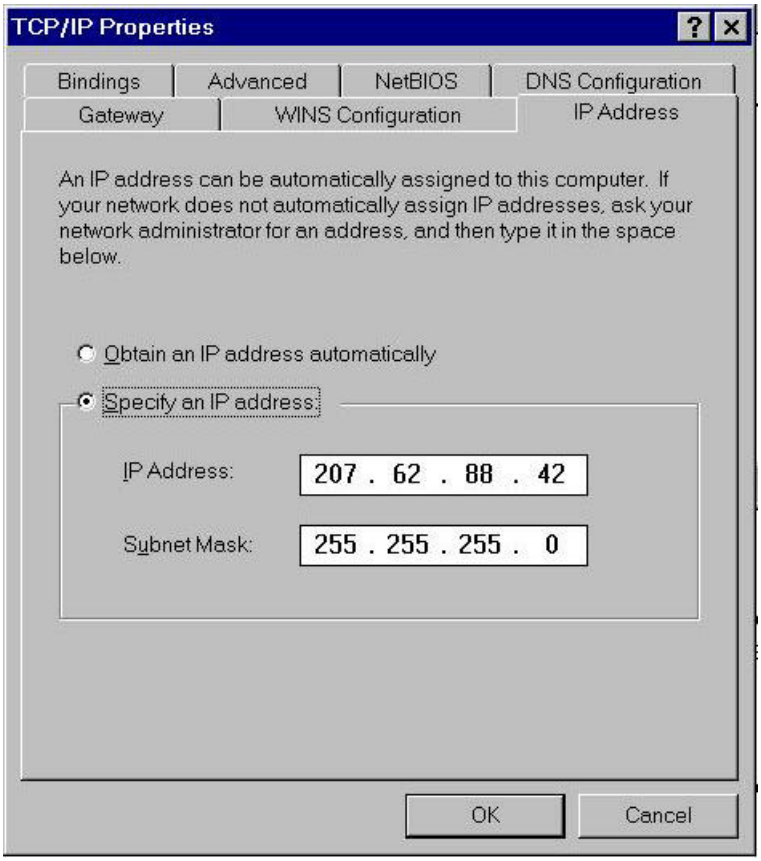
Click on the **TCP/IP** protocol (highlighted in the picture) and press the **Properties ...** button.

You should get the TCP/IP Properties Box.

There are six sections in this dialog box. We'll deal with them in order.



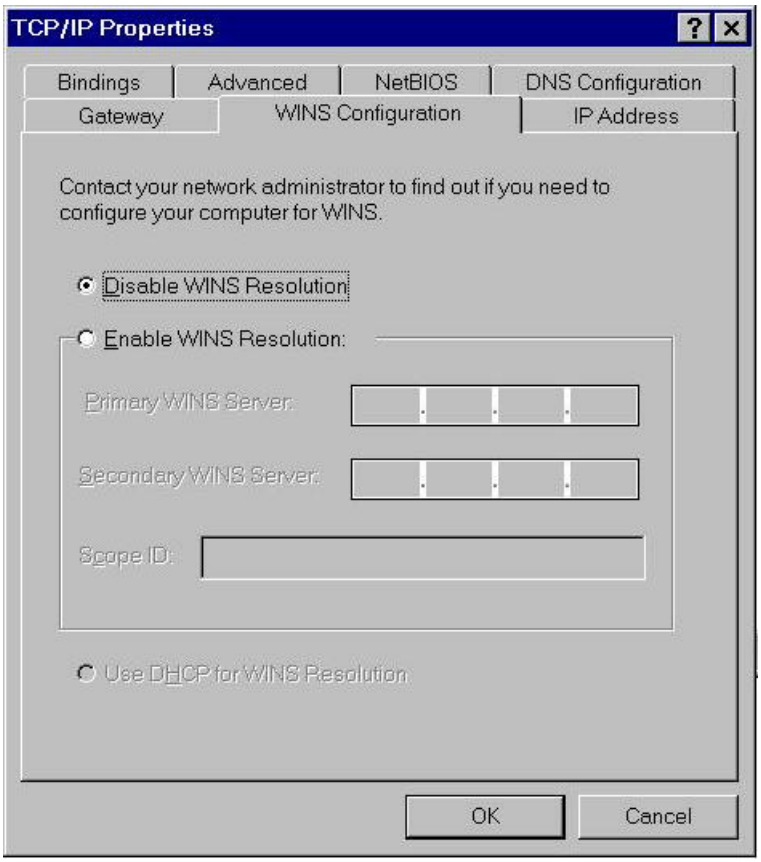
IP Address:



Select the **Specify an IP address** option. Then type in your IP address, which was assigned to you by your provider or LAN administrator (when running a Novell network, this number will be in your **NET.CFG** file, usually in your root directory). Next, fill in the **Subnet Mask** provided by your LAN administrator in the text area. This number will probably be **255.255.255.0**. If you were using *Trumpet Winsock*, these numbers are the **IP address** and **Netmask** values in the *Trumpet Winsock* **Setup** dialog box.

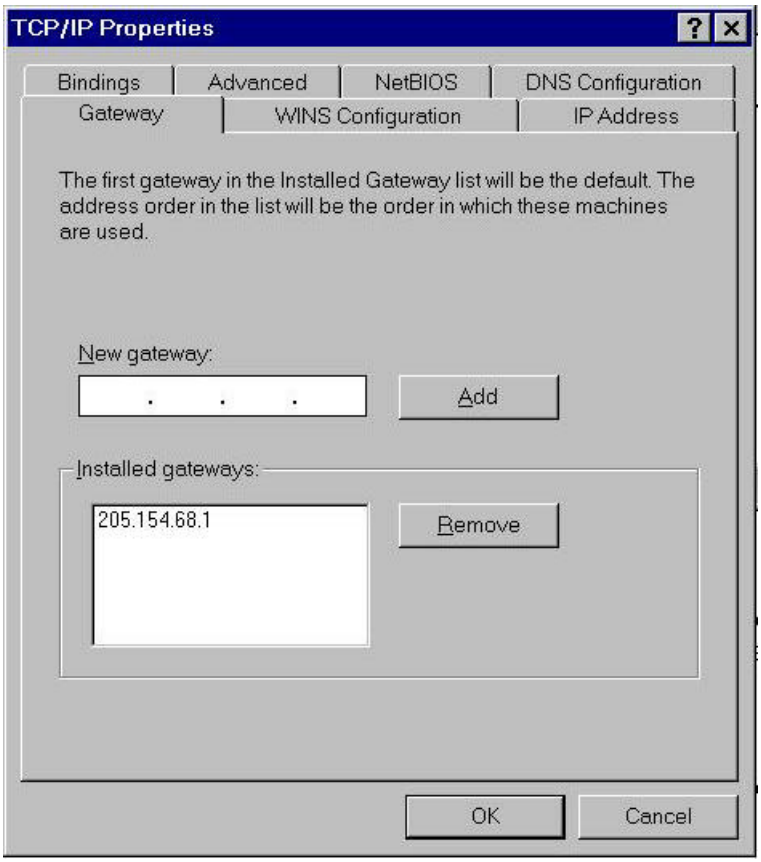
WINS Configuration:

Select the **Disable WINS Resolution** option for now, you can enable it later when you want to run **Peer to Peer Networking**.



Gateway:

Type in the gateway that you are using on your LAN. If you were using *Trumpet Winsock*, this number is the **Default Gateway** value in the *Trumpet Winsock* **Setup** dialog box. Get this number from your LAN Administrator, or from your Internet Provider (when running a Novell network, this number will be in your **NET.CFG** file, usually in your root directory). Once you've entered this number, press the **Add** button..



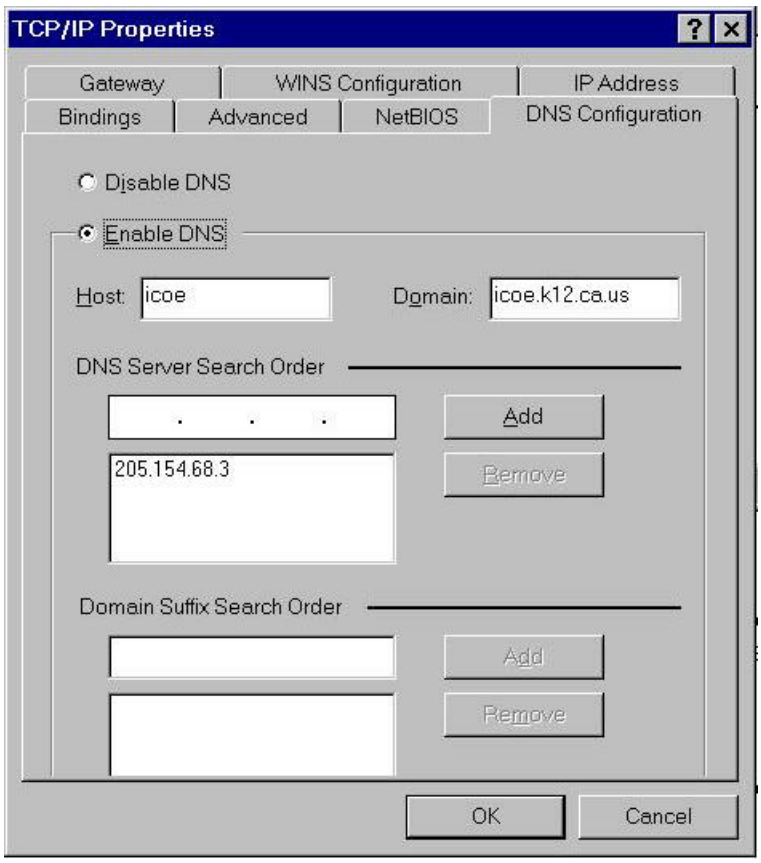
Bindings

By default, the **Client for Microsoft Networks** option is checked. Leave it alone. You may also have another client (such as Novell) loaded for your network. Make sure it is checked, as well.

Advanced

No changes are needed from the default.

DNS Configuration



If you were having problems getting connected, this is probably what has been giving you the most trouble. Select the **Enable DNS** option. This stands for **Domain Name Service**. Enter your user name in **Host** box. In the **Domain**, put in the name of your provider, such as **icoe.k12.ca.us** or **aol.com**. Your company may have its own DNS. Check with your LAN Administrator. In the **DNS Server Search Order** section, put in the **IP address** of your provider's name server and press the **Add** button. To find this number, you can call your provider, or log into your provider with a terminal window and type **nslookup**. Your provider's server will return the DNS address.

If you were previously using *Trumpet Winsock*, the DNS is the **Name Server** value in the *Trumpet Winsock* **Setup** dialog box. In the **Domain Suffix Search Order** section, type in the domain suffix (usually the same as the domain) and press the **Add** button. If you were using Trumpet Winsock, this is the **Domain Suffix** value in the *Trumpet Winsock* **Setup** dialog box. When you're done setting these options, press the **OK** button. Then, press the **OK** button in the **Network** dialog box. Windows 95 will ask you to reboot. Choose **Yes**.

Step 3: Getting Connected

Since Windows 95 automatically loads its TCP/IP stack upon startup, you should be able to start accessing LAN and/or Internet resources right away. Open your Web browser and start surfing!

Step 4: If You Still Can't Connect

If you think everything is set up correctly but are still having problems, try the **Network Troubleshooting Page**.

Network Troubleshooting

Books

- *Routing on the Internet* – Prentice Hall, by Christian Huitema, ISBN 0-13-132192-7
- *LAN to WAN interconnection* – McGraw Hill, John Enck & Mel Beckman, ISBN 0-07-019614-1
- *Enterprise Network Performance Optimization*, McGraw Hill, Martin Nemzow, ISBN 0-07-911889-5
- *Linking LANs, McGraw Hill, Stan Schatt, ISBN – 0-07-057063-9*
- www.amazon.com – Largest online bookstore. You can have it always searching for new books on specific topics. When the search robot finds a new book, amazon emails you to let you know its available. Very well integrated and books arrive quickly.

Problem Solving Sites

- www.dejanews.com – Usenet Search – Great for checking if others have solved the problem already. Start Here!
- www.cis.ohio-state.edu/hypertext/faq/usenet/top.html FAQs (Frequently Asked Questions) Galore. Ohio State archives them as they come across USENET. If it exists, you'll probably find it here.
- www.internic.net/ds/dspg1intdoc.html – Request For Comments (RFCs) The documents that created much of the Internet. Do you want to know how a protocol works, what is ftp really like?, can PPP to IPX?, check here. You can read it from the horse's mouth.
- www.w3.org – Where a lot of the Web started. Some very good documents here. If you need the definition on HTML, this is the place.
- www.microsoft.com – All types of issues with Microsoft. If you call Microsoft for help, this is where they look
- www.apple.com – All types of issues with Apple and shareware on the ftp server.

Search Sites

- www.altavista.digital.com – Read the details on how to search. Doing a correct search will save you much time.
- www.yahoo.com – More of a catalog search. Great for news. Their ticker tape is one of the best. On the PC the ticker tape is stand alone.
- Hit the search button on Netscape for more.

Domain Registration

- www.internic.net – For the .com, .org domains. They provide a web form for registering web sites.

- www.isi.edu – USC, Information Sciences Institute. Home of the .us domain (including k12.ca.us) They have a form online, but its not as nice as internics. If you fill out the Internic form with a k12.ca.us domain, it will forward it to www.isi.edu for you.

Hardware Vendor Sites

- www.cisco.com – One of the best vendor sites. Large Intranet once you have established a maintenance contract.
- www.3com.com – 3COM's web site, hubs, routers, etc..
- www.adtran.com – TSU/DSU
- www.usrobotics.com – The Modem company
- www.intel.com – Wintel platform, drivers, etc…
- www.mot.com – Motorola device drivers, modems, etc

Telephone Companies

- www.pacbell.com – Prices and some information about services. They have some good demo's on speed. Always check with rep before quoting prices off of web.

Software Vendor Tools

- www.aggroup.com – Etherpeek, Netwatch manufacturer
- www.visualnetworks.com – Visual Network hardware and Software for watching Frame Relay connections

Shareware Sites

- www.shareware.com – Tons of software with evaluations of download sites. I love their top 10 download lists. Want to find out what the new hot shareware is, check here.
- www.tucows.com – Tons of software. Easy jump points to the types of software you might be looking for.
- ftp.apple.com – If you own a mac, bookmark this one.

Glossary

10Base2 - Ethernet specification for thin coaxial cable, transmits signals at 10 Mbps (megabits per

second) with a distance limit of 185 meters per segment.

10Base5 - Ethernet specification for thick coaxial cable, transmits signals at 10 Mbps (megabits per second) with a distance limit of 500 meters per segment.

10BaseF - Ethernet specification for fiber optic cable, transmits signals at 10 Mbps (megabits per second) with a distance limit of 1000 meters per segment.

10BaseT - Ethernet specification for unshielded twisted pair cable (category 3, 4, or 5), transmits signals at 10 Mbps (megabits per second) with a distance limit of 100 meters per segment.

Access Method - Rules that govern how nodes on a network access the cable.

AppleTalk - Apple Computer's network protocol originally designed to run over LocalTalk networks, but can also run on Ethernet and Token Ring.

AUI Connector (Attachment Unit Interface) - A 15 pin connector found on Ethernet cards that can be used for attaching coaxial, fiber optic, or twisted pair cable.

Backbone - A cable to which multiple nodes or workstations are attached.

Bit - Binary digit in the binary numbering system. Its value can be 0 or 1. In an 8-bit character scheme, it takes 8 bits to make a byte (character) of data.

BNC Connector (Bayone-Neill-Concelman) - Standard connector used to connect 10Base2 coaxial cable.

Bridge - Devices that connect and pass packets between two network segments that use the same communications protocol.

Cable - Transmission medium of copper wire or optical fiber wrapped in a protective cover.

Client/Server - A networking system in which one or more file servers (Server) provide services; such as network management, application and centralized data storage for workstations (Clients).

CSMA/CA - Carrier Sense Multiple Access Collision Avoidance is a network access method in which each device signals its intent to transmit before it actually does so. This prevents other devices from sending information, thus preventing collisions from occurring between signals from two or more devices. This is the access method used by LocalTalk.

CSMA/CD - Carrier Sense Multiple Access Collision Detection is a network access method in which devices that are ready to transmit data first check the channel for a carrier. If no carrier is sensed, a device can transmit. If two devices transmit at once, a collision occurs and each computer backs off and waits a random amount of time before attempting to retransmit. This is the access method used by Ethernet.

Coaxial Cable - Cable consisting of a single copper conductor in the center surrounded by a plastic layer for insulation and a braided metal outer shield.

Concentrator - A device that provides a central connection point for cables from workstations, servers, and peripherals. Most concentrators contain the ability to amplify the electrical signal they receive.

Dumb Terminal - Refers to devices that are designed to communicate exclusively with a host (main frame) computer. It receives all screen layouts from the host computer and sends all keyboard entry to the host. It cannot function without the host computer.

E-Mail - An electronic mail message sent from a host computer to a remote computer.

End User - Refers to the human executing applications on the workstation.

Ethernet - A network protocol invented by Xerox Corporation and developed jointly by Xerox, Intel and Digital Equipment Corporation. Ethernet networks use CSMA/CD and run over a variety of cable types at 10 Mbps (megabits per second).

Expansion Slot - Area in a computer that accepts additional input/output boards to increase the capability of the computer.

Fast Ethernet - A new Ethernet standard that supports 100 Mbps using category 5 twisted pair or fiber optic cable.

Fiber Optic Cable - A cable, consisting of a center glass core surrounded by layers of plastic, that transmits data using light rather than electricity. It has the ability to carry more information over much longer distances.

File Server - A computer connected to the network that contains primary files/applications and shares them as requested with the other computers on the network. If the file server is dedicated for that purpose only, it is connected to a client/server network. An example of a client/server network is Novell Netware. All the computers connected to a peer-to-peer network are capable of being the file server. Two examples of peer-to-peer networks are LANtastic and Windows for Workgroups.

Gigabyte (GB) - One billion bytes of information. One thousand megabytes.

Hub - A hardware device that contains multiple independent but connected modules of network and internetwork equipment. Hubs can be active (where they repeat signals sent through them) or passive (where they do not repeat but merely split signals sent through them).

Infrared - Electromagnetic waves whose frequency range is above that of microwaves, but below that of the visible spectrum.

Internet - A global network of networks used to exchange information using the TCP/IP protocol. It allows for electronic mail and the accessing and retrieval of information from remote sources.

LAN (Local Area Network) - A network connecting computers in a relatively small area such as a building.

Linear Bus - A network topology in which each node attaches directly to a common cable.

LocalTalk - Apple Corporation proprietary protocol that uses CSMA/CA media access scheme and

supports transmissions at speeds of 230 Kbps (Kilobits per second).

MAN (Metropolitan Area Network) - A network connecting computers over a large geographical area, such as a city or school district.

MAU (Multistation Access Unit) - A Token Ring wiring hub.

Modem (Modulator/Demodulator) - Devices that convert digital and analog signals. Modems allow computer data (digital) to be transmitted over voice-grade telephone lines (analog).

Multiplexer - A device that allows multiple logical signals to be transmitted simultaneously across a single physical channel.

Network Modem - A modem connected to a Local Area Network (LAN) that is accessible from any workstation on the network.

Network Interface Card (NIC) - A board that provides network communication capabilities to and from a computer.

Network Operating System (NOS) - Operating system designed to pass information and communicate between more than one computer. Examples include AppleShare, Novell NetWare, and Windows NT Server.

Node - End point of a network connection. Nodes include any device attached to a network such as file servers, printers, or workstations.

Node Devices - Any computer or peripheral that is connected to the network.

PCMCIA - An expansion slot found in many laptop computers.

Peer-to-Peer Network - A network in which resources and files are shared without a centralized management source.

Physical Topology - The physical layout of the network; how the cables are arranged; and how the computers are connected.

Point-to-Point - A direct link between two objects in a network.

Ports - A connection point for a cable.

Protocol -A formal description of a set of rules and conventions that govern how devices on a network exchange information.

RAID (Redundant Array of Inexpensive Disks) - A configuration of multiple disks designed to preserve data after a disk casualty.

RAM (Random Access Memory) - The working memory of a computer where data and programs are temporarily stored. RAM only holds information when the computer is on.

Repeater - A device used in a network to strengthen a signal as it is passed along the network cable.

RJ-45 - Standard connectors used for unshielded twisted-pair cable.

Router -A device that routes information between interconnected networks. It can select the best path to route a message, as well as translate information from one network to another. It is similar to a superintelligent bridge.

Segment - Refers to a section of cable on a network. In Ethernet networks, two types of segments are defined. A populated or trunk segment is a network cable that has one or more nodes attached to it. A link segment is a cable that connects a computer to an interconnecting device, such as a repeater or concentrator, or connects a interconnecting device to another interconnecting device.

Sneaker-Net - Refers to a manual method of sharing files in which a file is copied from a computer to a floppy disk, transported to a second computer by a person physically walking (apparently wearing sneakers) to the second computer, and manually transferring the file from floppy disk to the second computer.

Speed of Data Transfer - The rate at which information travels through a network, usually measured in megabits per second.

Star Topology - LAN topology in which each node on a network is connected directly to a central network hub or concentrator.

Star-Wired Ring - Network topology that connects network devices (such as computers and printers) in a complete circle.

Tape Back-Up - Copying all the data and programs of a computer system on magnetic tape. On tape, data is stored sequentially. When retrieving data, the tape is searched from the beginning of tape until the data is found.

Terminator - A device that provides electrical resistance at the end of a transmission line. Its function is to absorb signals on the line, thereby keeping them from bouncing back and being received again by the network.

Token - A special packet that contains data and acts as a messenger or carrier between each computer and device on a ring topology. Each computer must wait for the messenger to stop at its node before it can send data over the network.

Token Ring - A network protocol developed by IBM in which computers access the network through token-passing. Usually uses a star-wired ring topology.

Transceiver (Transmitter/Receiver) - A Device that receives and sends signals over a medium. In networks, it is generally used to allow for the connection between two different types of cable connectors, such as AUI and RJ-45.

Tree Topology - LAN topology similar to linear bus topology, except that tree networks can contain branches with multiple nodes.

Twisted Pair - Network cabling that consists of four pairs of wires that are manufactured with the wires twisted to certain specifications. Available in shielded and unshielded versions.

WAN (Wide Area Network) - A network connecting computers within very large areas, such as states, countries, and the world.

Workgroup - A collection of workstations and servers on a LAN that are designated to communicate and exchange data with one another.

Workstation - A computer connected to a network at which users interact with software stored on the network.
