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ABSTRACT

The purpose of this guide is to provide basic networking information and planning assistance for technology coordinators and others involved in building networks for K-12 schools. The information in this guide focuses on the first few steps in the networking process. It reviews planning considerations and network design issues facing educators who need to make intelligent decisions about constantly evolving technologies. Much of the document focuses on developing a sound, standards-based network infrastructure. Material is provided on selecting wire, designing a wiring plan, and related facilities issues. This primer enables the even the "non-techie" to (1) understand network building blocks, (2) ask the right questions and know where to find the answers, (3) identify resources for network planning and design, (4) insist on a system based on standards, and (5) better evaluate vendor proposals. Chapters one through five focus on learning about networks. Chapter six outlines nontechnical considerations for making a network function well and serve its intended purpose. Appendices include a school networking needs analysis planning worksheet; sample wiring specifications; information on the OSI Seven-Layer Model; wiring guidelines for schools; snapshots of school networks; and networking resources for Northwest schools. Contains a bibliography and a glossary. (AEF)

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A project of the Washington State Office of the Superintendent of Public Instruction
Prepared by the Northwest Regional Educational Laboratory's
Northwest Educational Technology Consortium

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Contents

Preface

A *Guide to Networking for K-12 Schools* has followed an evolutionary path to a successful arrival. It is the result of a project originally masterminded and developed at the Washington State Office of the Superintendent of Public Instruction (OSPI) and turned over for final production to the Northwest Regional Educational Laboratory's (NWREL) Northwest Educational Technology Consortium (NETC). Along the way it has been touched by many capable hands, knowledgeable minds, and persevering temperaments. Among the most deserving of recognition are

Inspiration: Cheryl Lemke, former Educational Technology Program Administrator at Washington OSPI

Allocation: Judith Billings, former Superintendent of the Washington OSPI

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Introduction

The intent of A *Guide to Networking for K-12 Schools* is to provide basic networking information and planning assistance for technology coordinators and others involved in building networks for K-12 schools. It also serves as companion document to the *Wired* series of video conferences hosted by NETC.

This document assists you with designing a school network that meets teaching, learning, and administrative needs. The information focuses on the first few steps in the networking process. It reviews planning considerations and network design issues facing educators who need to make intelligent decisions about constantly evolving technologies.

Much of the document focuses on developing a sound, standards-based network infrastructure. An infrastructure that will meet current needs and grow with your network is vital. Accordingly there is a great deal of material on selecting wire, designing your wiring plan, and related facilities issues. Appendices contain more detailed wiring recommendations that you can use when working with wiring contractors.

This is by no means the definitive work on how to network schools—and the authors do not expect that you will become "network engineers" after reading it. The authors do believe, however, that with some basic information, you will be better informed, and thus able to make more intelligent decisions and choices.

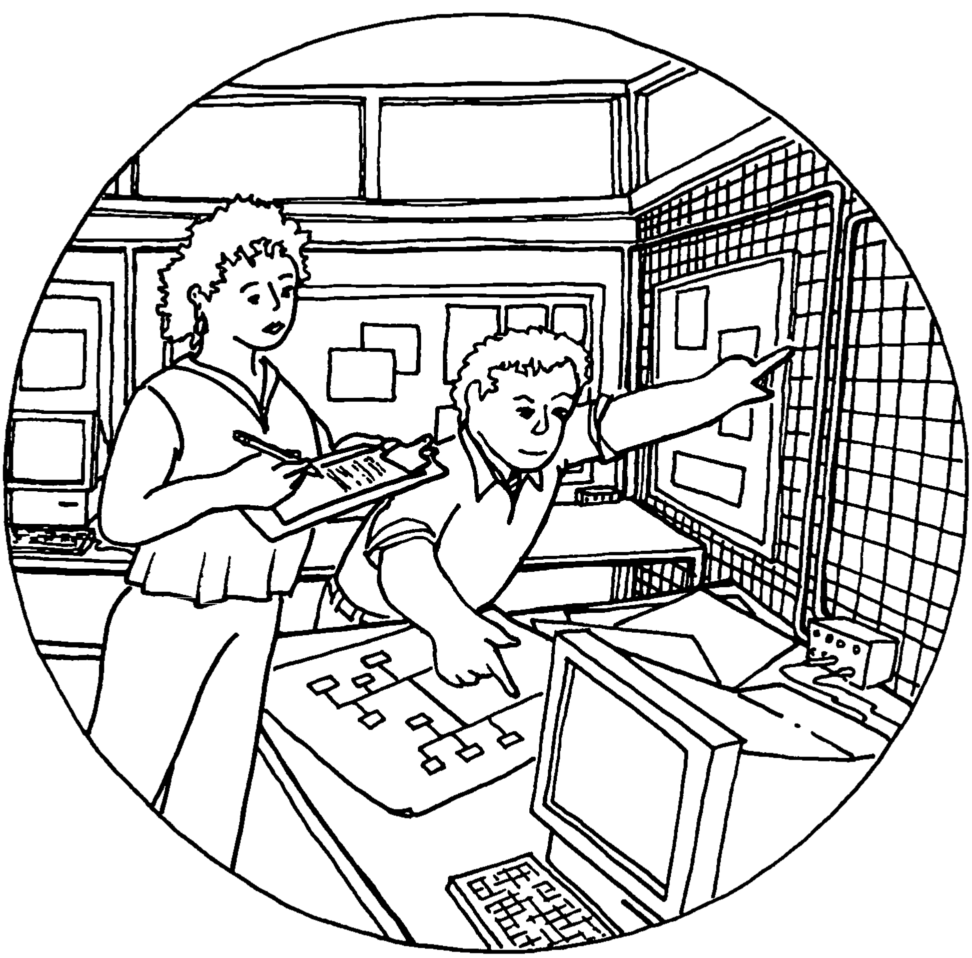
Even if you are a self-proclaimed "non-techie," you are perfectly capable of grasping networking basics. With this primer you will be able to

- Understand network building blocks
- Ask the right questions and know where to find the answers
- Identify resources for network planning and design
- Insist on a system based on standards
- Better evaluate vendor proposals

Chapters one through five focus on learning about networks. While not highly technical, the information in these chapters includes a number of new concepts that should be useful to you in planning a K-12 network.

Chapter six outlines nontechnical considerations to make your network function well and serve its intended purpose.

Appendices include a planning worksheet; sample wiring specifications; information on the OSI Seven-Layer Model; snapshots of school networks; and networking resources for Nothwest schools. A bibliography and a glossary are included to assist you in finding additional resources and mastering networking terminology.

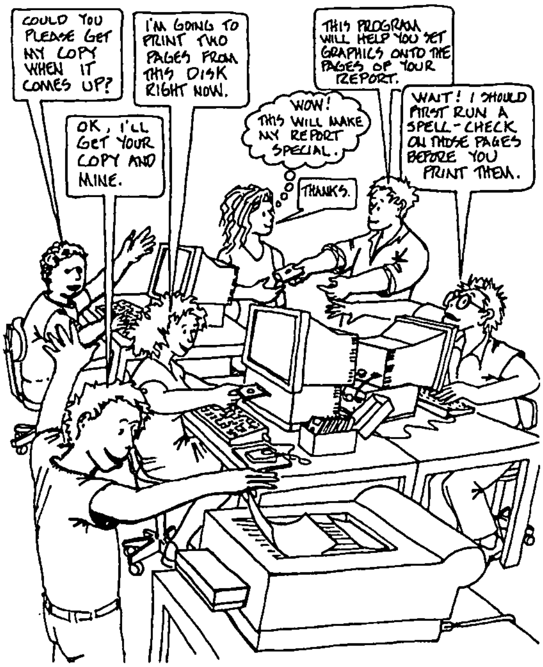


Why Network K-12 Schools?

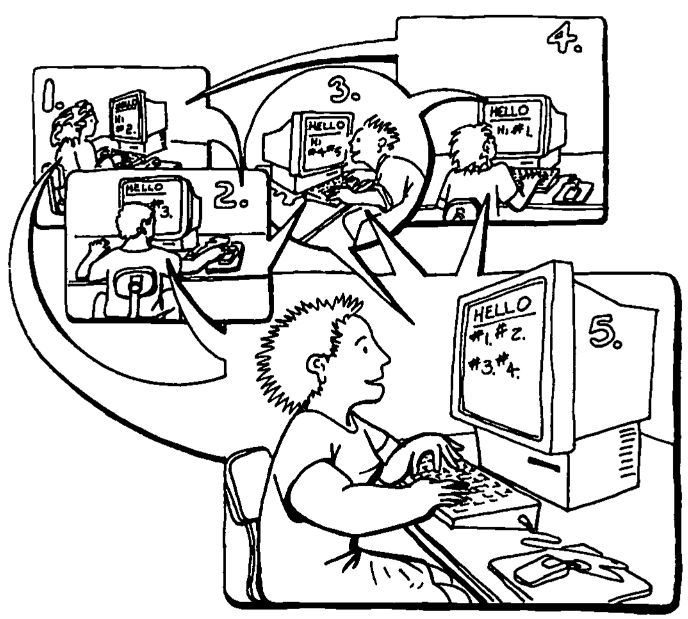
1

If you ask 10 people why they want to build a school network, you might get 10 different answers. Here are some of the benefits that can be derived from school networks:

- Both teachers and administrators can quickly access student information from a central resource. This information need only be entered *one* time.
- Administrative decisionmaking and information management can improve—from writing policies to creating budgets.
- Students' opportunities to learn collaboratively within the school and around the world can increase through access to networked information and online partners and mentors.
- Education-reform needs can more easily be achieved—including cross-age tutoring, learner-centered instruction, extended project work, and teacher as facilitator.
- Opportunities for schools to develop interdisciplinary curriculum, to bring in "virtual guest speakers," and to perform community-based research are increased.
- Teachers' opportunities for professional growth through online course work and access to current information are improved.
- Teacher isolation can be reduced through the use of e-mail groups of professional peers.
- Communications among teachers, administrators, and students can be greatly enhanced through the use of e-mail and internal Web sites (called intranets).
- Shared access to significant documents, such as lesson materials, allows changes as needed through online group collaboration.
- Scheduling of meetings, facilities, equipment, and services through e-mail and scheduling software becomes easier and more efficient.
- Sharing costly hardware resources such as printers, scanners, and CDs is cost efficient, and increases the ability to gather, format, produce, and deliver information.
- Sharing access to the Internet allows students and teachers to communicate with their peers, subject experts, and information sources around the world. Building a school network allows many students and teachers access to the Internet with better performance and lower cost than they could individually.



It is increasingly clear that electronic communications are rapidly changing our world. Students *must* learn how to access information efficiently, how to validate that information, and how to communicate and contribute effectively as team members in collaborative work environments. Students need to learn how to be informed consumers of information as well as capable producers of information. The school network is the training arena for learning these essential new skills.



Initial Steps

The First Step is Learning

The Second Step is Planning

2

The First Step is Learning

Your first step in building a school network will be *to learn*. You will need to become familiar with basic networking terminology and some fundamental ideas. This knowledge will allow you to plan and implement your network. A good, basic understanding will also help you to work effectively with the many vendors and contractors that will be involved in your network.

This document is a starting point for your learning, but there are many more resources, including: books, classes, state and regional educational agencies, vendors, service providers, and consultants. Increasingly, you can find conferences for educators or school board members that convene special technology strands and events that specifically address network issues.

Your learning will go beyond just gaining an understanding of networking. When building a school or district network, you will face many challenges that are not technical in nature. You will likely grapple with funding, support staffing, building codes, appropriate use, and other issues.

You should endeavor to learn about these issues from other schools and districts. Learn from the pathfinder schools and districts that have implemented highly successful networks while facing the same types of budgetary, organizational, and political challenges that you may face.

Once you develop a better understanding of your networking task, it's time to go on to the next step: planning your network.

The Second Step is Planning

Your school or district will need some kind of comprehensive technology plan to guide its network planning. Many schools and districts begin their technology planning by using their broad educational plan as the foundation or starting point to help identify what issues and needs will be addressed by technology.

A comprehensive technology plan has several elements. These include:

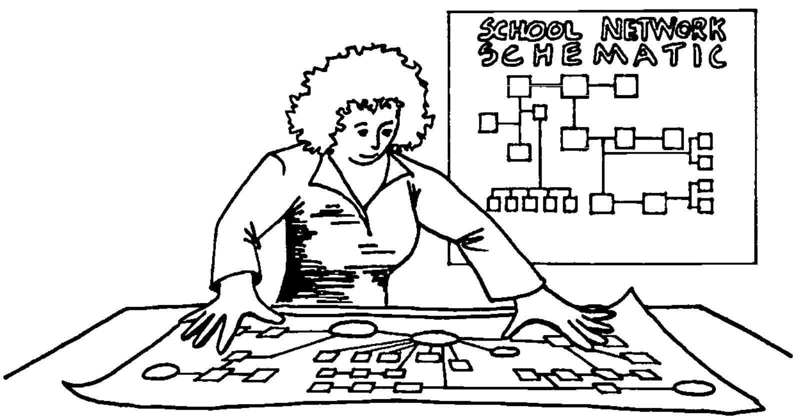
- Vision/mission/goal setting
- Existing equipment inventory and needs assessment
- Curriculum plans
- Hardware and software selection and purchase guidelines
- Networking plans
- Technical training
- Professional development
- Technology program management
- Ongoing maintenance and upgrade plan
- Evaluation and assessment model
- Funding plans
- User policy and appropriate-use guidelines

Although each element is important, this guide focuses on the network planning. There are several good resources for developing the broader comprehensive technology plans, including samples available from other schools and districts. Extensive information about technology plans, and some sample plans, can be accessed through the technology planning pages of the Northwest Educational Technology Consortium Web site (http://netc.org/tech_plans/).

A networking plan is also made up of several elements. Your networking plan may include sections on:

- User needs assessment
- Wiring diagrams and network "blueprints"
- Data storage, security, and backup plans
- Hardware and software standards and specifications
- Network management and maintenance plans
- Access policies and procedures

Networking plans are often developed by small committees or teams and may take months to develop. You will want your plan to take into consideration the needs of all those persons who are affected by your network. A planning team should seek input from a broad selection of potential users and other stakeholders. A thorough network needs analysis process to inventory staff needs is an important early task of a planning committee. (See Appendix A for a sample network needs analysis.)



The needs data you gather will have to be analyzed and prioritized. You may find that your stakeholders want more of a network than your resources permit. A large part of network planning is bringing stakeholder expectations in line with practical and technical limitations.

Your planning efforts need to be dynamic because your needs change as your network users are exposed to the power of networking. You also need to be able to adapt your plan to the constant improvements in technology.

It is vital that the people developing the networking plan have a good knowledge of general networking concepts. The following chapters introduce some of these general concepts.

Overview of Networks

Three Simple Parts

LANs and WANs

Networking Costs

Planning for Good Network Design

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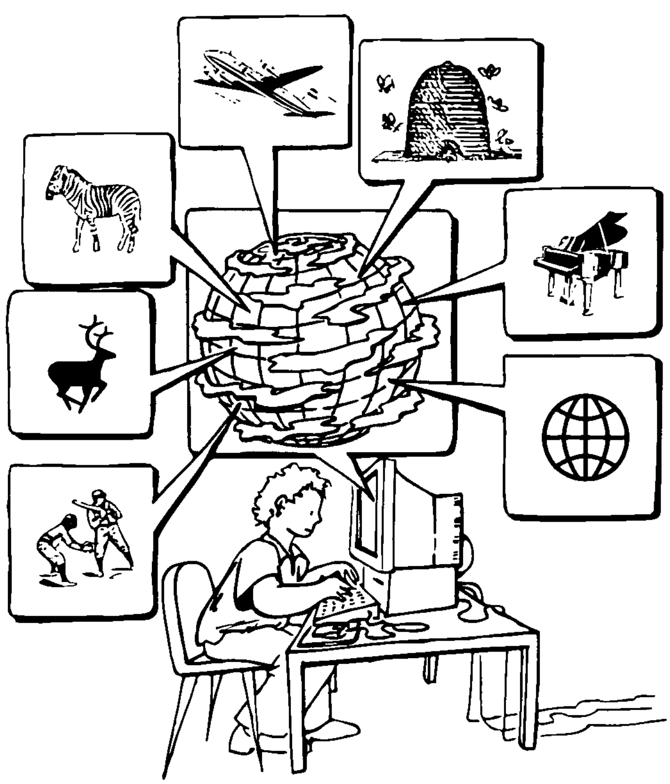
Three Simple Parts

Without even thinking about it, you use networks all the time. When you pick up the telephone, for example, you join the global telephone network. In general terms, a network is a communications system used to connect two or more users.

Many types of networks exist today. While a voice network connects two or more users for a conversation—between you and your best friend, for instance—a computer network connects users of devices such as computers, printers, or application programs so they can share information. With the introduction and proliferation of low-cost personal computers, computer networks have become commonplace. The largest of these networks is, of course, the global Internet—the network of networks.



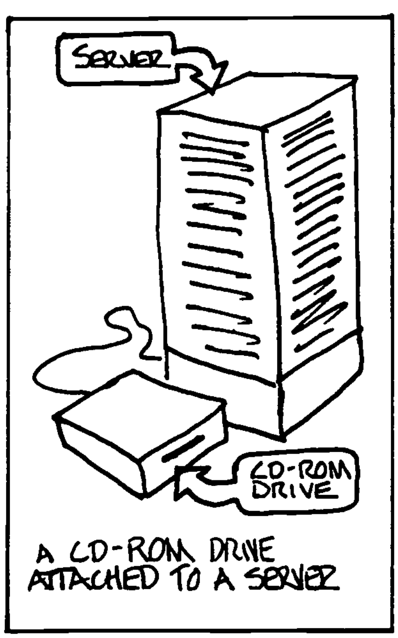
In the simplest sense, every computer network consists of three parts:

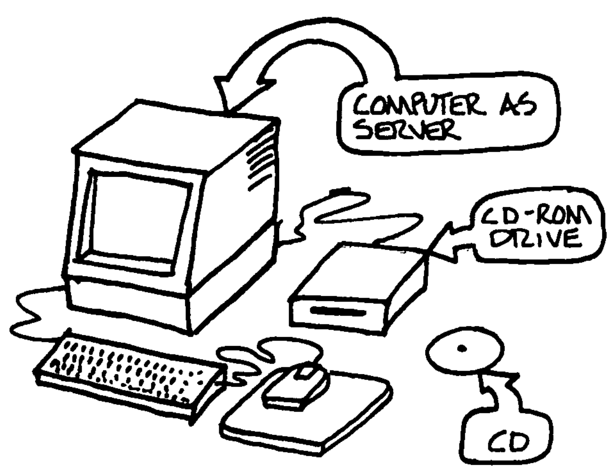
- **Clients:** The user workstations and peripherals
- **Infrastructure:** The wires, fiber optics, or transmission media that the data moves through
- **Networking electronics:** Devices that move, route, and store data for users

That is pretty simple, right? Just three parts. Well, it does get a bit more involved in practice. A network with 5,000 users might have thousands of components, but each would be one of the types described above.

The simplest networks are called *peer-to-peer* networks. In these networks each client has its own storage area, which might be shared with other clients. There is no central storage in this type of network. Peer-to-peer networks are often used in small classroom computer labs.

More commonly we see *client/server* networks. These networks have storage devices on the network that may hold data for users to share. If you have worked on a client/server network, you have probably heard the term *file server* used in reference to these storage devices. A client may use the network to connect to one of these storage devices and get some documents to view or edit.





LANs and WANs

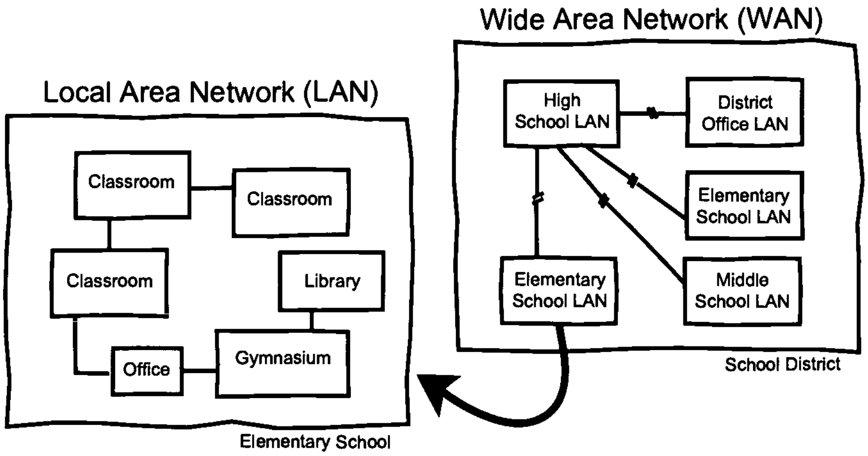
Computer networks come in all sizes. They are usually referred to by their size and scope. The term *LAN* has become almost synonymous with the word network. A *local area network*, or LAN, is a network in which all clients share a common infrastructure (wires) and are usually in the same building, or group of buildings.

In contrast, a *wide area network*, or *WAN*, is one that spans a larger geographic area. For instance, a network that links two or more LANs that are separated by some distance might be called a WAN.

A really big network made up of several diverse LANs and WANs is often called an *internet*. As noted earlier, the largest group of interconnected networks in the world is the global network known as the Internet (notice the capital I). Increasingly, large groups of networks are interconnected within an organization. This type of network has come to be called an *enterprise network* or an *intranet*.

Intranets have become enormously popular, and they often rely on the same standard software packages that most of us use for the Internet. For example, using a standard World Wide Web browser, teachers in a large district might navigate their own district's intranet to find class schedule information or a message board for sharing curriculum ideas. Such intranets may look and feel just like the Internet, but access to them is often limited to users within an organization.

OK, now you have some terminology at your disposal. You can call up your networking vendors and say: "We are looking to build a district WAN made up of 14 LANs. We estimate about 1,200 clients eventually, and of course we want to link our WAN into the Internet." That should get their attention!



Networking Costs

Building and operating a network costs money. Generally costs are determined by a number of factors, among them are:

- How many users will there be?
- Over what distance will the users be spread?
- At what speed of communication will the network run?
- How complex or simple will the network be?
- What type of client services are needed?
- How well designed is the network?

It is logical that a network connecting 20 students in a single classroom computer lab will be cheaper than a network that connects 300 teachers across large districts. That's fairly obvious.

But some of the other cost factors are not as obvious. For instance, a network in which every user has the same type of computer will be cheaper to build and operate than one in which there are several different types of computers. This is the complexity factor at work.

The type of services needed is another good example. A network where everyone needs only e-mail will be much cheaper than one where everyone needs live video conferencing. Accordingly, when you are planning, it is really important to separate the need-to-have services from the nice-to-have services. Remember that you will be networked for a long time; there will be plenty of time to add those bells and whistles.

ONGOING COSTS

Networking cost analysis should also take into account ongoing support costs. Many network planners use the rule that one full-time support person will be required for every 50-75 users. In schools, students and teachers are often involved in the network support. Using certified staff for day-to-day technical support may not be appropriate or practical in many situations! Remember, managing a school network can be a full-time job. What happens when the network goes down and the teacher/network manager is teaching a chemistry class? If you choose to use student or teacher time, it is important to be realistic about the time demands that will be created by your network-support needs.

Other ongoing costs are related to maintenance and upgrades for your network. If you are successful, demands for network services will increase steadily, and so will monitoring and maintenance costs. The phenomenal rate of change in the world of technology also requires that you plan for costs due to growth, improvements, and upgrades. And with each major change or improvement, there will be costs related to training, both for network users and the network-support staff.

INFRASTRUCTURE COSTS

When looking at typical costs for network components, the small percentage spent on infrastructure can be surprising:

Software—53 percent

Hardware—35 percent

Networking electronics—7 percent

Infrastructure—5 percent

Notice, too, that while infrastructure accounts for very little of the overall network cost; it also tends to last longer than the other networking components.

Component	Typical Life Span
Client stations (PC, Mac)	18-36 months
Network electronics (hubs, routers)	3-5 years
Infrastructure (wires, racks, wiring closets)	10-20 years

Because infrastructure is relatively inexpensive and long lasting, the obvious conclusion is to build the best infrastructure that you can. Unfortunately, in practice many networks are built on poor infrastructure, usually because the network was not planned for growth or costs were cut in the wrong places. For example, when a less expensive and lower-rated wire is selected it may not accommodate higher transmission speeds when you want to upgrade. Another common infrastructure mistake is to reduce costs by limiting the number of data ports (or drops) per classroom below the recommended four to six. The current price of $150 per drop is a very sound investment when compared to the cost to incrementally install additional cabling for new, dedicated, high-speed data ports while simultaneously continuing to provide for the existing ports.

Most network professionals say that the bulk of the problems your network could encounter come from a poor infrastructure. Think of network infrastructure like you would the foundation of a house. If you were to build a poor foundation under a house, wouldn't that house have problems? It does not matter how well built the house is above ground if the foundation is not solid.

A final note concerns the use of volunteers and students to install network infrastructure. The schools that have done this successfully have used the services of experts to train, oversee, or test the installations. In other words, make expert advice available to get the job done properly.

Planning for Good Network Design

Building a good, well-planned infrastructure is just one of the many tasks ahead, but it illustrates something that is true of the whole network implementation process: planning pays off! A well planned network will be

- **More reliable:** less downtime
- **Lower in cost:** less expensive to support, expand, and use
- **More flexible:** based on standards, easy to expand, uses parts from many vendors
- **Simple to support and use**

The alternative to good planning is building your network ad hoc. Some people mistakenly assume that they can save money by eliminating a planning process. They prefer to spend their budgets right away on new hardware and software. The next time there is money in the budget, they run to buy more equipment. This strategy may work for the smallest of classroom labs, but on larger networks, ad hoc networking ends up being expensive, hard to support, and very complex for users.

Networking Standards

Where Do the Standards Come From?

A Standard by Any Other Name . . .

Selecting Standards

4

The key to network planning is understanding networking standards. When architects design a building, there are certain specifications and building codes that should be met. So, too, computer network systems should be built to a set of standards.

From the very first computers networks in the mid-1970s until the mid-'80s, vendors were primarily responsible for defining the network components and how they worked. This translated into the IBM way, the Digital Equipment Corporation (DEC) way, the WANG way, and so on. There were few agreed-upon standards.

With the introduction of the personal computer, a requirement for interconnecting various computers became evident. It was no longer possible to survive in a "one vendor" world since no one vendor provided all the necessary components. A set of networking standards did not mean that all existing network schemes would go away, but that a common denominator was needed to facilitate the interconnection of incompatible systems. Today, most hardware manufacturers and software developers rely on standards to ensure that their products will interoperate with one another.

A product that is not based on standards is known as a *proprietary* product. Proprietary products are typically only available from one company. It's best to avoid using proprietary products if you can. The history of the computer industry suggests that the vendors of proprietary systems tend to do poorly in the market and often do not survive. In the worst case this could leave you with a network with few or no available parts. Generally a network that relies heavily on proprietary products is likely to be more expensive to support and less flexible.

Realize that many companies will still try to sell you proprietary solutions to your networking problems. This should not surprise you—they can make more money on products that have no competition! You need to carefully evaluate the product that you are buying and seek product information from several sources.

Where Do the Standards Come From?

The standards come in two types. The first type is *de facto* standards. These are standards that simply arose because most everyone in the industry started to do things a certain way. Often a de facto standard was promoted by a few large companies until it caught on.

The other type of standard is one recommended by a *standards organization*. These organizations, for the most part, exist to make sense out of chaos. Without standards organizations, it would be difficult for the multivendor networks of today to communicate.

A few of the major standards organizations are listed below. The initials or acronyms for their formal names may be a bit confusing at first; however, it's helpful to at least be aware of these groups because their names will often come up as you are implementing your network.

- **EIA/TIA.** The Electronic Industries Association (EIA) and the Telecommunications Industry Association (TIA) have produced a set of Building Telecommunications Wiring Standards that are used to install standards-based voice and data networks. Most commonly referenced are the EIA/TIA-568 and -569 standards, that relate to wiring standards and communication pathways and spaces, respectively.
- **CCITT.** The Consultative Committee on International Telephony and Telegraphy (CCITT) is a subsidiary of the International Telecommunications Union (ITU). The ITU was formed in 1865 and is now a special agency of the United Nations. Telecommunications carriers, such as AT&T and GTE, are the principal participants of the CCITT. It is this organization that set the V.x Standards for modem communications.

- **ISO.** The International Standards Organization (ISO) is composed of telecommunications manufacturers and users. The ISO developed the Open Systems Interconnection model, commonly known as the OSI model. This model serves as the standard communications structure for evolving network technologies.

  A basic understanding of the seven functional layers of the OSI model is most helpful in understanding how devices on a network communicate and the roles played by networking hardware such as repeaters, bridges, and routers. (See Appendix C for additional information on the OSI model.)
- **ANSI.** National standards bodies work on standards in their respective countries and are members of ISO. The American National Standards Institute (ANSI) is the recognized standards body of the United States. One of the jobs of ANSI is to coordinate ISO requirements for the U.S.
- **IEEE.** Among other functions, the IEEE (The Institute of Electrical and Electronics Engineers) establishes network protocol standards based on the OSI model.

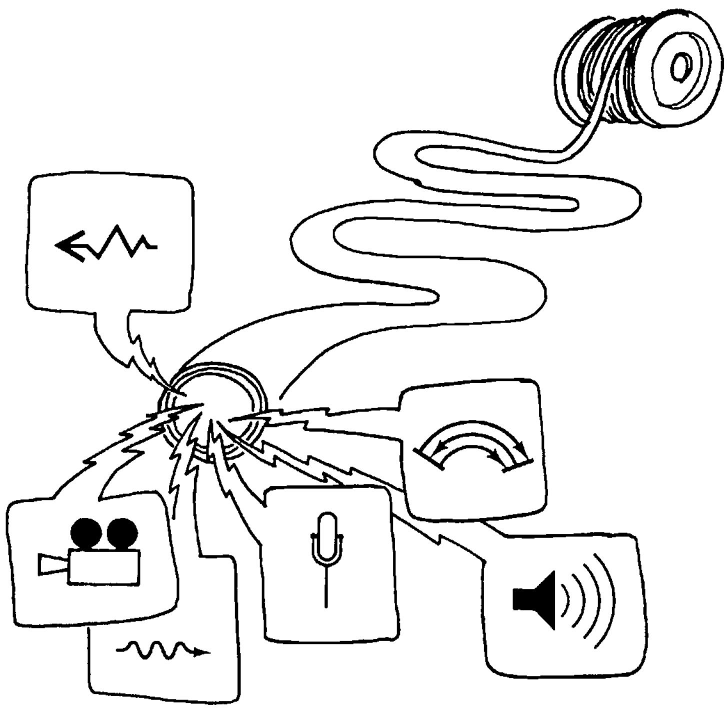
Many other standards groups exists. Typically the standards they will publish have alphanumeric names like V.34 or Q.931. You do not need to learn all these names; however, your vendors should be able to tell you what standards their products conform to.

A Standard by Any Other Name . . .

Standards set forth by these organizations are imbedded in most of the components that will be used in your network. There are standards for wire, for the connectors on the ends of the wire, for voltages on the wires, for how the client stations will "talk" using those voltages, and so on.

You should get comfortable with the following networking terminology commonly used to describe networks and the standards by which they function:

- **Protocols.** A protocol is a standard for how devices communicate. Protocols can be broken down into layers. For example, *physical protocols* specify things like voltage levels on wires, while *network protocols* might specify how a client might request a retransmit of some data that it needs. A group of protocols that work together is called a *protocol suite*. An example of a common protocol suite is *TCP/IP*, which defines communication on the Internet. (See Appendix C for information on the Seven-Layer OSI Model.)
- **Platforms.** A platform is a standard for a combination of a hardware and an operating system family. Typically, software applications are written to work on specific platforms. An example is the Macintosh platform: you might have a PowerPC running Mac OS 7.55 or a Mac Classic running Mac OS 6.08, but both would be considered Mac platform. The dominant platforms today are the PC (also referred to as a WinTel—Windows on an Intel processor), Mac, and UNIX platforms. Many school networks today are multiplatform, consisting of two or more platforms on the same network.
- **Media types.** A media type refers to the transmission material or pathway for the data. Media types include fiber optics, twisted pair copper wire, coax cable, radio waves, and so on.
- **Topologies.** The topology defines the shape of a network. Some networks are shaped like rings with all the client stations connected in a logical circle; others are shaped like stars with all the client stations connected to a central point. Probably the most common network topology today is the star as exemplified by 10BaseT networking. This networking scheme draws from many standards including the IEEE 802.3 Ethernet standard and EIA/TIA standards for network cabling.



Selecting Standards

By now you probably have guessed that one of your tasks as a network planner will be to select the best standards for your network. That can seem daunting at first, but with a good needs analysis you will likely find that your choices are pretty limited and will be dictated by

- **Needs.** What you want to do with your network?
- **Economics.** What standards can you can afford to implement and support?
- **Compatibility.** Do you need to work with existing systems or local services?
- **Availability.** Can you find hardware, software, and support?

You will discover that it usually makes sense to go with the most established standards. If 80 percent of new networks are using a standard called *10BaseT Ethernet*, then there are likely to be many sources for both products and support. It will also probably be supportable for a longer period of time than standards that have less momentum in the market.

Very often the latest-and-greatest networking technology is unproven, unstable, and costly—so be careful in selecting anything that is too "cutting edge." Go with standards that have been on the market for a while. You will save money and prevent headaches. That seems like common sense, but, nonetheless, many people get caught up in the appeal of the newest technology .

Another rule of thumb in selecting standards is to simplify. Use a few standards, and use them across the entire network if possible. This rule of thumb is good advice in districts with site-based management. Take heed from districts that let each site choose its own approach, and later had to standardize. A network that is multiplatform, uses four different media types, and runs three protocols is going to be complex and costly. Just imagine trying to find support people who happen to know about all your different standards. You want to build the simplest network that will meet your needs; reaching consensus about network standards at the outset will save tremendous time, money, and resources.

Common Components & Practices

Network Infrastructure

Bandwidth and Network Implementation

Network Electronics

The Network Client Platform

Network Operating Systems

Wide Area Networking

Seeking Qualified Help

5

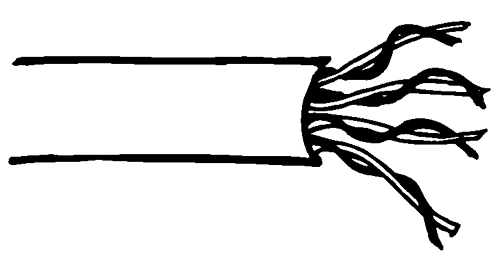
Now that you have an idea of what standards are, let us take a look at common components and practices in the design and construction of today's networks.

Network Infrastructure

MEDIA TYPES

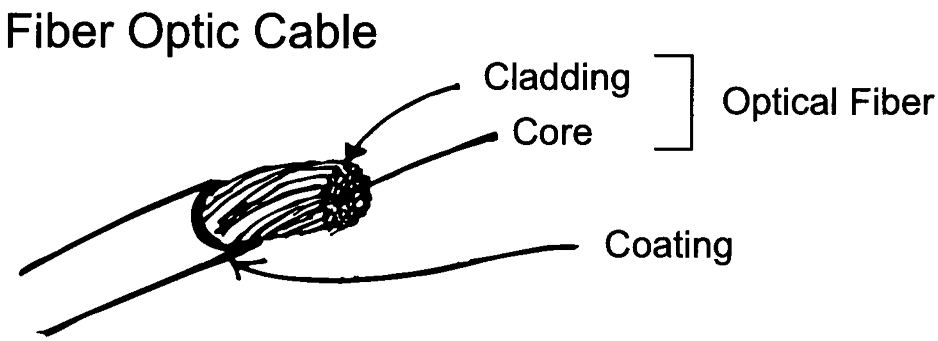
There are several media types you need to know about in planning and building your network.

Unshielded twisted pair (UTP) wire. Unshielded twisted pair has been used by telephone companies for years to attach phones for local service. Today it is used not only for voice applications, but also in data-network applications. Because of the use of UTP in data communications, seven specifications have emerged, ranging from Category 1 for voice grade to Category 7 for *ultra* high-speed data. Today's EIA/TIA standard is to use Category 5 UTP for LANs. Category 5 UTP has four distinct twisted pairs of wire within an outer sheath. This wire can handle data transfer rates in excess of 155 Mbps (megabits per second) and is likely to be supported for many years to come. It has become the most common media type for LANs today.



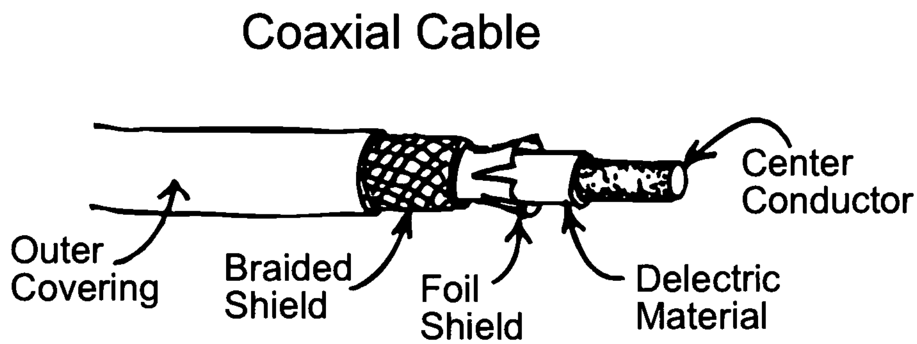
Four Pair Twisted

Fiber optic cable. Fiber optic cable uses light instead of electricity to carry data. This accounts for two of its advantages: (1) Data can be moved at extremely high speeds without generating interfering RF (radio frequency) signals and (2) Data transmission is not affected by the proximity of electrical equipment or high-voltage transmission. Most fibers are made of glass, plastic, or plastic-clad glass. The fibers are somewhat flexible, and the degree of flexibility depends on the fiber diameter. There are three components to optical fiber: the core, the cladding, and the coating. The cladding blocks exterior light sources and restricts the internal light to the core only. The coating is usually plastic and surrounds the cladding. Its purpose is to protect the fiber from physical and environmental damage.



There are two categories of fiber: single mode and multimode. Single-mode fiber has a smaller diameter core, generally uses laser as a light source, and can transmit data in excess of 25 miles without having to regenerate the signal. Multimode fiber has a larger diameter core, generally uses low-cost, light-emitting diodes as a light source, and can transmit data up to a mile. LANs and campus networks usually make use of multimode fiber. Both categories of fiber are generally much more expensive than twisted pair wire. Because of this, fiber is usually limited to situations where long distance runs or very high speeds are needed.

Coaxial cable. Coaxial cable is probably the most well-known type of cable. The term coaxial denotes a class of cable that has several layers of material surrounding a common axis. A center conductor, either solid or stranded, is surrounded by a nonconductive material, covered by a shielding material, then covered by an abrasion-resistant jacket. At one time, coaxial cable was the only media available for use in data networking. Today, the most common use of coaxial cable is for video distribution, while UTP and fiber are commonly used in data networking.



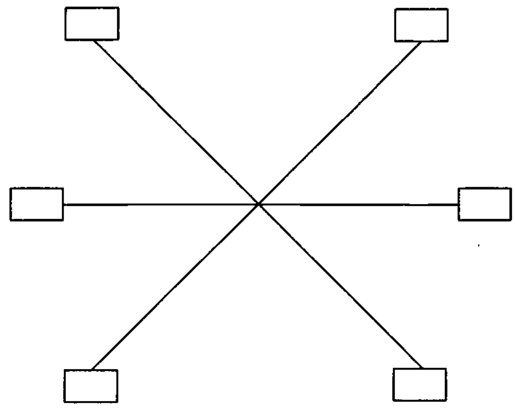
Wireless media. Several new technologies allow for the use of radio or microwave transmission for data networks. Wireless systems have special applications in interbuilding communication and might be useful in your campus or district networks. Be aware that there are trade-offs with wireless. Reliability, cost, and performance should be carefully analyzed.

The use of a particular media dictates the type of interface needed for the network electronics you use.

TOPOLOGY

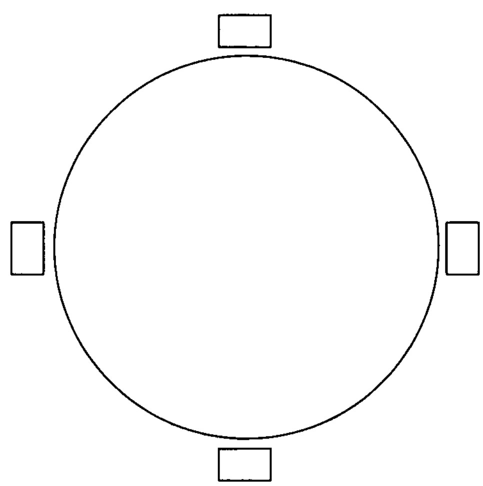
Each of the media described above can be used in different topologies. Again, the topology is just the shape or pattern that the network takes on as it is built. Networks are patterned in three general topologies: the star, the ring, and the bus.

Star topology. The star topology for a local area network looks like a star. All network wiring runs from the client to a central location or hub.



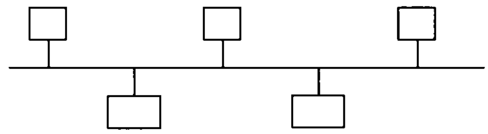
Star topology

Ring topology. The ring or loop topology connects computers in a continuous loop. In local area ring networks, though, the physical wiring topology really looks like a star. The logical ring topology depends on the network electronics you are using. IBM's Token Ring takes advantage of this topology. The token is constantly passing around the network. A computer can transmit when it gets the token.



Ring topology

Bus topology. The bus topology was the first local area network topology in use. In this pattern network clients are strung along a single cable. The cable must be electrically terminated at each end to function properly. A variation of the bus topology is the daisy chain. In a daisy chain, the first component is connected to the second, the second to the third, the third to the fourth, and so on.

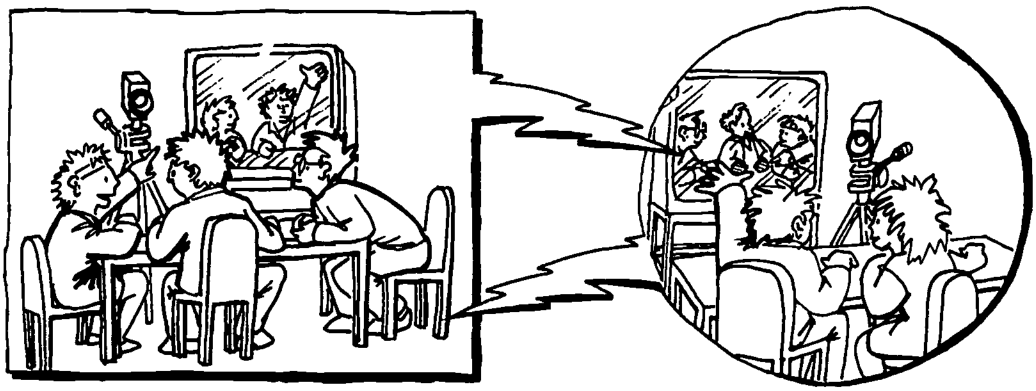


Bus topology

Each of the topologies creates different needs for support and troubleshooting. Most local area networks today use the star topology because it tends to be the easiest to troubleshoot.

Bandwidth and Network Implementation

The rate of data transmission over a network is usually referred to as its *bandwidth*. The more data you need to move in a fixed amount of time, the more bandwidth you need. In practice, your need for bandwidth depends on the network applications you use. For example, if you want simple e-mail and transfer of small files, then you need only a little bandwidth. On the other hand, if you intend to have regular digital video conferences, then you need a very large bandwidth.



Your need for bandwidth usually determines the media and data transmission protocols that you will select for your network. Common media and protocol combinations include:

LocalTalk and EtherTalk. LocalTalk is AppleTalk network protocols running over common phone wire and is a proprietary network implementation built into many models of Apple computers. It is relatively slow (243 Bps), but it is still popular in many small Mac labs. Apple Computer's implementation of AppleTalk over Ethernet (10 Mbps) is called EtherTalk. If you have a LocalTalk network and an EtherTalk (Ethernet) network, you can connect the two using a router, a software or hardware device that allows users on different networks to communicate and share resources. (More about routers shortly.)

Ethernet, 10BaseT, 100BaseT. Ethernet is the most common LAN protocol in use today. Estimates are over 80 percent of the installed networks use this protocol. The Ethernet protocol was originally used over coaxial cable with a bus topology. This proved difficult to support, and soon a new standard Ethernet implementation called 10BaseT emerged.

The topology associated with the 10BaseT standard is the star. In this topology, network clients are linked, using UTP wire, to a hub at the center of the star. The hub electronically "repeats" all the data on the network to the other users.

10BaseT is popular because it's inexpensive and fast enough (10 Mbps) for many of today's applications. A second generation of 10BaseT, called 100BaseT, offers 10 times the bandwidth, but at a higher cost. The 100BaseT networks may utilize the same

Category 5 UTP or fiber that the 10BaseT uses, protecting your investment in infrastructure. Many companies are fast at work on the next generation of 1,000BaseT, which they hope to deliver over Category 5 wire.

Token ring. Token ring is a network implementation pioneered by IBM using a ring topology. It has declined in popularity in recent years due to the rapidly declining cost of Ethernet. Many school sites may have some existing token ring networks in place. Proponents favor token ring's performance under heavy loads, while detractors feel it is too costly to implement and support.

FDDI. FDDI (fiber distributed data interface) is a fiber-based implementation that uses a ring topology. It provides high bandwidth and accommodates long distances. Typically it is used to connect groups of servers together, rather than client stations. It is sometimes used as a backbone that connects together many smaller network segments. Its high cost has limited its application.

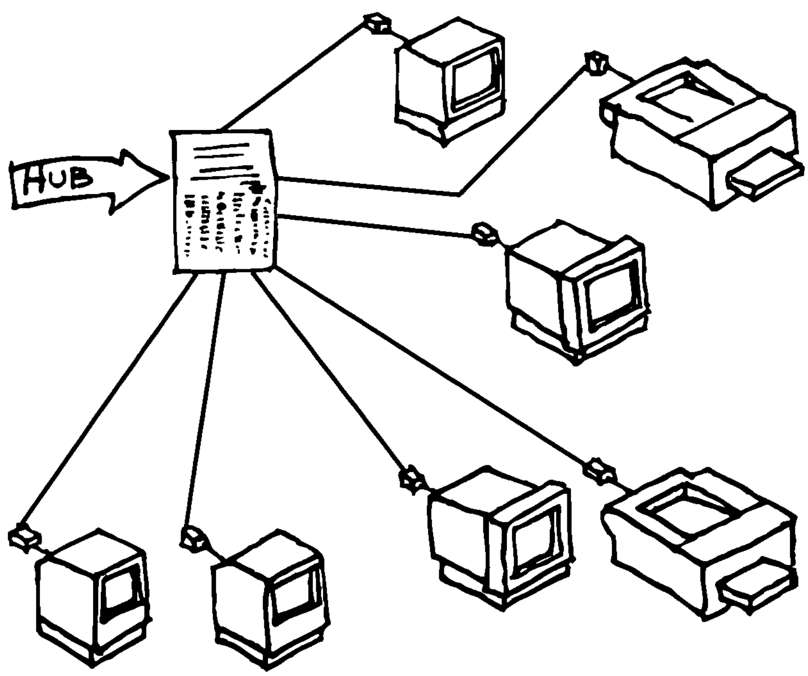
Others. There are many other network implementations in existence, but you are more likely to encounter the ones noted. Again, your network of choice will depend mostly on your need for speed and the limitations of your budget. The faster protocols cost more to implement, and while they may offer some advantages, they might not be practical.

Network Electronics

Network electronics exist to move your data around on your network. Become familiar with the following key components and their functions:

NICs. The network interface card (NIC) is an add-on board that serves as the connection between the client computer and the network infrastructure. In other words, to hook all your computers together, a special electronic circuit card called a NIC goes inside each computer. That's where you plug in the cable that connects the computer to the network. Some computers come with built-in network interfaces and do not require an additional NIC. You will find that NICs vary in cost depending on the type of protocol they support. For example, 10BaseT NICs are inexpensive when compared to FDDI NICs.

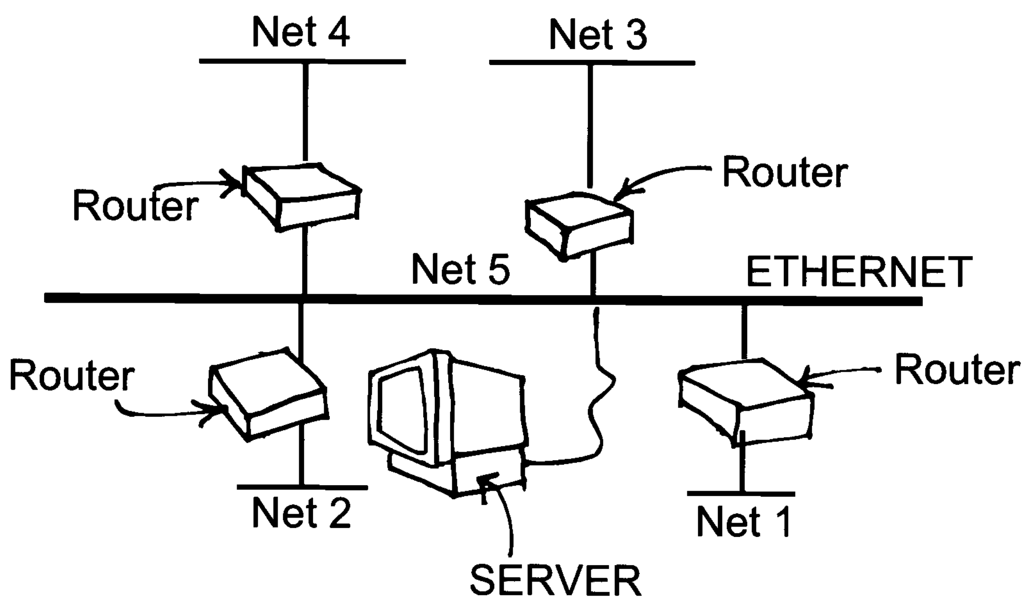
Hubs. A hub is a device that serves as the center of a star topology network like 10BaseT. It is also called a concentrator. Hubs come in two basic models: stackable and modular. Stackable hubs have a fixed number of ports available to connect network devices. There are 4-, 8-, 12-, 16-, and 24-port models. Modular hubs offer a great deal of flexibility. It is possible to have an Ethernet network, AppleTalk network, and token ring network running in the same hub. Greater flexibility also translates into higher costs, and modular hubs do cost more.



There are two types of stackable hubs; intelligent and nonintelligent. Intelligent hubs keep track of information about the data that passes through them. They provide basic management capabilities, while nonintelligent hubs do not. On a large district network, this is a desirable feature. On smaller networks, it is not as necessary.

Switches. Switches are electronics that allow you break up one large network into smaller functional pieces or hook up smaller networks into a large one. They are used to speed up a network that has a great deal of data traffic on it.

Routers. Routers are devices that connect networks to other networks. They select what data will go outside the network and what data will stay inside the network. In a large network, several routers might create a path for network traffic to follow to get to a specified destination. A router of some kind is needed for Internet access from a local area network.



A router is also used to hook up dissimilar network protocols. If you have a large 10BaseT network and you want to connect a few users on an old token ring network, you can put a router in between them. The router will handle the translation between the protocols.

Remote-access devices. Remote-access devices are used for dial-in access to a network. Some remote access devices can also be used to dial out. Typically these are modems, or groups of modems, called modem banks.

The Network Client Platform

For many people the selection of client stations is one of the key decisions in building a network, even though the stations might be used for only two or three years before being replaced. A substantial investment is made in some platform-related costs—namely, the costs for *user training*.

Platform selection is not easy, since many users have strong preferences toward the systems that they know. Today the dominant platform is the Windows-based PC, but in K-12 schools the Apple Macintosh-platform has long been favored, while colleges and universities have traditionally used UNIX-based platforms.

A single-platform network is the easiest to support and, from a financial standpoint, would be the most desirable. In practice, however, most large networks end up with a mix of platforms. For mixed platforms, support and use are simplified when platforms are grouped. For example, a district network might have Macintosh-platform clients in the K-8 grades, and Windows-platform clients in the high schools and administrative offices. While it is possible to mix platforms in a single classroom, it is harder to support and often more costly.

Another tip regarding client stations is to establish minimum standards. You may have several old computers around your school, but you should not put them on the network unless they meet minimum standards. They will need enough speed, memory, and storage to run the applications you want on your network. There is little cost saving in putting obsolete equipment on a network— this only creates higher support costs and frustrated users.

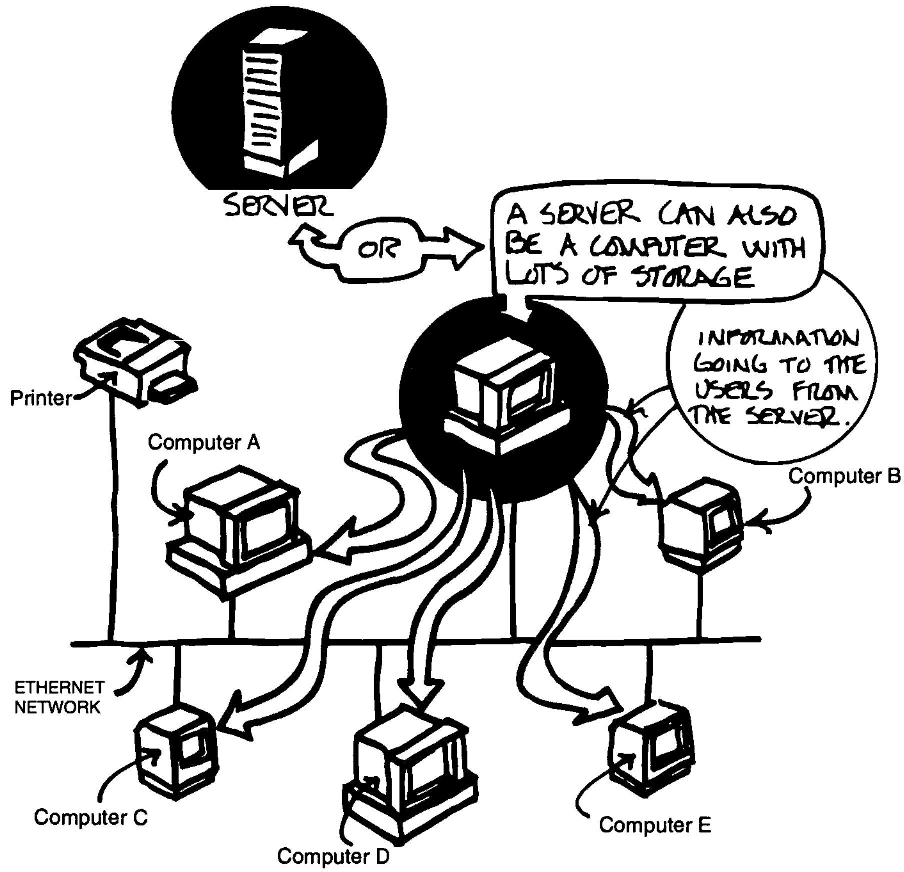
A similar rule applies to application software. Set limits on the software that will be run on your network, and standardize some core packages for core functions. Having five different word processing packages on a network may please your users at first, but soon they will be spending their entire days trying to convert documents from one form to another.

The selection of platforms and applications can be one of the greatest challenges of network planning. Whatever you choose, you will get ample feedback from users. Just remember to simplify.

Network Operating Systems

Small peer-to-peer networks often use the networking software that is built into the operating systems (Mac OS and Windows for Workgroups or Windows 95) to share files and devices.

Larger networks have special software of their own that allows them to share files, printers, and other services across the network as well as provide a high level of access security. This type of software is referred to as a Network Operating System (NOS). Typically, the NOS runs on a powerful computer called a server. The server is responsible for delivering the programs or data that users request.



There are a number of NOSs available from many vendors today including:

Vendors	NOS
Apple	AppleShare
Artisoft	LANtastic
Banyan	Banyan Vines
IBM	LAN Server (OS/2)
Microsoft	Windows NT
Novell	NetWare
Various Vendors	UNIX

Each of these products has it own features and is targeted toward a particular network type. Compare the costs and features of the various NOS options, and ask the following questions when selecting a NOS:

- Will it work with the platforms and protocols you want?

- Will you be able to find support people trained in the NOS of your choice?
- How is it licensed? Are there education discounts?
- What type of server hardware will the NOS require?
- How is the NOS doing in the market? Will the company be around to support it?
- Will it be easy to use?

When selecting a NOS, seek the opinion of several qualified networking pros. Many people have strong biases toward the product they know best, so weigh recommendations carefully before committing to a NOS.

Wide Area Networking

When you are ready to interconnect your LANs into larger district or wide area networks, you will encounter a whole new set of internetworking implementations.

Among the several types of internetwork communication connection options are the following:

- **Private fiber, coax, or copper lines.** Require know-how, equipment, and installation, but you have no monthly fees.
- **Private radio, microwave, or satellite-based wireless connections.** Require know-how, equipment, and installation, but no monthly fees. The technology is emerging and costs are coming down.
- **Channel space on an existing cable-TV system.** Works in some places where cable systems are set up with excess capacity, requires cable company cooperation, and will likely incur regular fees. Requires special modems that need to be matched to cable company specifications.
- **Telephone company data lines.** This is by far the most common option. It is available most places, and requires equipment, installation, and monthly fees. Many stan-

dards are available, and technology is mature, stable, and well understood.

Explore all of these options in planning your network. Most networks today will rely on the local telephone company offerings, but deregulation in this industry means that many new offerings will be available.

Your local telephone company is likely to be a good source of information for connection options available. It has standards-based services that will offer you different levels of connection speed and cost. Some of the standards worth knowing about are:

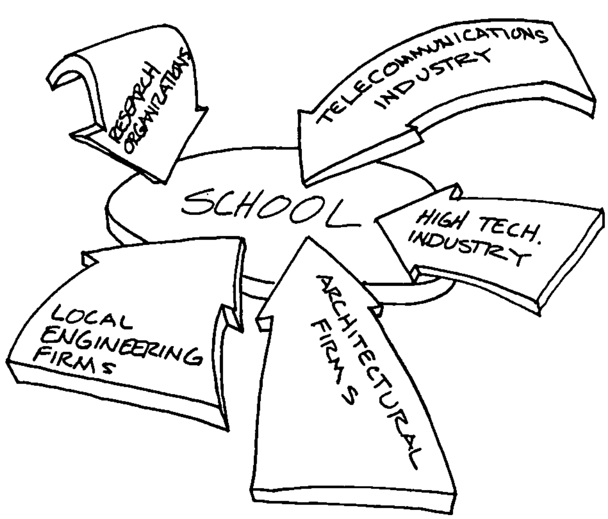
- Dial-up service. The oldest and often slowest option is the phone system and a modem. Modems have increased in speed over the years, but are still fairly unreliable and slow for network communication. Sometimes they are used to link e-mail systems at remote sites. This works for small remote sites. Modems also serve well as individual dial-up connections to the Internet, but if you choose to do this then look at your cost carefully. If you have more than six dial-up network users, it may be more cost effective to use a leased line.
- Leased-line service. Leased lines are lines that go point-to-point and have a fixed rate of speed. For example, a leased line might go from one school to another school in a nearby town. It might have a fixed speed like 56 Kbps (that is, 56 kilobits sent every second). Popular speed options for leased lines are 56 Kbps, multiple 56 Kbps, and T1. (A T1 line has a speed of 1.544 Mbps, some of which is used for overhead.) Building a large network with leased lines can get expensive since you must go point-to-point with the lines.
- Frame relay services. These lines go from a point to a central "cloud." An example might be seven schools connected into one frame cloud. All seven could communicate with each other through the cloud. The speeds available are similar to those of leased lines but service can be purchased with guaranteed base rates of speed and extend "burst" rates that allow for periodic faster transmission when your network is busy. Frame relay is a great option for multisite networks since less equipment and fewer lines are needed. Not all areas offer frame relay service, so check with your local telephone company to see what it offers at all your school sites.
- ISDN services. This service allows for digital dial-up. In other words, you can make a call to a site and communicate digitally. This is similar to the way modems are used

today, but ISDN is much faster and more stable. Of course, ISDN is also more costly than the phone and modem combination. ISDN is ideal for sites that need periodic access to a network rather than full-time access.

- **B-ISDN or ATM services.** Broadband ISDN is the next generation of ISDN. It is much faster and scarcely available today. B-ISDN will likely be based on a very high speed technology called ATM (Asynchronous Transfer Mode). While very costly today, this emerging technology will probably become commonplace within five years.

Seeking Qualified Help

When you plan your network it will become apparent that there are several ways to build the network you want using the various network components described. If you are building a large network or multisite network, seek the services of a qualified network engineer or network architect. These individuals are familiar with the types of media, transmission protocols, electronics, and network operating systems needed to support different applications. They will work with you to design a network that has the capacity and performance that you are likely to need.



Network Implementation & Management

Network Management and Support

Network Training

Security and Access

Initial Funding and Ongoing Support Funding

6

You now have a better understanding of some of the standards and components that go into a successful network. Perhaps you are already planning how those standards will be used in your network. That's good, but it's time to take a step back and look at some other aspects of the network.

A network is not built by good technical planning alone—it also takes money, policy decisions, staffing considerations, security implementation, and training plans. This chapter looks at some of the essential nontechnical aspects of building a school or district network.

Network Management and Support

Imagine for a moment that your network is built. It was well designed, based on standards, and works great. You're happy, but school starts in a week and you need to get the network ready for students and teachers to come in and use it. You have to set up accounts and passwords for everyone, and you need some way to show everyone how to log in for the first time. Then you must ensure that everyone has the correct level of access, so privacy is preserved. Then there's the backup. And you'll need to be there to answer questions. Pretty soon you realize it's a full-time job just *managing* the network you worked so hard to build.

A useful analogy can be drawn to the support of a fleet of school buses. When districts first started using buses, they realized that they would need a budget, facilities, mechanical support, drivers, and often a manager to keep the bus system working. Networks are no different.

Network management is a full-time job. In fact, in business the rule of thumb is that for every 50-75 users on a network, there needs to be at least one full-time employee (FTE) providing support and management services. Imagine the staff hours needed if your district had 3,000+ potential network clients!

MODELS FOR NETWORK SUPPORT

Network-support staffing is one of the greatest challenges facing schools. Many creative staffing models have been used by schools to meet this challenge. Most schools that will have networks with more than 100 users will need to adopt one of these models. Here are a few for you to consider:

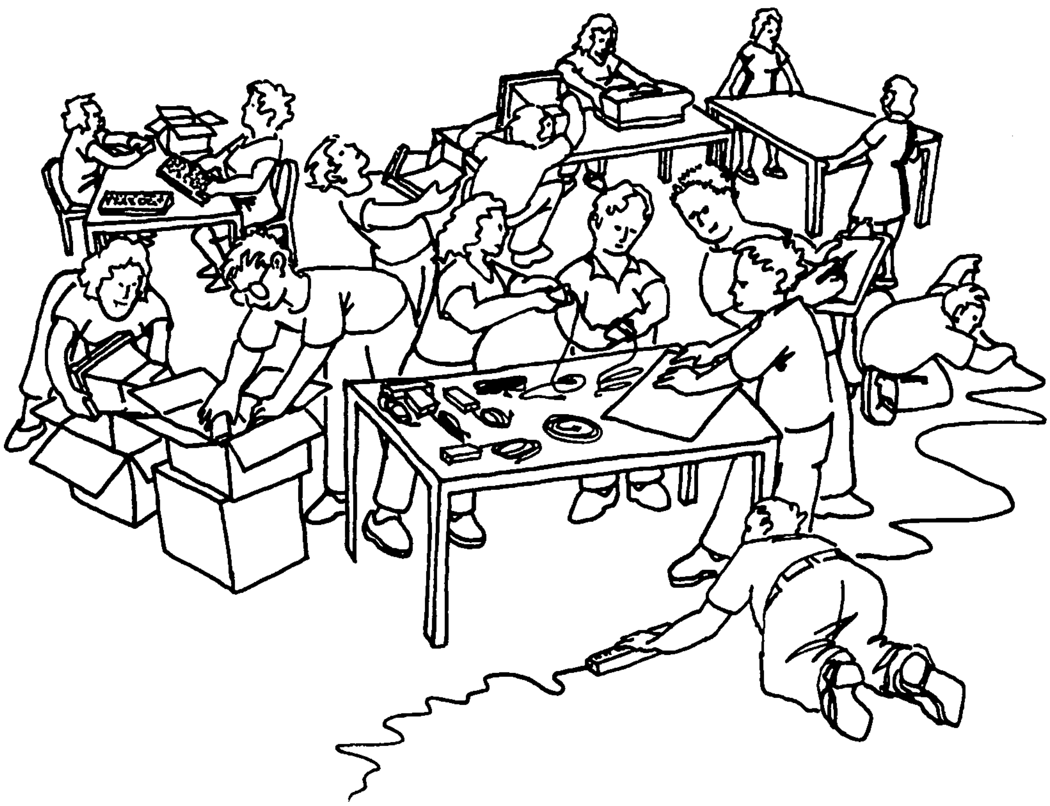
Fully staffed support model. Experienced school network managers say that expecting teachers to manage large networks "on the side" is unrealistic. The number of hours teachers have is limited, and user support is probably not the best use of those hours. Accordingly, many schools choose to hire nonteaching staff to support the network. Typically, a multisite school or district hires a highly qualified network manager or network coordinator, and a team of several technicians to support the building LANs. Ratios of 100 to 250 users per full-time technician seem to work for most schools. This is the most expensive option, but it usually results in a reliable network. In smaller districts, the network manager is often also the technology coordinator involved in curriculum planning and staff development.

Manager/teacher-coordinator model. Some schools chose to use a full-time manager and teachers at the school building sites to augment the support. This usually requires teachers to set aside nonteaching periods to perform the support functions. One problem with this model is that user needs at a site rarely conform to the scheduled teacher's support hours.

Manager/student "tech team" model. A number of schools have chosen to involve students in network support. Students are required to complete a course in computer-systems support, often taught by the network manager. The students are then allowed to serve as part of the tech support team. During a class period, in addition to saving costs and developing student responsibility for the network, the students learn skills that will serve them in the workplace.

Other models may work for your school district. You will need to take into account your resources, geography, and user level. Regardless of the model you use, most networks with over 100 users need to develop some type of self-help support system for basic troubleshooting. One school district manager of a 2,000-user district WAN describes his system with the phrase, "Ask three, then ask me." This means, for example, that a student with a file management problem first seeks help from three peers, other students, before moving up to the next level of support, the teacher. If the teacher needs advice, he or she seeks it from three other teachers. This hierarchy ensures that the support team will be highly leveraged.

A final network-support reminder is that networking development and implementation never ends. There are ongoing planning, policy, and upgrade issues to consider. Don't leave it to your network technical staff exclusively to enforce policies or to determine when to upgrade. Some schools have found a network users' group serves as a good communication vehicle between users and the technical staff.



Network Training

In addition to network management, you need a plan for training decisionmakers, network-support staff, and network users. Training is often overlooked when planning and budgeting for network implementation, but it is *vital* to the success of the network.

Your network training program should, of course, integrate with the broader program of technology staff development.

In the larger districts, the oversight of the training function is often separated from the network management function. Another common division is to separate technology integration staff development and network support/training functions. If your district has an aggressive set of technology curriculum development objectives, it is probably not wise to give this responsibility to network managers; they will not have the time. Of course, each district's needs and resources will differ.

TRAINING NEEDS AND LEVELS

The first group that may need training is comprised of the planning team and key decisionmakers. Many schools have found that having a networking overview course early in the planning stages can be invaluable. Schools typically do not have a qualified network manager on staff in the early stages of planning, so they use consultants or vendor representatives to teach the initial course. The goal of the course is to bring everyone up to speed on basic terminology and provide key players with a strategic vision of the implementation process.

The next group that needs training is the support team. Whether you are using specialized staff, teachers, or students, they need to know the network. This is best handled by the network manager. In an ongoing fashion, your network manager should reserve time to meet with the support team and bring them up-to-date.

Finally, you will need to train all of your users. The initial basic training for networking can be quite challenging to arrange across a large staff. Time for training is always the scarce commodity, so careful planning is essential. The following tips come from experienced school network teams and administrators:

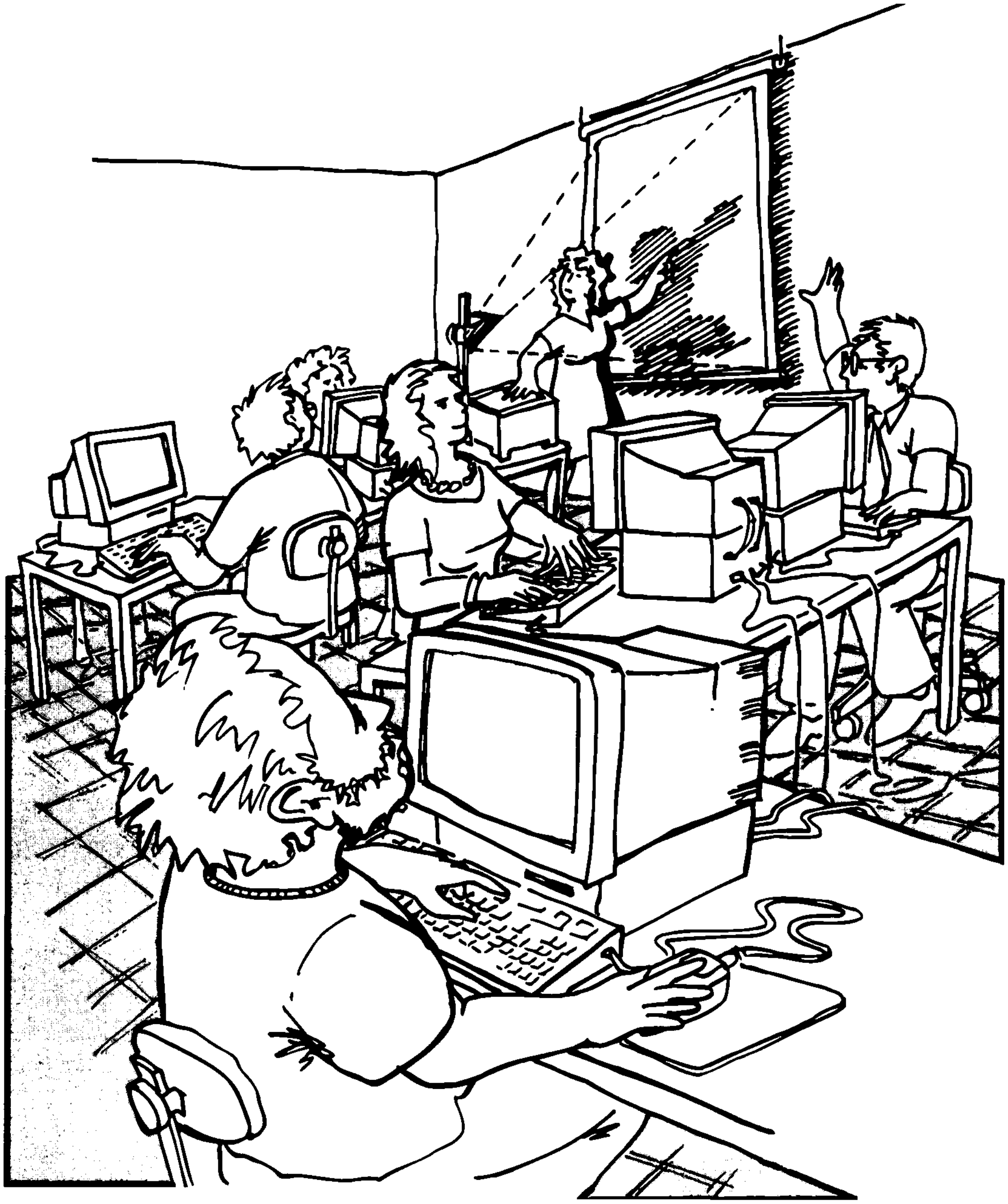
Training strategies:

- Assess training needs and priorities annually. Conduct user skill self-assessments. Gather evaluation data from all training offered. Plan training using all of this input.
- Like music, technology comes more easily to some people than to others. You will have a large range of skill levels initially and ongoing. Group classes by user skill level.

- Initially focus a short class on the very basics: logging on, file management, security, policy, and maybe one key application. You'll need to conduct this class over many days at different hours.
- Use a training hierarchy; take your most technology-savvy teachers and prepare them to teach networking basics.
- Make a districtwide commitment to ongoing training at all levels. Provide training opportunities for intermediate and advanced users including your technical-support staff and network managers.

Time strategies:

- Set up a substitute rotation to allow all trainers and staff to attend classes. For example, offer a class several times in one day, hire substitutes for the day, and rotate them into classrooms to release teachers.
- Prepare self-guided instructional units for some of the basics. Offer open lab time with students or teachers serving as technology mentors supporting the learners.
- Motivate all class attendees: Do attendees know the benefits of networking to them and their students? Will they receive clock hours or credit for their attendance? Can teachers satisfy certification requirements when attending classes? Some states in the Northwest now offer an educational technology endorsement with certification.
- Consider partnering with a local college. Can you make your network classes worth college credit?
- Consider evening and weekend inservices for network training and provide some of the incentives described above.
- Consider establishing a consortium to share expertise and leverage resources. Many districts in your state are going through similar technology training.



Security and Access

The most talked about issues in school networking are those related to security and access. Schools that implement networks need to protect

- **Hardware:** from theft, damage, etc.
- **Data:** from prying eyes and data loss.
- **Humans:** from violation of rights; exposure to unsuitable material; abuse; or scams.

There are complex and sometimes daunting challenges with each, but most schools have been highly successful in meeting them. Let's look at each separately.

HARDWARE SECURITY

Building a network requires a large capital outlay in equipment. For many schools computer hardware is second only to building cost in terms of capital expenditure. Experienced school network managers recommend the following:

- Lock your server rooms and wiring closets and limit access to a few individuals.
- Lock down machines with commercially available computer cable locks.
- Use equipment in supervised areas.
- Use video monitoring as needed.
- Tag and track all hardware inventory.
- Limit people authorized to open or service equipment.
- Establish rules that prohibit food and drink near equipment.
- Put all critical network equipment on an uninterruptible power supply (UPS).
- Buy power (surge) protection for all sensitive hardware and phone lines.

Some loss will be unavoidable, but common-sense practices can dramatically reduce hardware loss costs. Be aware that computer service agreements rarely cover damaged equipment. Be sure to budget for failure, damage, and loss in support budgets.

DATA SECURITY

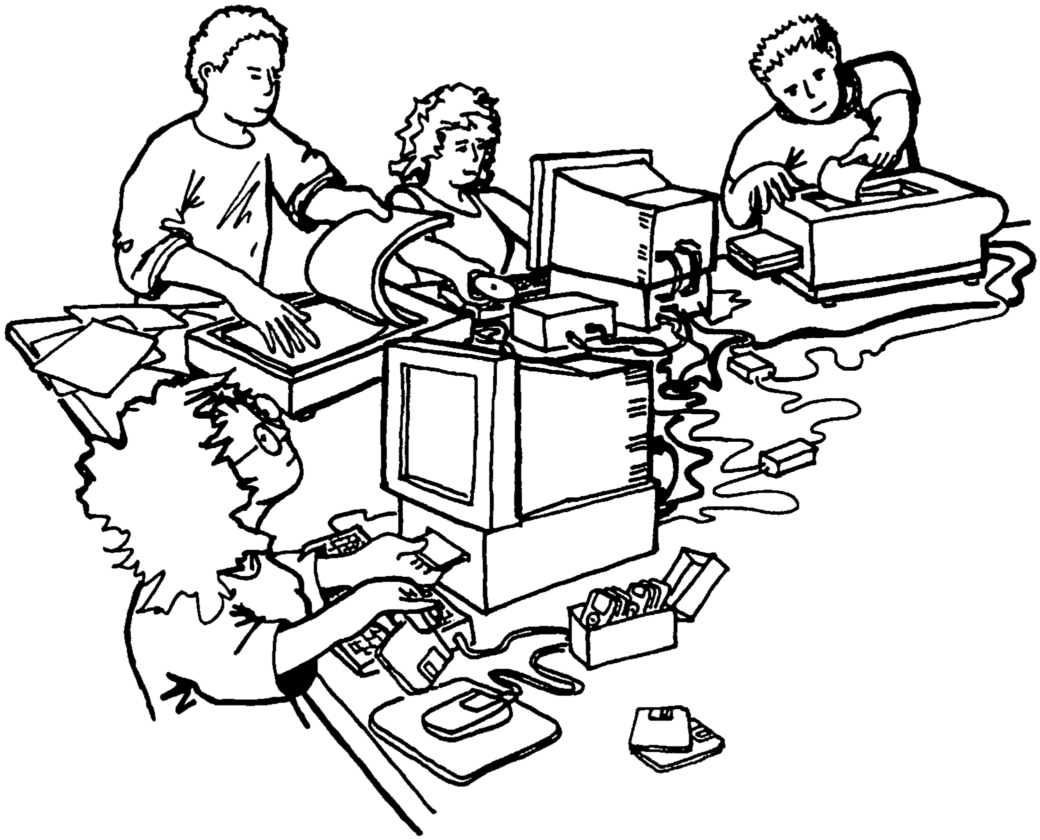
The news media and movies would lead one to believe that all networks are easily "hacked" into and unsecured. This is far from the truth. The networking software available today allows networks to be made quite secure, and in practice most networks operate securely most of the time. While hacking by users within your system is a possibility, it usually can be traced and rarely results in significant problems.

For protection from outside hackers, special computers, known as *firewalls*, are set up as security guards. These computers run software that monitor all traffic between your network and the world. Any unauthorized users are denied access. The software may be configured to severely restrict access in either direction.

If you plan carefully, ensure regular data backup, and have a good disaster plan ready, the potential for data losses is very small. These are the principal functions of the network manager. A qualified network manager should have a good track record of maintaining secure, well-backed-up network data.

Of course, the degree of privacy you can ensure ultimately depends on well-trained users. A password written on a self-adhesive note and left on a desk may give students access to a teacher's account. Accordingly, certain data should be kept off the network, or limited to only the most highly secured accounts.

Like fiscal security, data security depends on conservative practices and common sense.



USER ACCESS AND PROTECTION

Most everyone has heard stories of students gaining access to unsavory materials and money scams via the Internet, or employee privacy invaded on local LANs. These stories point to a need for some type of user protection and clear policies.

Access to undesirable material is a critical issue. New software technology can block or filter access, but ultimately these filters are clumsy and often limit the useful work that students can do. A better approach is to educate and provide guidance for users, especially students, to help them understand and qualify information they find on the Net. Teaching users proper network ethics and etiquette will pay off in the long run, both for the school and the community.

Beyond providing guidance, schools need to protect themselves and their network users with an acceptable use policy (AUP). The AUP is essentially a contract that spells out user rights and responsibilities. Failure to meet the terms of the AUP is grounds for short- or long-term suspension of network access privileges.

Luckily for K-12 schools that are beginning this process, many K-12 districts have already had to deal with the most common policy issues, and have crafted excellent AUPs to serve as models. Also several K-12 AUPs are now online. A selection of AUPs can be accessed through the Northwest Educational Technology Consortium technology planning pages (http://www.netc.org/tech_plans/aup.html).

AUPs can establish different classes of users with different rights and responsibilities. These types of AUPs are especially important if community members will be using network resources or if students will be given remote access from home. Schools should be cautious when planning for these types of outside access and carefully consider the ramifications. In some cases private Internet access providers may take exception to unlimited Internet access via publicly funded school networks.

Initial Funding and Ongoing Support Funding

It is essential that you consider both initial funding for network installation and ongoing support funding. Initial funding often comes from sources that include:

- Tax/bond levies
- State, federal, and private grant programs
- Corporate donations
- Loans

A good way to improve your chances of funding a school network is to invite key community members to be part of your initial technology planning committee. Adding a few people who are well-versed in large-project financial planning will help, too.

Ideally, ongoing funding to support technology and school networking should be provided as a line item in annual school or district budgets. While grant or bond funding provides capital improvements and new technology initiatives, it is a shaky way to support ongoing operations. Experienced administrators in high tech-districts indicate that technology expenditure ranges from 2 to 4 percent of total district budgets, and many leading planners recommend spending 5 percent on technology. Remember, the more standardized your network, the cheaper it will be to support.

GET READY FOR GROWTH

Planned obsolescence. You should assume that your network will grow. Within a year of initial implementation, users become accustomed to the network and have a laundry list of new capabilities they would like to see implemented. Part of the network manager's responsibility is to find, among the many wants, a group of realistic and achievable technologies for the district to pursue.

Charting a long-term course for a district or school network amid rapidly changing technology and limited funding can seem impossible. In practice, the design philosophies used in planning your new network can make the task much easier. Remember these fundamentals:

- Standardize
- Simplify
- Don't try to be cutting edge
- Learn from what other schools have done

Application of these fundamental ideas, along with a solid knowledge of the technologies you've chosen, will help you implement technology that meets your school's teaching, learning, and administrative needs for years to come.

School Networking Needs Analysis

A

GENERAL INFORMATION

School District: ______________________________

School Name: ______________________________

Address: ______________________________

City: ______________ State: ________ ZIP: ____________

Contact: ______________ Title: ______________

Phone: ______________ Fax: ______________

NETWORK REQUIREMENTS/SERVICES

How do you envision using a network; what types of services do you wish to have? Please indicate what services are important to you and provide some details about them.

File sharing. *The ability for more than one person to look at or modify a file.*

Applications sharing. *Programs stored on one computer and used by many people.*

Print sharing. *Sharing a printer or printers among many users.*

E-mail. *E-mail capability within the building/district.*

Library system. *Complete library management or catalog system.*

Information services/database sharing. *Data services or local data services.*

Internet access. *Yes or No? For how many? Performance level needed?*

Telecommunications. *Modem/fax access from the network; can needs be met through direct Internet access?*

Remote access. *Access to the network from the outside, i.e., home.*

Network security. *Will data need to be stored and protected from unauthorized access?*

Remote management. *Do you need to manage the network from one point?*

Wide area networking. *Connect all schools within your district together.*

Other(s).

NETWORK PROTOCOLS

What type of network do you think you need? What types of things would you like to send over your network?

Do you have existing networks to integrate? Should these be replaced (it can be more costly to integrate)?

Ethernet: 10 or 100 Mbps speed; requires each workstation to have a network interface card; requires network hub(s).

FILE AND INFORMATION SERVERS

What file servers have you considered? Explain.

Apple server-based. *Works with Mac workstation clients only.*

Novell based. *Intel-based server operating system; works with DOS/Windows/Mac/UNIX clients.*

Windows NT-based. *Intel-based server operating system; works with DOS/Windows/Mac/UNIX clients.*

Added CD-ROM towers. *These can be attached to main file server or dedicated CD-ROM server.*

Other(s).

CLIENT COMPUTER TECHNOLOGY

What type(s) of computers do you currently have and what types do you envision? Clients older than two years old might be better left off system—costs can be higher to integrate than to replace.

Computer type and quantities:

Apple platform	Existing	Planned
Intel PC platform	Existing	Planned
UNIX/other platform	Existing	Planned

Printer type and quantities:

Dot matrix	Existing	Planned
Inkjet/StyleWriter	Existing	Planned
Laser/LaserWriter	Existing	Planned
Other(s)	Existing	Planned

NETWORK WIRING

Estimate the following:

Number of classrooms:
Number of computers per classroom:
Number of printers per classroom:

Number of offices:
Number of computers per office:

Number of computer labs:
Number of computers per lab:
Number of printers per lab:

Number of other networked printers:

Ideal number of data jacks per classroom:
Ideal number of data connections per jack:

Possible data closet/server room location(s):

USER INFORMATION

How many users do you envision will be using the server(s) at a time?

How many users in total will use the system?

What types of users do you envision, and what will be the users' levels of technical skill?

What types of acceptable-use issues will you face?

Who will develop and enforce acceptable use policies?

At what times will users need to use the network? At what times will they need the help of support staff?

TRAINING

How many users will need to receive an initial training?

What are the goals of your training?

In what areas will you need to provide training (i.e., data security, file management, network basics, word processing, special software, etc.)?

How do you envision training staff in computer and network use?

SUPPORT

Who will provide onsite support of the network?

What ratio of users to support people are you expecting? Is the ratio realistic for your type of network?

Who will provide central support for a WAN network (if needed)?

How will you find qualified support people and staff these positions?

How will you find qualified outside/outsource support people when needed?

EMERGENCY PLANNING

Consider what courses of action you would take if the network and/or file server(s) were incapacitated.

Data storage backup systems.

UPS (uninterrupted power supply) system.

Human resources available.

Outside resources available. *Regional educational agencies/local consultants/other*

Service contract(s).

Locations. *(Include a map of all buildings to be involved in the networking process.)*

Sample Wiring Specification

B

Telephone and Data Cable Systems Specifications

for SCHOOL DISTRICT: ____________________

Please note: This highly detailed sample specification is provided for *instructional purposes only*. While it was used at one point in time by a Northwest school district, please keep in mind that standards and guidelines change, state or local regulations may differ, and the level of specification required will vary by project.

PART I GENERAL

1.01 DESCRIPTION

A. Provide a complete, tested, cable-distribution system for data system (local area network) interconnections. The data distribution system shall include fully terminated fiber optic backbone and UTP station cables.

B. Optical fiber backbone cables: Individual 6- or 12-fiber optical cables shall be installed from the termination enclosure in the new DATA MDF (main distribution frame) room to fiber optic termination enclosures in each new DATA IDF (intermediate distribution frames) communications closet.

C. Provide system design services (development of specific details consistent with the contract documents) as required to complete shop drawings for data cable systems including detailed documentation for owner review and detailed documentation of as-built conditions.

D. Network electronics equipment will be furnished by others. The contractor shall coordinate with other system vendors where appropriate to facilitate equipment installation, scheduling, protection of equipment, and access to the project site in order to provide the owner a substantially complete project in a timely manner.

E. The successful communications contractor shall attend a mandatory pre-construction meeting with individuals deemed necessary by the owner prior to the start of work.

F. The successful bidder will not be determined by price alone, but by a rating system to include a combination of price, qualifications, training procedures, student participation, and proposed documentation package.

1.02 DESIGN

A. Floor plans: Furnish floor plans for owner review showing outlet locations with an indication of outlet type and proposed label. Floor plans shall be coordinated with architectural and electrical power plans and shall be produced at the same scale as the electrical power plans.

B. Terminal elevations: Furnish details showing terminal block and backboard elevations including all cable terminals, spaces for equipment, equipment racks, and station cable routing. Communications equipment closets (intermediate distribution frames—IDFs) and entrance closets (main distribution frames—MDFs) shall be arranged to maximize the utility and growth potential available in spaces shown on the floor plans. Terminal elevations shall be based on detail elevations included in the contract documents and shall show additional detail as indicated herein.

C. Outlet locations: Provide as shown.

D. Terminal schedules: Furnish terminal schedules showing terminal block positions for all station cabling. Terminal outlet schedules shall show proposed labels for all four-pair UTP horizontal cables at station outlets along with patch panel locations.

1.03 SUBMITTALS

A. Project initiation: Within 14 days of Notice to Proceed, the low voltage contractor shall furnish the following in a single consolidated submittal:

1. The name of the person who will act as the low voltage contractor's official contact with the contractor/owner/engineer.

2. Electrical permits: The contractor shall obtain all required permits and provide copies to the owner/engineer.

3. Complete manufacturer's product literature for all cable, patch panels, cable supports, cable labels, outlet devices, and other products to be used in the installation. In addition, whenever substitutions for recommended products are made, samples (when requested by the owner/engineer) and the manufacturer's supporting documentation demonstrating compatibility with other related products shall be included.

4. A time-scaled construction schedule, using PERT/CPM, indicating general project deadlines and specific dates relating to the installation of the cable distribution system. At a minimum, this construction schedule shall include the following milestones:

   - Start of communications space construction
   - Start of fiber optic cable terminations
   - Start of Category 5 UTP (including related termination hardware)
   - Station cable installation
   - Start of Category 5 UTP and fiber optic backbone cable testing
   - Final inspection

5. Shop drawings (within 28 days of Notice to Proceed).

6. Proposed contractor Category 5 UTP and fiber optic cable test result forms.

B. Project completion: As a condition for project acceptance, the contractor shall submit the following for review and approval.

1. Complete manufacturer's product literature and samples (if requested) for all pre-approved substitutions for the recommended products made during the course of the project.

2. An exception list of deviations (in materials, construction, and workmanship) from that specified in this section and shown on the project drawings. The

owner will review this list and declare each item as either an approved exception or as one the contractor must correct.

3. Inspection and test reports: During the course of the project the contractor shall maintain an adequate inspection system and shall perform such inspections to ensure that the materials supplied and the work performed conform to contract requirements. The contractor shall provide written documentation indicating that materials acceptance testing was conducted as outlined in Part 3 below. The contractor shall also provide documentation indicating that all cable termination testing was completed and that all irregularities were corrected prior to job completion for owner/engineer analysis.

1.04 SYSTEM INSTALLER

A. The data cable system installer shall be a firm normally employed in the low voltage cabling industry with a reference list of five (5) projects and contact names to confirm successful Category 5 UTP and fiber optic cable plant projects.

B. The owner reserves the right to exercise its discretion to require the contractor to remove from the project any such employee of the contractor deemed by the owner to be incompetent, careless, insubordinate, or otherwise objectionable.

C. The selected system installer should be factory certified for the products it installs and be able to provide a factory warranty of no less than 10 years covering both product and performance of materials installed. Quality and workmanship evaluation shall be solely by the owner/engineer and designated representatives.

D. The selected system installer must be licensed and bonded in the state of ______________.

E. All cleanup activity related to work performed will be the responsibility of the low voltage communication (system) contractor and must be completed daily before leaving the facility.

F. Any cable system installation company bidding on state school projects should have at least 1 BICSI-certified RCDD on staff.

1.05 REGULATORY REQUIREMENTS

A. All work shall be performed in accordance with the latest revisions of the following standards and codes:

Uniform Building Code	International Conference of Building Officials (ICBO) Regional Office, 12505 Bellevue-Redmond Road, Bellevue, Washington 98005
Local Building Code and Local Electrical Code	
NEC 1990 [1993]	National Electrical Code

B. Other References:

EIA/TIA-568	Commercial Building Wiring Standard
EIA/TIA-569	Commercial Building Standard for Telecommunication Pathways and Spaces
EIA/TIA TSB36	Additional Cable Specifications for Unshielded Twisted Pair Cables
EIA/TIA TSB40	Additional Transmission Specifications for Unshielded Twisted Pair Connecting Hardware
EIA/TIA 455-A	Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components
EIA/TIA SP-2840	Commercial Building Telecommunications Cabling Standard — Issue 1 — 5/7/93 (This standard will replace EIA/TIA-568, TSB36, and TSB40 in its final form. Where this standard modifies information in the existing approved standards, especially concerning

cable termination and testing procedures, this standard shall govern)

C. Governing codes and conflicts: If the requirements of this section or the project drawings exceed those of the governing codes and regulations, then the requirements of this section and the drawings shall govern. However, nothing in this section of the drawings shall be construed to permit work not conforming with all governing codes and regulations.

1.06 ABBREVIATIONS

DC	Direct current
IDF	Intermediate distribution frame usually residing in a telecommunications closet and consisting of station wire terminals, riser cable terminals, and various equipment
MDF	Main distribution frame usually residing in the building entrance room and consisting of riser cable terminals, utility service cable terminals, PBX terminals, PBX, and various other equipment
PBX	Private branch exchange, a telephone switch
UTP	Unshielded twisted pair (telecommunications station cable)

PART 2 PRODUCTS

2.01 GENERAL WIRING

A. The wiring plan shall be installed per requirements of these specifications utilizing materials meeting all applicable EIA/TIA standards.

B. Materials shall be as listed or shall be equivalent products of other manufacturers meeting the intent and quality level of the EIA/TIA TSB36 and TSB40 specifications. All approved equivalent products will be published by addendum prior to bid. In some cases, specific materials are called out to maintain a uniformity of application across the district. The contractor shall maintain the same material uniformity for all school projects.

C. All installed wire shall be tested "100 percent good" after installation by the installer.

D. All products shall be new and brought to the job site in original manufacturer's packaging. Electrical components (including innerduct) shall bear the Underwriters Laboratories label. All communications cable shall bear flammability testing ratings as follows:

CM	Communications cable
CMP	Plenum-rated communications cable
CMR	Riser-rated communications cable

E. Initial cable inspection: The contractor shall inspect all cable prior to installation to verify that it is identified properly on the reel identification label, that it is of proper gauge, containing the correct number of pairs, etc. Note any buckling of the jacket that would indicate possible problems. Damaged cable or any other components failing to meet specifications shall not be used in the installation.

2.02 STATION WIRING

A. The wire provided for all outlets shall be one four-pair UTP, Category 5 cable per jack:

1. Duplex data outlet (shown as an open diamond) shall have two data cables each with a jack.

2. Telephone/data outlet (duplex jack, shown as a half-filled diamond) shall have one voice cable and jack and one data cable and jack.

B. The Category 5 four-pair UTP cable must be UL Performance Level tested. Each 1,000-foot spool must be individually tested with test results affixed to the spool.

Recommended Products: AT&T, Belden, Comscope, General Cable, Montrose, Quabbin, or pre-approved equivalent.

2.03 STATION HARDWARE

A. Flush-mounted jacks shall be high-quality Category 5 RJ45 modular jacks with circuit board construction and IDC-style or 110-style wire, T568A terminations. Jacks shall meet EIA/TIA TSB40 recommendations for Category 5 connecting hardware.

B. Faceplates shall match manufacturer for RJ45 outlets at all locations.

C. Surface mount jacks shall be high-quality RJ45 modular jacks per A above.

Recommended products: AMP Communications Outlet System Dual Port Installation Kit or pre-approved equivalent.

2.04 DATA MDF/IDF TERMINATION HARDWARE

A. New data Category 5 termination hardware: The Category 5 data station cable shall be terminated on Category 5 RJ45 patch panels with circuit board construction in all IDF/MDF locations. The RJ45 patch panels shall be either wall mounted or rack mounted with cable management panels per communication detail sheets. The contractor is responsible for all wall brackets, patch panels, and cable management panels for all IDF/MDF layouts and equipment rack configurations.

Recommended products: AMP Communications Outlet System Single Port Module Patch Panel Kits (preloaded) or pre-approved equivalent.

B. Wall brackets must be provided for all patch panels and cable management panels for wall mount applications.

Recommended products: AMP, AT&T, Nevada Western, Ortronics, or pre-approved equivalent.

C. Cable management panels must have five (5) D-rings for wire distribution with a minimum panel dimension of 3½" x 19".

Recommended products: AMP, Nevada Western, Ortronics, or pre-approved equivalent.

2.05 DATA DISTRIBUTION EQUIPMENT RACK

A. Provide equipment racks in locations indicated on the drawings. Racks shall be equipped as detailed on the drawings and as hereafter specified.

B. MDF/IDF locations provide CPI part #46353-503, 7'-tall equipment rack or equivalent.

C. Distribution rack grounding: Provide grounding kit similar to IBM part #4716804 for each MDF/IDF. Rack shall be grounded using stranded #6 AWG insulated copper conductor. Provide all required bonding material and hardware and bond to building grounding electrode subsystem at building electrical service entrance.

2.06 FIBER OPTIC CABLE SPECIFICATIONS

A. Fiber optic cable shall be UL-listed type OFNP; six or twelve 62.5/125 micron-graded index multimode fibers, each with a color-coded PVC buffer. Maximum attenuation shall be 3.75 dB/km at 850 nm and 1.0 dB/km at 1,300 nm. Minimum bandwidth shall be 160 MHz/km at 850 nm and 500 MHz/km at 1,300 nm and contain no metallic elements.

2.07 FIBER OPTIC CABLE TERMINATIONS

A. Optical fiber connectors shall be ST or SC connectors.

Recommended products: AMP, AT&T, Siecor, or pre-approved equivalent.

B. Optical fiber termination enclosures: The enclosures used in the DATA MDF/IDF rooms shall provide termination panels for ST or SC connectors and be of sufficient size and capacity to terminate 100 percent of the fiber count of the inside or outside fiber optic cables. Patch panels must be wall or 19" rack mountable depending on MDF/IDF applications. Provide all termination accessories and enclosures and test for a complete fiber optic distribution system.

Recommended products: AMP, AT&T, Siecor, or pre-approved 12- or 24-port patch panels.

PART 3 EXECUTION

3.01 GENERAL

A. The contractor shall avoid penetration of fire-rated walls. Sleeving shall be installed for access where necessary.

B. Any penetration through fire-rated walls (including those in sleeves) will be resealed with an Underwriters Laboratories-approved (UL) sealant. Typical of this type of product is Flameseal. Contractor shall also seal all floor, ceiling, and wall penetrations in fire or smoke barriers and in the MDFs, IDFs, and wiring closets.

C. Allowable cable bend radius and pull tension: In general, communications cable cannot tolerate sharp bends or excessive pull tension during installation. Refer to the cable manufacturer's allowable bend radius and pull tension data for the maximum allowable limits.

D. Cable lubricants: Lubricants specifically designed for installing communications cable may used to reduce pulling tension as necessary when pulling cable into conduit. After installation, exposed cable and other surfaces must be cleaned free of lubricant residue.

Recommended products:

Twisted pair cable: Dyna-Blue, American Polywater.

Optical fiber cable: Optic-Lube, Ideal.

E. Pull strings: Provide pull strings in all new conduits, including all conduits with cable installed as part of this contract. Pull test is not to exceed 200 pounds.

F. The contractor shall replace any damaged ceiling tiles that are broken during cable installation.

G. The contractor shall replace or rework cables showing evidence of improper handling including stretches, kinks, short radius bends, over-tightened bindings, loosely twisted and over-twisted pairs at terminals, and cable sheath removed too far (over 1½ inches).

3.02 LABELS

A. The labeling plan shall be developed by the contractor. The contractor will label all outlets following the detailed shop drawing design, using permanent/legibly typed or machine-engraved labels approved by the owner. The labeling information for patch panels located in the MDF/IDFs will include the MDF/IDF number, patch panel number, and sequential port number. Outlets shall be labeled to match the corresponding label in the MDF/IDF. All copper/fiber terminations for riser/backbone cables in the IDF(s) shall be labeled with the IDF number, patch panel number, and sequential port number. MDF labeling for all copper/fiber terminations for riser/backbone cables will match IDF labeling.

B. A floor plan clearly labeled with all outlet jack numbers shall be included in the as-built plans.

C. All labels shall correspond to as-builts and to final test reports.

3.03 STATION WIRING INSTALLATION

A. The low voltage contractor shall supervise the installation of communications cable. All Category 5 and fiber optic cable shall be installed by individuals trained in low voltage data cable system installations. All Category 5 four-pair UTP cable must be handled with care during installation so as not to change performance specifications. The contractor shall not over-tighten tie wraps or over-bend the Category 5 four-pair UTP cable.

B. Exposed station cable will only be run with owner approval. Approval will be granted only when no other option exists. When station cable must be run surface to a single outlet, surface raceway shall be used to cover the cable.

C. All cabling and associated hardware shall be placed so as to make efficient use of available space in coordination with other uses. All cabling and associated hardware shall be placed so as not to impair the owner's efficient use of their full capacity.

D. All cabling placed in ceiling areas must be tied or clamped. When cable is placed in ceiling areas or other nonexposed areas, fasteners shall be placed at intervals no greater than 60 inches. Attaching cable to pipes or other mechanical items is not permitted. At all runs of 20 or more cables, provide cable rings at 60-inch (maximum) centers to hang cable. Communications cable shall be routed to avoid light fixtures (18-inch minimum spacing), sources of heat (12-inch minimum spacing), power feeder conduits (12-inch minimum spacing) and EMI sources (12-inch minimum spacing).

3.04 STATION HARDWARE

A. Surface mount jacks (where permitted) shall be securely attached to walls or permanent furnishing and will not be attached to the floor under any circumstances. Use of adhesive tape for this purpose will not be allowed.

B. Flush-mounted jacks shall be mounted in a faceplate with backbox.

C. RJ45 jack pin assignments:

1. Pin connections for both telephone, data station cable outlets, and patch panels shall match EIA/TIA-568 modular jack wiring recommendation T568A, which is both 10BaseT and ISDN compatible.

2. Pin connections at data jack panels shall match pin connections at outlets—straight through wiring.

3. Terminations at telephone terminal blocks shall match the pair sequence:

1	W-Bl, Bl
2	W-O, O
3	W-G, G
4	W-Br, Br

3.05 BACKBOARD CABLING/EQUIPMENT RACK CONFIGURATION

A. Cable installation in the entrance room and communications closet must conform to the project drawings. All cabling shall be routed so as to avoid interference with any other service or system, operation, or maintenance purposes such as access boxes, ventilation mixing boxes, network equipment-mounting access hatches to air filters, switches or electrical outlets, electrical panels, and lighting fixtures. Avoid crossing areas horizontally just above or below any riser conduit. Lay and dress cables to allow other cables to enter the conduit/riser without difficulty at a later time by maintaining a working distance from these openings. Use a minimum of 36 inches for a service loop to the patch panel.

B. Cable shall be routed as close as possible to the ceiling, floor, or other corners to ensure that adequate wall or backboard space is available to current and future equipment and for cable terminations. Cables shall not be tie-wrapped to existing electrical conduit or other equipment. The minimum bend radius shall be observed.

C. Lay cables via the shortest route directly to the nearest edge of the backboard from the mounted equipment or block. Lace or tie-clamp all similarly routed cables together and attach by means of clamps screwed to the outside edge(s) of the backboard vertically and/or horizontally, then route via "square" corners over a path that will offer minimum obstruction to future installations of equipment, backboards, or other cables.

D. Provide rack and jack panel hardware as required for all data station wiring.

E. Do not over-tighten cable ties or binding on Category 5 station cable. Observe Category 5 cable bend radius.

3.06 TWISTED PAIR CABLE TESTING

A. The owner/engineer shall be notified one week prior to any testing so that the testing may be witnessed.

B. Before requesting a final inspection, the contractor shall perform a series of end-to-end installation performance tests. The contractor shall submit for approval a proposal describing the test procedures, test result forms, and timetable for all copper and fiber optic plant wiring.

C. Acceptance of the simple test procedures discussed below is predicated on the contractor's use of the recommended products (including but not limited to twisted pair cable, cross-connect blocks, and outlet devices specified in the products paragraph) and adherence to the inspection requirements and practices set forth. Acceptance of the completed installation will be evaluated in the context of each of these factors.

D. At a minimum, the contractor shall test all station drop cable pairs from IDF/MDF termination patch panels to outlet device, RJ45 jacks.

E. Each wire/pair shall be tested at both ends for the following:

1. termination order
2. polarity (pair reversals)
3. continuity
4. shorts
5. grounds
6. attenuation
7. near end cross talk (NEXT)
8. cable length (record all lengths)

F. When errors are found, the source of each error shall be determined and corrected and the cable retested. All defective components shall be replaced and retested. Defective components not corrected shall be reported to the owner/engineer with explanations of the corrective actions attempted.

G. Test records shall be maintained using a form approved by the owner. The form shall record closet number, riser pair number or outlet ID, outcome of test, indication of errors found (i.e., a, b, c, d, e, f, or g), cable length, retest results after problem resolution, and signature of the technician completing the tests.

H. Test results for each Category 5 four-pair UTP cable must be submitted with identification to match labels on all patch panel ports and RJ45 jacks and must match as-builts associated with that cable.

3.07 FIBER OPTIC CABLE TERMINATIONS

A. Fiber optic cable shall be installed in innerduct from fiber patch panels to plenum entrances. Innerduct shall not be installed in plenum ceilings unless it is UL-approved plenum rated. Outside gel-filled fiber optic cable shall be installed in conduit or UL-approved, plenum-rated innerduct in all plenum ceilings.

B. Terminations shall be performed by a manufacturer-trained, certified technician.

C. Terminations shall be made in a controlled environment. The contractor may choose to have the cables assembled offsite, although testing must be completed with the cable in its final installed condition.

3.08 FIBER OPTIC CABLE TESTING SPECIFICATIONS

A. All testing shall be performed by trained personnel.

B. The procedure for testing fiber optic cables requires the use of a high-quality OTDR (optical time-domain reflectometer) equipped with a printer. The printed data shall show, in addition to any summary information, the complete test trace and all relevant scale settings. The OTDR must have the capability to take measurements from bare fiber strands as well as ST or SC connector terminations.

C. All fiber optic cable shall be tested on the reel before installation to ensure that it meets the specifications outlined herein.

D. After installation the contractor shall test each fiber strand in accordance with EIA 455-171 Method D procedures (bi-directional testing) at both 850 and 1,300 nm. A form shall be completed for each cable showing data recorded for each strand including: length, total segment (end-to-end) loss (dB), and connector losses (dB) at each end. In addition, the printed data strip for each strand shall be attached to the form.

E. Acceptable fiber optic cable and connector loss shall not exceed 1.5 dB. The contractor is responsible for obtaining minimum loss in fiber connections and polishing per manufacturer's specifications.

3.09 INSPECTION

Conformance to the installation practices covered above are to be verified when completed. In some cases, the customer may inspect before acceptance. The following points are to be examined:

A. Is the design documentation complete?

B. Have all terminated cables been tested per the specifications?

C. Is the cable type suitable for its pathway?

D. Have the pathway manufacturer's guidelines been followed?

E. Have the installers avoided excessive cable bending?

F. Have potential EMI sources been considered?

G. Is cable fill correct?

H. Are hanging supports within 60 inches (five feet)?

I. Does hanging cable exhibit some sag?

J. Are telecommunications closet terminations compatible with equipment?

K. Have station jack instructions been followed? *(Inspect visually.)*

1. Jacket (sheath) removal point.
2. Termination positions.
3. Pair terminations tight with minimal pair distortions.
4. Twists maintained up to termination.

L. Have patch panel instructions been followed? *(Inspect visually.)*

1. Cable dressing first.
2. Jackets (sheath) remain up to the connecting block.
3. Pair terminations tight and undistorted.
4. Twists maintained up to the connecting block.

M. Are the correct outlet connectors used (568A or 568B)?

N. Is the jacket maintained right up to the connection?

4.0 TRAINING REQUIREMENTS

Section 4.0 specifies the documentation and training information the school district is requesting as part of this proposal. Student learning is an important aspect of the district's networking project. The district will place a high value on the training and documentation the vendor can make available to the district's students, teachers, and staff.

4.1 Describe training courses available locally. How many of these courses could be held on district premises?

4.2 Describe licensed course materials that could be made available to the district for student curriculum.

4.3 Describe available factory-authorized training courses where applicable.

4.4 Describe previous training experience of the company and staff.

5.0 STUDENT PARTICIPATION REQUIREMENTS

Student participation in the construction of the campus cabling systems is a goal of the district. Section 5.0 asks each bidder to propose how it might employ district students in the installation of the school(s) cabling systems this summer.

5.1 Propose how you would employ students in the installation and testing of the district's campus cabling systems.

A. How many students?

B. Would they be paid? How?

C. Describe what they will learn about networks from the experience.

6.0 CABLING SPECIFICATIONS AND PRICING—FIBER OPTIC CABLE AND CATEGORY 5 FOUR-PAIR UTP

Section 6.0 lists the district's specifications for school wiring systems. The district is installing a standardized Category 5 LAN in all its facilities. The cabling system will be used to construct a LAN in each school. It is impossible to know the exact number and locations of all network drops in all schools at this time. We are requesting that all bidders respond with pricing based on a unit of installation, i.e., cost per drop, cost per foot of wire, etc. The district will control the cost of each school's installation by controlling the number of units of installation, i.e., number of drops.

6.1 CONCENTRATOR TO DROP—ESTIMATED QUANTITY

Category 5 four-pair UTP cable, jumper cables, all patch panels, jacks, and wiremold.

6.2 CONCENTRATOR TO CONCENTRATOR—ESTIMATED QUANTITY

Six-, 12-strand fiber including ST, ST II type, or SC connectors and patch panels.

6.3 CABLE INSTALLATION PRICES

The district requires that vendors price cable installation as a cost per drop. Labor and material costs should be bundled into a flat charge per drop.

A. Price per Category 5 four-pair UTP drop during initial school installation.

   1. Price for one (1) cable per drop, to include all connecting hardware and faceplate.

   2. Price for two (2) cables per drop, to include all connecting hardware and faceplate.

B. Price per additional Category 5 four-pair UTP drop after initial school installation, to include all connecting hardware and faceplate.

C. Price per foot installed of the following media types for concentrator to concentrator connections (building backbone).

   1. Six-strand fiber optic cable including ST, ST II type, or SC connectors and all connecting hardware (LIUs, couplers, etc.).

   2. Twelve-strand fiber optic cable including ST, ST II type, or SC connectors and all connecting hardware (LIUs, couplers, etc.).

D. Installation cost per foot of conduit—½, ¾, and one inch. Price for both metal and plastic.

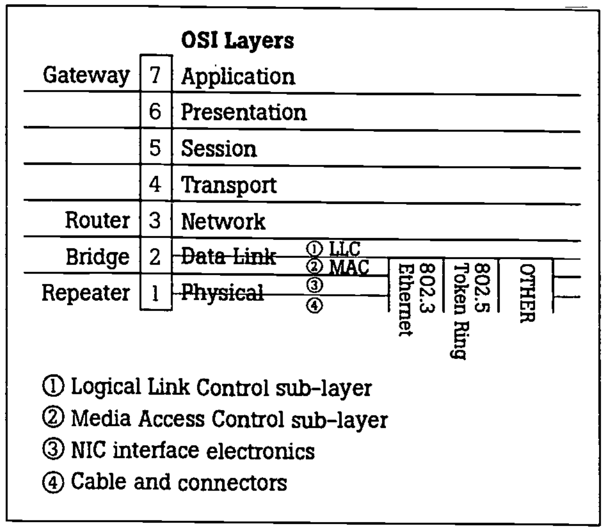
E. Installation cost per foot of innerduct—one inch internal diameter for both non-plenum and plenum rated.

F. Wiremold per foot installed. Price for both metal and plastic. All for size to accommodate one, two, and four cables.

The OSI Seven-Layer Model

C

You can look at protocols as being either open system or proprietary. An open system is a standard, published protocol controlled by a standards body while a proprietary protocol is privately controlled. The open systems interconnection (OSI) model is the basis for open system protocols and describes a network architecture composed of layers. The seven layers of the OSI model reflect the functions in data communications networks; it serves as a framework for the various networking standards. It has become a common reference point when discussing network protocols, features, and hardware. The functional layers of the model are shown in the figure below and compared to various interconnect device functions and to several media access protocols.



OSI seven-layer model compared to various interconnect device functions and to several media access protocols

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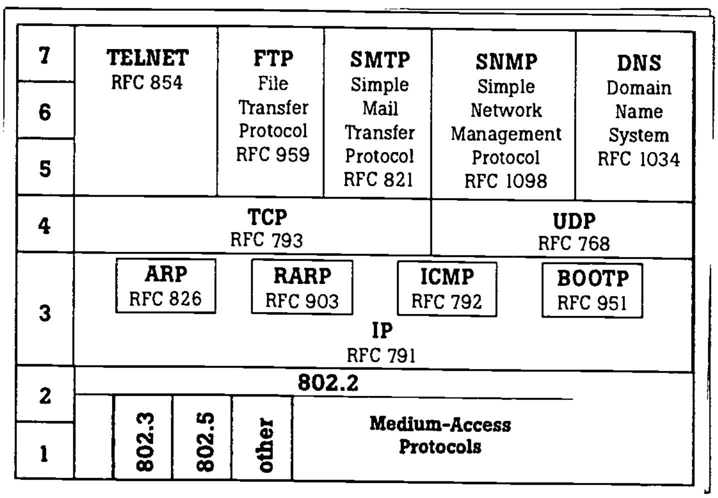
THE SEVEN LAYERS DESCRIBED

- **Physical layer:** The lowest layer of the model, it provides the transmission of data. This layer defines electrical and mechanical properties.
- **Link layer:** This layer controls the transmission of blocks of data between network peers over a physical link. It monitors and resolves errors that may occur on the physical layer.
- **Network layer:** The third layer routes data from one network node to others.
- **Transport layer:** This layer ensures that data from the source arrives at the destination correctly and in proper sequence.

- **Session layer:** The layer provides the capability for cooperating applications to synchronize and manage their dialog and data exchange.
- **Presentation layer:** This provides services that interpret the meaning of the information exchanged.
- **Application layer:** This layer directly serves the end user. It supports end applications such as file transfer and database access.

The diagram below shows how a common suite of protocols (TCP/IP) used for the Internet are related to the OSI model.



Partial list of TCP/IP protocols in relation to the seven-layer model
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INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE) STANDARDS AND THE OSI MODEL

The IEEE has established network protocol standards based on the OSI model. IEEE standards documents are developed within the technical committees of the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Board.

The family of IEEE 802 standards includes publications, projects, and activities that define standards, recommended practices, and guidelines in the following areas:

IEEE Std 802	Overview and Architecture
IEEE 802.1 series	Glossary, Network Management, and Internetworking
ISO 8802-2 (ANSI/IEEE Std 802.2)	Logical Link Control
ISO/TEC 8802-3 (ANSI/IEEE 802.3)	Ethernet Specification (CSMA/CD)
ISO/IEC 8802-4 (ANSI/IEEE 802.4)	Token-Passing Bus Access Method
IEEE Std 802.5	Token-Passing Ring Access Method

A complete list of IEEE 802 standards can obtained by writing to:

Secretary
IEEE Standards Board
Institute of Electrical and Electronics Engineers
445 Hoes Lane
PO Box 1331
Piscataway, NJ 08855-1331

Wiring Guidelines for Schools

D

PATHWAYS

Building pathways. Horizontal building pathways are *facilities for the installation of telecommunications cable from the telecommunications closet to the work-area telecommunications outlet.* Pathways can be underfloor; accessfloor; conduit (protective tubing that encases cable or wire); tray (holds the cable); and wireway, ceiling, and perimeter facilities. In most cases, underfloor and accessfloor distribution is costly and impractical for school buildings. Generally, horizontal pathways in school buildings utilize conduit, tray, and wireway and/or ceiling facilities. But please remember when examining ceiling facilities for horizontal pathways, suspended ceiling supports should *not* be used to hold wiring, and wiring should *not* lie directly on the ceiling tile.

For ceiling distribution systems, use cable-tray systems (rigid, prefabricated structures that support telecommunications cables and wiring), conduit, and/or cable rings. Open ventilated cable trays are recommended for ceiling distribution systems, even though they are the most costly option. Trays should be installed as close as practicable above the ceiling tile and have adequate support to withstand the stress of pulling the cables. A minimum of 12 inches should be maintained above the cable tray for access.

The most practical solution for a school's wiring infrastructure usually involves using a mix of cable tray, cable ring suspension, and conduit. Whatever choice is used, the solution should be installed to meet the requirements of the National Electrical Code and local building codes.

Interbuilding pathways. Interbuilding pathways link multiple buildings for local area or campus telecommunications. If utility tunnels exist between buildings, they provide the preferred route for interbuilding telecommunications pathways. Underground conduits may also be used for interbuilding pathways. In a campus environment, conduit should extend from the building entrance facility through the exterior for interbuilding connectivity. A conduit is considered full when 40 percent of the inside diameter is utilized. Interbuilding pathways using conduit should be designed in accordance with the EIA/TIA-569 Commercial Building Standard pathway design specifications.

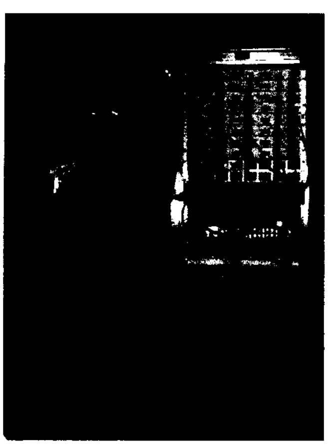
MEDIA STANDARDS

Unshielded twisted pair. The minimum standard for horizontal distribution wiring is six cables of Category 5 four-pair, 24-gauge unshielded twisted pair (UTP) wiring terminated in each classroom. The standard specifies 100-ohms impedance at one megahertz, satisfying Integrated Services Digital Network (ISDN) and Institute of Electrical and Electronics Engineers (IEEE) 802.3 10BaseT requirements.

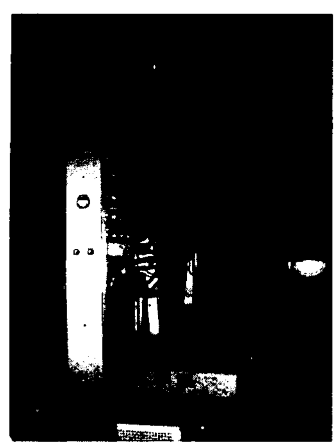
Fiber optics. The media standard for both intra- and interbuilding backbones is 62.5/125 micron graded-index multimode optical fiber cable. A minimum of a six-fiber strand cable should be installed for each cable run.

TELECOMMUNICATIONS CLOSETS

A telecommunications closet, also known as an MDF (main distribution frame) and also called a wiring closet, is a local communications equipment room. This should be dedicated space providing a secure environment for the installation and termination of cable, network electronics, and other telecommunications equipment.



Front view of racks in an MDF



Back view of racks in an MDF

The MDF, the point where the backbone and horizontal distribution facilities intersect, should be located near the center of the area served, preferably in the building core area. Every effort should be made to secure as large an area as possible. When one MDF is insufficient to cover a building, additional wiring closets, called IDFs (intermediate distribution frames), must be established. The same parameters apply for both MDFs and IDFs. A telephone should be installed in each location, and each door should have a lock.

Locate telecommunications closets *away* from any sources of electromagnetic interference, such as electrical power-supply transformers, motors, and generators. There should be *no water sources* in this area.

One telecommunications closet for each 10,000 square feet or less is the Washington state standard as specified in the Telecommunications Architectural Standards from the Department of Information Services. The minimum closet size for that square footage, per the Commercial Building Standard, is 10 by 11 feet. The recommended minimum ceiling height is 8 feet, 6 inches. Closets should be designed with adequate conduit or openings through beams and other obstructions into the accessible ceiling space.

Do not install false ceilings. Although you may see false ceilings in commercial buildings where space is available, school buildings do not typically have this kind of square footage.

Power needs for the closet(s) vary, but you should plan for at least two dedicated 20-amp power circuits per closet.

The MDF contains wiring terminations and communications equipment to serve a floor. This equipment may include modular fiber distribution panels, wiring termination panels, telephone systems, concentrators/hubs that connect communications lines, routers that connect users on different networks, CATV (cable television) equipment, and equipment racks.

Environment. Telecommunications closets require continuous climate control. Air conditioning should maintain temperatures in the range of 65 to 75 degrees Fahrenheit, with relative humidity in the range of 40 to 55 percent.

Carpet should *not* be installed in closets. Tile or sealed concrete floors will protect equipment from static electricity and dust.

The major components of the building electrical system should not be co-located in the telecommunications closet. In Washington, this is the state standard. *Closet space should be dedicated to serving telecommunications needs only.* Electrical installations supporting telecommunications functions only should be located in the closet.

TELECOMMUNICATIONS CLOSET TERMINATIONS

Each closet should contain at least one universal self-supporting 19-inch data rack. Each rack should be securely mounted to the floor and braced to the wall using a section of cable tray. Racks must be grounded in accordance with National Electrical Code requirements.

If fiber optic cable is to be terminated in the closet, attach a fiber optic patch panel to the uppermost part of the data rack. Terminate the fiber optic cable with ST or SC connectors. The maximum optical attenuation for each mated connector pair must not exceed the connector manufacturer's specifications.

Terminate Category 5 cable on Category 5 RJ45 patch panels in all closet locations. All incoming cables should be routed on the tray and neatly dressed down to the patch panels. A cable management panel should be installed directly above and below each patch panel.

BUILDING WIRING

Here are some tips for properly wiring workstations for students and teachers.

Student workstation wiring. Each classroom should have *at least two* student workstation outlets. A duplex power outlet with ground should be in close proximity to the student workstation outlet. Run two cables of Category 5 four-pair, unshielded twisted pair from the outlet to the wiring patch panel located in the telecommunications closet. The cables must be a *continuous run* and not spliced. The maximum cable length must not exceed 295 feet as specified in the Commercial Building Wiring Standard.

Each outlet should consist of either flush-mounted or surface-mounted, high-quality Category 5 RJ45 modular jacks with Krone IDC-style or 110-style wire T568A or B terminations. Consistency must be maintained throughout the installation. Jacks must meet EIA/TIA TSB40 recommendations for Category 5 connecting hardware.

Each outlet must be terminated with two individual cables. One outlet allows for voice and the remaining outlet allows for data. The color stripes on each cable must correspond with the color stripes on the edge connector. Faceplates must match the manufacturer for RJ45 outlets at all locations.

Teacher workstation wiring. Each classroom should have *one* teacher information outlet. A duplex power outlet with ground should be in close proximity to the information outlet.

Run two cables of Category 5 four-pair, unshielded twisted pair from the outlet to the wiring patch panel located in the telecommunications closet. The cables must be a *continuous run* and not spliced. The maximum cable length must not exceed 295 feet as specified in the Commercial Building Wiring Standard.

The outlet must consist of either flush-mounted or surface-mounted, high-quality Category 5 RJ45 modular jacks with Krone IDC-style or 110-style wire T568A or B terminations. Consistency must be maintained throughout the installation. Jacks shall meet EIA/TIA TSB40 recommendations for Category 5 connecting hardware.

Each outlet must be terminated with two individual cables. One outlet allows for voice and the remaining outlet allows for data. The color stripes on each cable must correspond with the color stripes on the edge connector. Faceplates must match the manufacturer for RJ45 outlets at all locations.

CAMPUS BACKBONE WIRING

The backbone is like a high-speed, long-distance freeway that connects cities. Fiber optic cabling is recognized as the cable standard for interconnecting buildings in a campus environment. The fiber optic cable should contain a minimum of six fiber strands and be placed in conduit. The cable must meet or exceed FDDI ANSI Standard X3T9.5 requirements for 100 Mbps transmission.

Snapshots of School Networks

E

Get Wired: Designing Your School Network is a videotape of a satellite teleconference sponsored by the Northwest Educational Technology Consortium. It offers some true stories about school and district networks with insider views about how the networks were developed, and the various avenues taken to get there. Following are these three very different network stories from school districts—from an embryonic, one-person effort to a campus and district system.

Technology evolves, networks grow and change, and local planning sets the course. So, while these stories are snapshots taken at only one point in time, they are instructive because of their differences.

BUTTE, MONTANA

In this network story, one person crusaded to bring the future to the schools, piece by piece at first, and finally with a five-year technology plan to prepare the Butte Public Schools students to meet the future.

A while back, the Butte economy had been devastated with the closing of a major copper mine. In response, Butte people shaped a fresh future. The community began to transition successfully to a new economic base in medicine and technology.

With a school district facing drastic cuts—and certainly no money for computers—a former kindergarten teacher, who became a technology coordinator, pieced together a do-it-yourself venture. First holding bake sales to buy hardware, then begging for and borrowing other components, she outfitted and wired a computer lab in her middle school, plus a library and 12 classrooms. She created a local area network in her middle school. Along the way, her colleagues also saw the vision and contributed money from their own very tight budgets.

Technology planning in Butte is no longer a one-person effort; it became a five-year plan with a goal of a computer in every classroom, and teacher training underway. Putting the technology cart before the planning horse is not the best way to get a local area network, but sometimes *starting* is the only way to make it happen. And sometimes it starts with just one person.

MONTESANO, WASHINGTON

Montesano, Washington, a short ride from Grays Harbor on the Washington Coast and within commuting distance of Olympia and other Puget Sound cities where many of its residents work, has a timber-based economy—and a school district technology planning committee, formed about 1994. This committee designed an implementation plan for technology.

With district and community leaders moving forward with the knowledge that today's students are going into a labor market where many of the jobs that they will perform don't even exist today, they recognized that learning how to learn new things is a necessary educational approach with technology critical to it.

The first piece of the district's technology plan was to build a local area network at each district building. The LANs would then link through a wide area network.

With an enrollment of over 1,500 students in two elementary schools and a single junior/senior high, Montesano School District wired the junior/senior high in the summer of 1995, and built an operational LAN with 187 ports providing five stations per classroom. At the time this snapshot was taken, the second elementary school was being wired.

JUNEAU, ALASKA

When a school district is geographically large, technology and networking make good sense. When a school district serves what is probably geographically the largest state capital in our nation—at 3,108 square miles—technology and networking make the greatest sense of all. This district, Juneau Borough School District, stretches 10 miles down the coastline of southeast Alaska, and serves about 5,400 students. It had a staff of about 300 when the snapshot was taken. Networking is keeping the school district connected with its local communities, as well as the outside world.

As of fall 1995, Juneau had a fully operating local area network in each of eight campuses, and a wide area network linking the district. The citizens of Juneau approved a second technology bond measure to fund a second phase—access to tools and information, providing more workstations per classroom, software, and training.

Building the network was the result of a broad technology plan that included restructuring for educational improvement. Diverse people were involved in the planning process that focused on the essential question: What do we want students to be able to do with technology? The answer: Access information whenever they need it, wherever they are located, at any time, from any source. Planning the infrastructure then, had to relate to this goal, and equipment decisions focused on: Will this piece of equipment provide the access we intend for our students and teachers?

School Networking Resources

F

NORTHWEST EDUCATIONAL TECHNOLOGY CONSORTIUM

The Northwest Educational Technology Consortium (NETC) is operated out of the Northwest Regional Educational Laboratory (NWREL) and is one of six federally funded Regional Technology in Education Consortia (R*TEC). The national program was established in the fall of 1995 to help states, local educational agencies, teachers, school library and media personnel, administrators, and other education entities successfully integrate technologies in K-12 classrooms, library media centers, and other educational settings, including adult literacy centers and teacher education programs.

The members of the Northwest consortium include the six state education agencies of Alaska, Idaho, Montana, Oregon, Washington, and Wyoming, the Educational Service District 101 (based in Spokane, Washington), and NWREL as the lead grantee. The activities of the consortium in each member state are tailored to the needs of each state and are coordinated to complement existing delivery mechanisms or programs. Member states have identified four priorities for NETC services and products:

- Integrating technology with teaching and learning
- Identifying and supporting leaders at the building level
- Developing and implementing technology plans
- Building infrastructure for networking and telecommunications

NETC uses technology whenever possible to disseminate information and to provide staff development or technical assistance, including:

- Internet and state telecommunication networks
- Web site: http://www.netc.org/
- Moderated online discussion groups
- Satellite teleconferences
- Desktop video conferencing
- CD-ROM and video

Resources to Support School Network Design:

Get Wired: Designing Your School Network. Originally broadcast May 8, 1996, as an interactive satellite teleconference, this two-hour video provides basic information on planning a school network. The hosts, experienced network designers, provide examples of school networks, address network design features, and discuss planning considerations that face educators needing to make intelligent decisions about constantly evolving technologies.

You're Wired: Now What? Originally broadcast October 30, 1996, as an interactive satellite teleconference, this two-hour video examines issues and considerations in implementing and maintaining a network. Segments include: Support & Administration, Security & Access, Training & Professional Development, and Growing the Network. The video features panels of educators from districts with working networks of various size and scope.

The above videos are available for $20.00 each (includes shipping and handling) from: Northwest Regional Educational Laboratory, Document Reproduction Service, 101 S.W. Main Street, Suite 500, Portland, OR 97204-3297, phone: 503-275-9519, fax: 503-275-0458.

Networking Issues in K-12 Schools. This CD-ROM provides awareness and basic understanding of the issues involved in planning, implementation, and using networks in K-12 schools. With a technology committee member in mind, it offers broad information helpful to a wide range of roles—including school board members, superintendents, administrators, teachers, technology coordinators, students, and community members. The material assumes the user has little or no technical knowledge about networks but is in a decisionmaking role for school networking.

This CD-ROM will be shipped in the fall of 1997 to each school in the six-state NETC region. Information on ordering additional copies or on obtaining copies from outside the region will be available from NETC at that time.

Contact Information

Northwest Educational Technology Consortium
101 S.W. Main Street, Suite 500
Portland, OR 97204-3297
Messages: 800-211-9435
E-mail: netc@nwrel.org
Fax: 503-275-0449

Seymour Hanfling, Director
Voice: 503-275-0650
E-mail: hanflins@nwrel.org

ALASKA

Current status of school networking:

Networking and connectivity in Alaskan schools ranges from none to schools that have T1 connectivity and Internet access on the desktop of every computer. Almost all schools on the road system have at least begun the process of networking their buildings and coping with the problems of integrating obsolete and obsolescent equipment into their systems. Bush school districts also range widely in technology infrastructure, from the North Slope Borough with interactive video conferencing at every village and Internet access to every desk, to some small interior districts that operate with radiophones and cannot afford the enormous telecommunications charges for even an e-mail system. Alaskan school districts are waiting on tenterhooks for the decisions of the state Public Utilities Commission in regard to the universal access provisions of the Telecommunications Act of 1996.

Future developments impacting school networking:

The Alaska Science & Technology Foundation is awarding grants of $10,000 to schools that write technology plans for networking. The grants will fund wiring, network hardware such as routers and hubs, and the costs of installing connections to local providers.

They cannot be used for workstations, software, or training, but may be used to purchase a server if the school does not already have one. The Technology Literacy Challenge Fund grant applications are at district offices now with an expectation of a May decision on awards. A corporate donation of more than 1,500 Macintosh computers plus $600,000 for networking, software, and training was made by British Petroleum -Alaska to 15 districts statewide. The major thrust of this donation is for staff development and curriculum integration.

Resources to support school network design:

The University of Alaska Southeast (Juneau) will begin a distance delivery class on networking during the summer 1997 semester. This campus will maintain a Web site on networking. The university's Anchorage campus will begin an educational technology master's degree program with the fall semester.

Key contacts:

Rick Cross, Deputy Commissioner
Alaska Department of Education, 801 W. 10th Street, Suite 200, Juneau, AK 99801
Phone: 907-465-8689, fax: 907-465-3396
E-mail: Rick_Cross@educ.state.ak.us

Della Matthis, School Library Coordinator
Alaska State Library, 344 W. 3rd Avenue #125, Anchorage, AK 99501
Phone: 907-269-6568, fax: 907-269-6580
E-mail: dellam@muskox.alaska.edu

IDAHO

Current status of school networking:

The schools in Idaho are in various stages of networking. As of November 1, 1996, 18 percent of the schools had no network, 21 percent had small LANs, and 24 percent had a district WAN. Currently Idaho is in year three of a five-year plan to integrate technology into the schools with $10.4 million dollars being allocated annually by the Idaho

Legislature. As of November 1, 1996, 31 percent of the schools in Idaho had no Internet access, 35 percent had dial-up Internet access, and 34 percent had network Internet access.

Future developments impacting school networking:

The state of Idaho is working to establish a fast packet contract that will allow equal connectivity access across the state. The Public Utilities Commission has been working with U S WEST to establish expanded, local calling areas.

Resources to support school network design:

The Idaho State Department of Education staffs two people who work onsite with the schools in Idaho. Dr. Debra Dirksen works with schools on evaluation techniques and the integration of technology into the classroom. Dawn Wilson works with schools in the design of school networks. Their contact information is below. An Internet home page is also maintained to disseminate information to the schools. The URL is http://www.sde.state.id.us:80/edtech/index.htm.

Key contacts:

Rich Mincer, Educational Technology Supervisor
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Dr. Debra Dirksen, Educational Technology Specialist
Idaho State Department of Education, PO Box 83720, Boise, ID 83720-0027
Phone: 208-332-6972
E-mail: ddirksen@sde.state.id.us

MONTANA

Future developments impacting school networking:

The extension of SummitNet (Montana's state government and education network) to the county seats throughout Montana provides an opportunity for rural school districts to obtain bandwidth in the 56 Kbps and T1 range for Internet access and access to state government and university system resources.

A request for proposal is being developed by the state department of administration to provide local Internet dial-up access throughout all local dialing areas in Montana. This service will be provided by local Internet providers through a contract with the state. This service would be beneficial to schools that have not completed their networking, or that do not have sufficient enrollment to justify a higher bandwidth.

The telecommunications legislation of 1996 and the 1997 Montana Legislature's Senate Bill 89 will both provide opportunities for schools, libraries, and local medical care providers to access a universal service fund. The establishment of these funds is currently under review by the U.S. Congress, the Federal Communications Commission, and the individual state public service and utility commissions. Federal rules should be developed by May, 1997 and rules issued thereafter.

A Web site to support school networking:
http://www.metnet.mt.gov/netday.html

Networking contacts:

Network Montana contact:
SummitNet Educational Network Services
Attn: Tom Morarre
Phone: 406-243-6677
E-mail: morarre@selway.umt.edu

Wiring contacts:

Sgt. Rogers
Malmstrom AFB, 341st Communications Squad
Phone: 406-731-4615
E-mail: rogerssm@malmstrom.af.mil

Jerry Jessup
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Phone: 406-444-0171

Office of Public Instruction contacts:

Networking/technology planning:
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Phone: 406-444-4326
E-mail: sbuswell@opi.mt.gov

Steve Meredith
Phone: 406-444-3563
E-mail: steve_meredith@metnet.mt.gov

Instruction/technology integration:

Michael Hall
Phone: 406-444-4422
E-mail: mhall@opi.mt.gov

OREGON

Current status of school networking:

The goal in Oregon is to have all classrooms with a direct connection to telecommunications by the year 2000. Currently, classrooms, schools, districts, and educational service districts (ESDs) are in various stages of connection. Most ESDs are already connected with Tl lines. About a third of school districts and schools have a direct connection. However, many administrators have only one direct connection to share. But within schools only about 15 percent of the classrooms are on a local network. This means that the teachers still rely on phone modems where there are phone lines. Right now many of those phone lines are in the school library so at least most teachers can get telecommunications access of sorts. Nearly 80 percent of the schools have telecommunications access of some type and can reach the Internet.

Future developments impacting school networking:

There are two basic developments taking place. The first is commercial ISPs (Internet service providers). The second is an organization of the ESDs called OPEN that is assisting schools in connecting to a statewide network for schools. OPEN has a contract through the state of Oregon with the telcos (telephone companies) in Oregon to provide fast packet technology to any school in the state at the same rate regardless of location. The consortium of telcos has hired a separate crew that is connecting about 20 schools per week as schools become ready. The contract with the telcos will certainly be influenced by the FCC and PUC regulation changes affecting schools, libraries, and hospitals.

Key contacts:

Jim Sanner, Instructional Technology Specialist
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Tom Cook, Director OPEN
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Phone: 503-699-2320
E-mail: tomcook@OPEN.k12.or.us

WASHINGTON

Current status of school networking:

Through the Washington Education Network (WEdNet), approximately 180 of the 296 school districts in the state have a routed connection to the Internet, and our latest survey indicates that at least 43 percent of school buildings in the state have instructional Internet access. In addition, a recent sample survey indicated that approximately 67 percent of school buildings have a local area network (LAN), and 47 percent of them are connected to a wide area network (WAN).

Future developments impacting school networking:

In 1996, the Washington state Legislature appropriated $42.3 million for the establishment of the K-20 Educational Telecommunications Network, intended to be an integrated and interoperable educational technology network serving kindergarten through higher education and promoting access for Washington citizens. The legislation outlines three phases of construction for the network. The first will link the nine educational service districts (ESDs), the main campuses of four-year, higher education institutions, and the 32 community and technical colleges. The second phase will connect the state's 296 school districts; public, higher education, off-campus, and extension centers; branch campuses of the community and technical colleges; and independent, nonprofit, baccalaureate institutions as prioritized by the network's oversight committee. Phase three is expected to add public libraries, state and local governments, and community resource centers to the network.

Resources to support school networking:

Each of the nine educational technology support centers (ETSCs) at the state ESDs provides technology training and support, and each contracts with a network specialist to provide assistance with network planning and design in its region. In addition, the Office of Superintendent of Public Instruction is coordinating NetYear 98: Learning through Technology to assist schools in planning, wiring, and integrating networked resources into the curriculum to improve learning. The latest update on educational technology resources and projects can be found on the OSPI Web page at http://inform.ospi.wednet.edu/edtech/.

Key contacts:

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Glossary

ANSI (American National Standards Institute)

This is the principal group in the U.S. for defining standards. ANSI represents the U.S. in the International Standards Organization (ISO).

ASCII (American Standard Code for Information Interchange)

A seven-bit binary code standardized by ANSI for use by personal computers and some mainframes to represent alphanumeric and graphical characters. An additional bit is included to form an eight-bit character byte.

analog transmission

Transmission of a continuously variable signal at a constant rate. The normal way of transmitting a voice signal has been through analog transmission.

AppleTalk

A networking protocol suite defined by Apple Computer, Inc. for communication between computers and peripherals.

application

Software that performs a specific function, such as e-mail.

backbone

A wiring scheme that is used to provide interconnections between telecommunications closets, equipment rooms, and entrance facilities in a telecommunications wiring system.

bandwidth

The range of frequencies that can be passed by a transmission medium. A measure of the information transmission capacity of a medium to transmit a signal. The greater the bandwidth, the greater the amount of information that can travel over the medium at one time.

baseband

A transmission method in which the entire bandwidth of the transmission medium is used by a single digital signal.

baud

A unit of signaling speed. Usually used interchangeably with bits per second.

bit rate

The speed at which bits are transmitted, usually expressed in bits per second (Bps).

bridge

A device used to connect local or wide area networks that use the same protocol.

broadband

A transmission method in which the bandwidth can be shared by multiple simultaneous signals.

bulletin board service (BBS)

A system for providing online announcements and conferencing. Access is usually through dial-in modem.

Bus topology

A network topology in which devices are connected to a single cable with terminators at each end.

CCITT (Consultative Committee for International Telegraphy and Telephony)

A group within the International Telecommunications Union (ITU) that defines data communications standards.

client

A node that requests services from a server.

client-server computing

A technique in which processing can be distributed between nodes requesting information (clients) and those maintaining data (servers).

coaxial cable

A transmission medium with a single-wire conductor. The capacity of coaxial cable is much more limited than that of fiber optic cable.

common carrier

A licensed, private, utility company that supplies data and voice communications services.

CPE (customer premises equipment)

Telecommunications equipment that is physically onsite at a school, business, or home.

CSU/DSU (channel service unit/data service unit)

The CSU terminates a digital channel (circuit). It provides network protection, maintenance loop back testing, automatic loop equalization, and regeneration of received line signals. The DSU provides a standard interface to the router. It also performs decoding, timing, generation, and recognition of control signals.

dedicated phone line

A phone line used for a specific telecommunications activity, i.e., a modem line used for dial-in/out only.

digital transmission

A transmission of discrete, separate pulses or signal levels, it contrasts with analog transmission.

e-mail (electronic mail)

Written messages that are transmitted across networks or within one network. The messages are usually stored on an e-mail server and can be accessed by the addressee only.

EMI/RFI (electromagnetic interference/radio frequency interference)

A form of "noise" on data transmission mediums that can reduce data integrity and increase transmission errors.

Ethernet

A name for a physical layer networking protocol that is based on a contention access scheme. Originally running at 10 Mbps over coax, the standard now also runs over twisted pair wire (10BaseT) and Fiber (10BaseF). A faster variant of the standard runs at 100 Mbps (called "Fast Ethernet" or "100BaseT"). A still faster emerging standard is called "Gigabit Ethernet" and will run at speeds of 1,000 Mbps.

EtherTalk

Apple Computer's implementation of Ethernet.

FDDI (fiber distributed data interface)

A 100 megabits per second (Mbps) network protocol that uses fiber optic cable as the transmission medium.

Fiber optic cable

Glass or plastic fibers over which modulated light pulses from laser or LED (light emitting diode) can transmit data. It is not subject to interference or electronic eavesdropping.

FTP (file transfer protocol)

A transmission control protocol/Internet protocol (TCP/IP) application governing file transfer.

gateway

A device connecting two or more networks that may use different protocols and media. Gateways can connect local area networks or wide area networks.

hub

A concentrator or repeater in a star topology network where node connections meet.

IEEE (Institute of Electrical and Electronics Engineers)

A professional organization within the ISO that assists with the creation of network standards.

Internet

A group of interconnected networks, all using TCP/IP as the common network protocol. The Internet grew from ARPANET, the first major packet switched network. The National Science Foundation (NSF) was given responsibility for supervision of the Internet when the Department of Defense separated Milnet, the military production network, from the ARPANET in 1983.

intranet

A group of interconnected networks set up to distribute information within an organization and usually only accessible within the organization, it may use a familiar World Wide Web browser for navigation.

Internet service provider

A business or enterprise that acts as an intermediary between the Internet and the connecting individual or agency. Usually geographically close, the connecting site can vary from a commercial organization to a university.

ISDN (integrated services digital network)

A network specification for transmitting voice, data, and video over existing, two- or four-wire telephone lines, it is not yet widely available.

ISO (International Standards Organization)

An international organization that creates networking standards including the OSI (open system interconnect) model.

LAN (local area network)

A computer network located within a building or group of buildings. The network is a system of software and hardware and is usually connected by a common data transmission medium.

modem (modulator-demodulator)

A device that connects a computer and a phone line, or a terminal server and a phone line. It converts digital and analog signals.

multiplexing

The division of a single transmission medium into multiple, logical channels supporting many simultaneous sessions.

network

A system of software and hardware connected in a way to support data transmission.

network device

A computer, printer, modem, or any other device connected to a network.

NIC (network interface card)

An adapter board that provides the physical connection between a computer and the network medium.

node

Any device on a network that has an address.

NOS (network operating system)

Controlling software for a network that oversees resource sharing and can provide security and administrative tools.

protocol

A standardized set of rules that specifies the format, timing, sequencing, and error checking for data transmission between network devices.

print server

A network device that allows multiple users to send print jobs to a printer regardless of whether that printer is currently busy.

repeater

A device that regenerates signals to extend transmission distance.

ring topology

A network topology in which nodes are connected to a closed loop. No terminators are required because there are no unconnected ends.

router

A network device that connects networks and forwards data of a specific protocol type based on an address.

server

A network device that provides shared resources and services to other network devices (clients).

star topology

A network topology in which nodes are connected to a common device such as a hub or concentrator.

T1

A 1.544 megabit per second (Mbps) multichannel transmission system for voice and/or data provided by common carriers.

TCP/IP (transmission control protocol/Internet protocol)

A protocol suite developed by ARPA (Advanced Research Projects Agency). TCP/IP is the protocol used by the Internet.

terminal server

A network device that connects remote computers to a network through the use of phone lines and modems.

token passing

A network access method that requires nodes to wait for their turn before transmitting data.

Token ring

A four or 16 megabits per second (Mbps) network protocol using a ring topology and a token-passing access method.

UTP (unshielded twisted pair cable)

A wiring scheme with one or more pairs of 18- to 24-gauge copper strands usually covered with plastic or PVC.

WAN (wide area network)

A network capable of transmissions over large, geographic areas.

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