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Building a computer network for schools

Abstract

With the increased use of computers in schools, it should come as no surprise that schools are quickly beginning to see the incredible potential of connecting those computers together. The opportunities a computer network in schools can provide for administrators, teachers, and students are immense and are beginning to be realized across the nation.

This paper will by no means make the reader an expert in setting up a computer network. It is merely to introduce you to the basics of computer networking, some of the unique qualities of a school network when compared to networks done elsewhere, and show that networked computers are an important asset to any school system and worth the initial inconvenience they may cause.

BUILDING A COMPUTER NETWORK FOR SCHOOLS

A Graduate Research Paper

Submitted to the

Division of Educational Technology

Department of Curriculum and Instruction

in Partial Fulfillment

of the Requirements for the Degree

Master of Arts

UNIVERSITY OF NORTHERN IOWA

by

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July 8th 1997

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Chapter One:

Introduction

With the increased use of computers in schools, it should come as no surprise that schools are quickly beginning to see the incredible potential of connecting those computers together. The opportunities a computer network in schools can provide for administrators, teachers, and students are immense and are beginning to be realized across the nation.

In relative terms computers are a new and constantly emerging form of educational technology. It was not long ago that many schools were lucky if they had one computer for the entire school. The emergence of the desktop personal computer has changed all of that. The PC has afforded many people, schools included, the opportunity to take advantage of the power of the computer to enhance productivity and efficiency for both students and teachers. Along with this growth has come the ability to connect these computers together. This ability has caused an increase in the things a single PC can do. A network provides a way for PC users in a small area to communicate with one another in ways that not long ago would have been considered impossible.

Another advantage of the networked computer is the sharing of resources. Once it would have been necessary to buy 25 copies of a program a teacher wished to use in class, this can now be accomplished by purchasing one version of the program with a license for 25 work stations. The same can be said of printers. Instead of purchasing a printer for each individual computer networks allow a school to buy a few high quality printers and share them in a manner that better suits their needs from a cost and effectiveness standpoint. When computer users are tied to using a stand alone computer the user will need a copy of a program for each computer and if the program is updated the school would need to buy enough new

copies of that program for each computer. When a networked copy of the application is upgraded and the entire system will be upgraded. The cost savings from sharing resources and reduced need for some equipment alone, makes networking a necessity for the always cost conscious school districts. There are many other reasons networks have grown in popularity.

Networking popularity has grown for four main reasons: One is the downsizing of many organizations. This downsizing refers to the replacing of very large mainframe computers with a network of PC's. This can save large sums of money in hardware, software, and maintenance. Second is the ability to access data and people over vast distances. For schools the potential here is just beginning to be tapped. Networked computers allow a student or other user to search libraries in other towns, states, and even countries. Third is a reason already mentioned that of being able to share resources like applications or equipment. And fourth, a rather technical reason, the movement toward network communication standards which allow for communication between different types of computers and networks (Rains & Palmer, 1994).

Purpose

The opportunities a network can offer a school are difficult to deny, unfortunately, as is the case with much new educational technology, most educators know very little about networking computers. Many educators see networking technology as a frightening hassle that they would just as soon not have to deal with. Rather than investigate the exciting educational opportunities it can provide one will often here excuses like 'it's just a fad', or "I can do the same thing only faster by hand".

- This paper will be exploring the process of: setting up a school network. It will:
- look at ways to asses the needs of the school,
- look at who should be involved in this decision making process,

- look at the goals of the district,
- develop a timeline to get your network installed and running,
- look to the future growth of the network,
- explain what a network is and the common types of networks usually involved in schools,
- provide tips for planning the schools network,
- looking at network arrangement options, ways that workstations can be connected,
- the role of the server, selecting the best operating system, and mapping out the plan;
- provide tips for installing the hardware and software of a network,
- including cabling and router options,
- and finally some tips to make the most of the network once it is up and running, including training of the users, maintenance to keep the network running smoothly once it is up and running, and decisions to make to assure that you are getting the most out of your network and keeping it up to date.

This paper will in no means make the reader an expert in setting up a computer network. It is merely to introduce you to the basics of computer networking, some of the unique qualities of a school network when compared to networks done elsewhere, and that networked computers are an important asset to any school system and worth the initial inconvenience they may cause.

CHAPTER TWO

Review of the Literature

One of the big problems with technology in schools is buying technology simply for the sake of having it. While simply having the technology will provide some benefit, simply by being used just because it is there, a great deal of time, energy, and money can be saved if some time is spent at the beginning of the process. Determining what you have, what you would like to have, where you plan to be in the future, and will this technology help you get there are important questions that need to be addressed. Networks are no exception.

It is certainly possible for a school to simply hire a company to install a network in the district and have everything work the way it is desired. The chances of that happening are not high without some school input and effort in the planning. One of the difficulties in incorporating technology in schools is the rapid changes that are taking place and the expenses that go along with them. Some planning and goal setting at the beginning of the process will go a long way to resolving problems in the future (Lowe, 1996). Planning certainly won't eliminate all the problems, but with a clearly defined goal that a district is striving toward it will be much easier to make decisions that will be beneficial to the district and help keep decisions focused on that goal. With all the technology that is out there it is easy to lose your focus and begin purchasing items that may be "neat" but may not be used by the network users.

Investigate the Need

Before putting in a network a district needs to ask the question "what do we need a network for?" This step should not be the first technology related decision that the school will make. A technology plan should already be in place. A plan that has been well thought out involving all the stakeholders in the school, the

teachers, the administration, the students, community members, and business should all have an opportunity to voice their opinions and a committee of members from each group should reach some consensus and establish district goals. This technology plan will normally include some type of mission statement and a series of long and short term goals that the district has for using technology in the school, how technology will fit in with the other educational goals of the district, and what the schools long range plans are for the future. Once this has been accomplished the process of setting up a network can begin (Lowe, 1996). By looking at the district's technology goals and how a network can aid in the process of reaching those goals should aid in the decision whether the school needs a network and how it can meet those established goals. If networking does not address any of those items then one of two things is true, either you don't need a network, or you need to revisit the technology goals for the district.

Once it has been established that a network will help in meeting the goals of the district or a need has been established it then becomes necessary to focus on what specific aspects of networking are most important for the district and what the district needs the network to do. Will the network primarily be used to allow students to access various programs or applications from different workstations? Will it be used to allow teachers to take attendance and input grades? Will the network be used by the administration to communicate more effectively with different buildings? Or, will it primarily be used as a means of hooking up to the Internet? Perhaps it will be used for all of these. The main thing is that before the choice of what networking system that will be used, some prior planning and investigation of what the main uses of the network will be can help tailor the network to best meet the district needs both in the present and in the future (Lowe, 1996).

For any assessment to be truly effective a district will also need to take an inventory of what materials are currently in the district, both hardware and software. It is difficult to get "there" if the district doesn't know where it is "now". Not all computers and programs will work with the same efficiency, or at all, when put on a network. Fortunately communication problems are decreasing with implementation of standards by the industry allow different systems to talk to each (Lowe, 1996). But, there are still machines out there that just won't work very well and there may just be a bunch of them in the district.

So what specific information do you need to know about the districts computers. One thing is the processor type and clock speed. Is it a Pentium II, Pentium, 486, 386, etc.? Is the clock speed 25MHz, 33MHz, etc.? This can usually be found on the box the computers came in. Everybody keeps those right? If not, many PC's will display the processor type when they are turned on.

Next is the size of the hard disk and how its partitions are arranged. The two main things you need to know about hard disk size are the bytes of total disk space and the bytes available on the disk. Next are things like the amount of conventional memory and the version of DOS or Macintosh operating system. If you are using DOS, the type of monitor the computer has, type of printer attached to the computer, if there is one, and what software will or is likely to be used on the computer is needed. One way to quickly gather this information is by using a program called "Microsoft Diagnostics" which will automatically display all the information you need. Unfortunately it only works if you have DOS Version 6.0, 6.2, or 6.22 or Microsoft Windows 3.1 (Lowe, 1996).

A detailed inventory may be a pain staking process but it can save time and money later when wondering why the network does not work or when something does go wrong and there is a need to call in the networking expert who will charge large sums of money for each minute enlisted to look at the problem. The detailed

inventory list created, which needs to be kept up to date and well organized, can become a cost effective asset when diagnosing a problem, looking to upgrade the network, or merely as a means of documentation for the insurance company should the chemistry teacher happen to blow up the building, accidentally of course (Lowe, 1996).

Set Goals

After determining your schools needs, setting up goals for the short and long term, and compiling a detailed inventory of what the district already has, it is still not yet time to jump in to the actual construction of your network. To better assure that the district will be getting what it wants and what the district hopes it needs it would be a very good idea at this time to take a look at other schools that already have a network set up and look at what they have done. Ideally the technology coordinator can visit several schools to see what they have done. Take the time to look at other networking plans and talk to the district technology planner about what things have worked well, what things would be done differently, and any other suggestions they might have that can only be learned by going through the process. Other schools may also have suggestions on a good network expert to consult when it does come time to install the district's network or when problems are encountered. Or, on the other side, network experts who were not very helpful. If possible on the visit try to talk to as many different groups as possible, as sometimes the person in charge of setting up the network may have a different opinion of it from those actually using it. The more information you can get at this stage can help you and the potential users to a much smoother transition once the network is up and running (Lowe, 1996).

Now certain that a network is needed, a clear picture of what the network should do for the school both long and short term, and a look at some other schools to see what will and will not work has been completed. Ready or not it is now time

to get into the nuts and bolts of building the schools network. Don't be concerned about not knowing everything. Remember technology is always changing it is impossible to know everything and if a coordinator waits schools will never have any technology.

What Exactly is a Network?

One of the biggest problems with implementing technology in schools is the fear that potential users have of the technology. Many feel uncomfortable with something new and will feel embarrassed if their students know more about the process than they do, with networks this is a likely scenario as it is an emerging technology one most students have grown up with while many teachers have not. Many people view networks as a magical wire connected to a black box and if things do not work smoothly frustration with the technology will quickly develop. Although there are some technical aspects to networks, they are not nearly as magical or complex as many view them.

Networking technology is not a unique and independent discovery but is dependent on many things that most computer users are already familiar with. The computer network has historical ties to the telephone and telegraph which provided the underlying technology of networks. Basically a network is simply a way of exchanging information and ideas very rapidly (Derfler & Freed, 1993).

The first effective method of communication over wire was the telegraph. Invented by Samuel Morse in 1844 this invention came at a perfect time for America as it rapidly expanded west with a need for communication over a wire (Derfler & Freed, 1993). The telegraph seems quite simple by today's standards but it provided the link between the established businesses of the east and the new frontier of the west and thus laid the foundation for networks of today.

The telegraph worked by having an electromagnet connect to a battery via a switch. When the switch was pressed down a current would flow through the battery from the senders end down the line to the receivers end and into a sounder at the end of the line. The telegraph could only have two positions on or off, but by spacing how long it was on or off, long distance communication became possible.

Next in line was the telephone (Derfler & Freed, 1993). Credit for this invention generally goes to Alexander Bell although it was also invented at roughly the same time by Elisha Gray who arrived at the patent office a few hours after Bell had acquired the patent. Regardless of who got credit for the invention it also proved to be an important forerunner to today's networking structure. All telephones consist of a transmitter and a receiver. Bell's first attempt was a design which used a membrane attached to a metal rod. The rod then reached down into a cup of mild acid. As the user spoke into the transmitter, the sound, through vibrating, would move the membrane and as the membrane moved the rod up and down in the acid the electrical resistance between the rod and the base would vary. This design had many drawbacks, one of which was users regularly getting acid on their hands. Bell's second design used the principle of magnetic induction in the place of the acid. Here sound striking the membrane moved the rod back and fourth inside a coil wire producing a weak electrical current. This design also had its drawbacks as well but at least it didn't burn the user with acid (Derfler & Freed, 1993).

The first practical telephone was actually designed by Thomas Edison, who found that certain carbon compounds changed their electrical resistance when put under different pressures, in this case the pressure was sound (Derfler & Freed, 1993).

Once the telephone became practical for communication over distance a complex set of wires were set up across the country in which a switch board

operator would connect the two desired parties phones to each other (Derfler & Freed, 1993). As the phone grew in popularity the switch board system proved to be inadequate and was replaced in part by the dial phone invented by Almon Strowger in 1889, thus eliminating the need for an operator for each call that was made.

Although it was Morse's telegraph that opened up the new frontier to electronic communication it had many problems (Derfler & Freed, 1993). One was that it allowed for only one conversation on a line at a time, wire at the time was expensive and very brittle. This problem led inventors like Edison to work on a concept called multiplexing, a concept that would allow several operators to use the same line at the same time. This improved the system but still left the problem of the need for trained operators at both ends of the line. This pushed inventors to work on a printing telegraph. An invention that eventually was made successful by a Frenchman named Baudot. Who also developed his own code of information replacing the familiar but difficult to work with Morse code. This proved to be the first machine that allowed electronic messages to be sent by almost everyone. For fifty years after its invention the teletypewriter was the preferred method of electronic communication, other than voice (Derfler & Freed, 1993).

All computer networks today owe their existence to two early networks set up by Western Union and Bell. Western Union was a point to point network spanning the North American continent. The Bell system also began as a point to point system. As users signed up for service they were connected to the system. This rapidly growing maze became the public telephone system of today. Although now it has expanded to an even more complex web of cables, microwave towers, fiber optic cables, and communication satellites (Derfler & Freed, 1993).

The computer and the telephone were products of different technology and different times but in many ways they were made for each other. Today's

telephone networks could not exist without computers and conversely the existence of world wide networks would not be possible without the telephone networks (Derfler & Freed, 1993).

The earliest computers had few of the features we have now grown accustomed to. Most had no keyboard or screen and were primarily used by scientists to do large cumbersome calculations. As the computers became affordable for general businesses the efficiency and accessibility quickly became an important concern (Derfler & Freed, 1993).

The first method of getting information in and out of the computer was the punch card system. A machine would translate the operators key strokes into a series of holes punched in a card. The card reader would then sense the holes and recreate the operators keystrokes (Derfler & Freed, 1993).

This system proved to be bulky, inefficient, and time consuming. This led to the next step in human machine interaction, the interactive printing terminal. Instead of punching holes in a card the terminal sent the key strokes directly into the computer. These early terminals were usually teletypewriters. This provided for an immediate response from the computer, something the punch cards could not do. This led to new uses of the computer, perhaps the most significant of which was the use of on-line processing. Users would lease a phone line and place terminals in different cities allowing for the computers to communicate over great distances. The first business to take full advantage of this was the airlines using the process to make reservations. Although it was a start there were still many problems to be worked out (Derfler & Freed, 1993).

The next significant breakthrough was the Carterfone. The Carterfone did not physically connect to a phone line. It was a device that allowed mobile two way radios to connect to a telephone line. This invention did not make AT&T very happy, but after a two year legal battle the FCC ruled that a third party could

connect to the phone line as long as it did not harm the network. This ruling along with a couple others opened the floodgates to new equipment that could legally connect to the phone lines. An area that previously was exclusively controlled by AT&T (Derfler & Freed, 1993).

Now that different systems were allowed to access the phone lines it opened the doors for different methods by which communication would take place over wire. Gradually Baudot's 5 letter system replaced Morse code. In 1966 several American companies in the communication industries collaborated to replace the Baudot code. The result was the ASCII code using a 7 bit code representing 128 characters. This system was widely adopted by communication and computer equipment worldwide eventually emerging into the 8 bit codes we are familiar with today (Derfler & Freed, 1993).

Now that a method of communication had been established next came an agreed upon method of physically connecting the devices to the network. The RS-232C standard defines the function of signals in the serial interface as well as the physical connection used by that interface. In other words all the connectors and things that they would connect to had a common form or standard. Instead of each company making their own individual plug in that would only work with its outlet. The RS-232C normally uses a 25 pin D-shell connector with a male plug on the data terminal equipment and a female plug on the data communications network (Derfler & Freed, 1993).

As the use of computers spread, a need arose to connect computers and terminals by ordinary phone lines. The answer put forth by AT&T was the Bell 103 modem. This device would convert the on-off pulses of computer data into on-off analog tones that could be transmitted over a normal phone line (Derfler & Freed, 1993).

The improved technology and connections allowed computers to move out of special computer rooms and on to users desk tops. By allowing hundreds of users to share the same computer system the cost per user dropped dramatically. It now became economically feasible for even small businesses to have computers. First through mainframe time sharing and eventually into the age of the personal computer (Derfler & Freed, 1993).

The next improvement from the Bell 103 was another modem product called a smart modem. This product invented by Hayes Microcomputer used a CPU chip to control the circuitry and provided for automatic dialing and answering (Derfler & Freed, 1993).

The componets for setting up a Local Area Network, or LAN, were now in place. A Network Operating System, or NOS, a family of programs that run the networked computers was now needed. Networked peripherals, including printers, modems, were rapidly advancing. Network Interface Cards, or NICs, devices inside the computer that change incoming signals into a more powerful signal that the computer can use to send messages across a network cable, were being produced. And network cabling, which most commonly came in the form of unshielded twisted pair, which is inexpensive but only works over short distances. Coaxial cable is a little faster than untwisted shielded pair but is more cumbersome to work with. Shielded twisted pair is expensive but very fast compared to others. And fiber optic which is as fast as you can get but extremely expensive; were beginning to be widely used (Derfler & Freed, 1993).

With the componets in place, three different types of networking cabling systems commonly began to be set up; Ethernet, Token Ring, and ARCnet. In Ethernet the NIC's share a common cable and use a system called CSMA/CD, which stands for carier sense multiple access with collision detection. Which basically means the card listens to make sure the line is clear to send the

information. If it is clear the packet of information is sent and then it makes sure the packet did not collide with another packet and if it did the information would be resent later. Token Ring and ARCnet are similar in that they wait for a "token" to come by and then send the information along with the token. It does not have the collisions of data you would have with Ethernet but it is much slower (Derfler & Freed, 1993).

Once a cabling system is selected a way of running the whole process is needed this is commonly done on a computer called a server. The three most common types of servers are, print server, file servers, and communications servers, on a server based LAN. A server based system provides good control, backup, and management. Powerful server-based networks offer security, excellent data management, fast response, and room to expand.

A server usually makes the network run more quickly and effectively but is not required. The alternative to a server based network is a peer to peer network which does not have a dedicated server. They offer lower start up cost, simplicity, and enough power to meet the needs of most organizations (Derfler & Freed, 1993).

One can quickly see that network set-up can be a fair amount of work. For this reason it must be remembered what a network can do for a school. There are three primary purposes or uses for networks (Lowe, 1996). Networks allow computers to share information. For example a school could have the grading program or application loaded up on a computer in the guidance office and instead of having each teacher record their scores by hand or on a separate disk and then have to input them into the main system. With a network the grades could be automatically added to the main system. The second main reason for networking is to share resources. In schools this can be a very strong bargaining tool in favor of networking the districts computers. A network will allow a system to share

printers, disk space and CD-ROM drives. As anyone who has ever worked in a school system knows, cost is always a consideration. And in the long run the bottom line is networking can save money by allowing the sharing of resources. The third and final reason for networking is that it allows for the sharing of programs. Instead of needing to load a specific program in each student's workstation networking allows the instructor to simply load a properly licensed program on the server and it is readily available to all students that need access to it. This can be a huge time and cost saver to a district and an individual teacher.

It is for these reasons, just as in the business world, that most schools find it beneficial to network their computers.

Whatever network system you choose to install some network management program is probably needed. This gathers statistics on the movement of data and watches for conditions that exceed programmed limits. When a problem is detected the central system will be alerted and information rerouted or a call for human intervention will be made (Derfler & Freed, 1993).

After establishing a LAN, the next logical progression is to connect that LAN to other LANs, or the network of one school building to another. This can be accomplished through the use of repeaters, bridges, and routers.

A repeater is typically a little box that connects two segments of networking cable. It then repeats, retimes and regenerates the digital signals and sends them down the line. They are usually inexpensive and are easy to install.

A bridge is a little more complex and expensive. Bridges read the address on each packet of information to determine its destination, it does not look inside the data, merely at its destination and sends it on its way.

A router takes the process one step further. A router reads the information in the packet, determines its destination, discards the outer package, repacks it, and retransmits the data. When a LAN is connected with routers the hardware does not

matter because multiprotocol routers are available. This makes routers especially valuable when connecting an Ethernet network to a Token Ring network (Derfler & Freed, 1993).

One organizational possibility of connecting LANs is a Metropolitan Area Network or MAN. This a method of connecting a LAN within a city or campus. The most common method of linkage is the phone line, this however usually carries speed limitations and charges. Thus there are other ways to meet this need. The two most common being FDDI which uses two rings of fiber to carry the data. And IEEE802.6 which is a metropolitan utility serving a large number of organizations across several miles. An alternative that is fast gaining in popularity is networking over microwaves or a wireless network.

Two alternatives to LAN to LAN set ups are: Circuit-Switched Digital Services; which allow the user to dial up to make a connection for a limited amount of time, this is usually less expensive than leasing a dedicated line, or Packet Switching Networks; in which you pay a flat monthly fee and a fee based on how much data is received by each of your ports. This method can be much more attractive than the full period leasing when you are only transferring data a few times a day.

One of the particularly useful aspects of networking is workgroups, or students working together on a common project. One way this can be accomplished is On-line Information services. Examples of this include CompuServe, Prodigy, and America Online. These services normally operate on a large mainframe computer system and allow subscribers to access a host system via a local phone line (Derfler & Freed, 1993). This can allow for connections worldwide and is one way of getting your school connected to the Internet, although most schools find a less expensive method through an area education agency or working something out with a local Internet service company.

Another particularly attractive feature of this interconnectivity is Electronic mail or e-mail. A e-mail system can create, read, forward, reply, track, and log messages. The e-mail program can simplify information sharing tasks and help alleviate the problem of phone tag. An e-mail system is vital cog in information sharing and can greatly increase the the efficiency of sharing information over a failry large geographic area.

Finally the idea of client/server computing is addressed. This method makes it possible to produce useful, yet small, programs from computers to provide on-call capabilities. This allows for workgroup programs that can store and retrieve data , appointments, manage projects, and to control and schedule the flow of work within the organization (Derfler & Freed, 1993)

Finalize the Plan

Now familiar with the history of network component and the basics of a computer network it is now time to begin the serious nuts and bolts planning of making the network best suit the district needs. The technology planning already established a need for the network and set some goals of what the district would like the network to do, now comes the planning of the topology or network mapping, cable selection, network arrangement, selection of a network operating system, and set up of servers.

The need to begin with an inventory of what computers and other equipment you currently have which should include some detail as to the capabilities of those computers and what networking capabilities they have has previously been mentioned. This step can not be emphasized enough and needs to be regularly updated. The importance of always keeping in mind why it is the school needs a network in the first place and having the plan fit those needs, as there are many different capabilities that networks can do and each of those capabilities usually has a price tag of some form that goes with them, must always remain the focus.

So the district now has three very important decisions to make; what operating system to use, what server arrangement will you use, and how will the network be connected. One additional decision that needs to be made is a designation of the network manager. Regardless of how simple the network is things can and will go wrong. For this reason it will normally work best if a single person is responsible for managing your network. The manager does not have to be an expert in every aspect of the network, but more importantly needs to be well organized and keep the network that way. He/she should have some network problem solving skills and perhaps more importantly know when to call in the real networking expert. That expert should likely be consulted or at least informed of the three big decisions that you are about to make.

Now back to the decision making. Which operating system to select. The network operating system or NOS is the program or application that will end up running your network (Lowe, 1996).

One option that may be made is to use the Apple Talk application that is already installed in the Macintosh computers. This built in system can handle many of the normal networking functions adequately, when the network is not very large or overly stressed by use. It can also be improved by installing an Ethernet card enhancing the capabilities and efficiency of the network. This may be your best networking option but when considering the likelihood that the network will be growing in the future and will eventually become a much larger monster to handle. Most schools do not find this system as the best long term solution to developing a school network. It is a system that can easily be out grown.

Some of the other most popular network operating systems currently being used are Novell's NetWare, Windows NT Server, Artisofts, LANtastic, Microsoft's Windows for Work groups and Windows 95.

They all have their own advantages and disadvantages the key being to find the one that best meets your needs.

Novell's NetWare is by far the most popular NOS. It can be used for very large and very small networks. NetWare is known for the following advantages. Seeing that DOS had its own limitations when it comes to networking NetWare does not run DOS NetWare itself is the operating system, thus able to eliminate the network limitations of DOS. NetWare servers need to be dedicated, in other words the server can not also be used as a workstation thus making the network run more efficiently. NetWare's file server is far superior to DOS in the way its file server and directories are organized. NetWare also provides a special filing system which allows you to purchase specialized software for running a school network. NetWare also has the ability to keep working even in the event of a hardware problem because of a feature called system fault tolerance. And perhaps most importantly for schools NetWare can be used on DOS, OS/2, or Macintosh computers (Lowe, 1996).

On the down side of NetWare, it is more complex than other network systems. It is usually more expensive because of the need for the dedicated server and the way it is sold.

Windows NT is the Microsoft version of NetWare and has many of the same features as NetWare the only difference being that NetWare has been around a little longer and is thus a little better tested.

LANtastic, Windows 95 and Windows for Workgroups are of the simpler peer to peer network variety. The reason they are usually considered simpler is that they do not require a dedicated server, they usually do not include some of the extra feature so fewer things can go wrong, and they can usually be purchased in kits that allow for an easier start up (Lowe, 1996).

With these pluses naturally come some negatives. Peer-to-peer networks are generally not as efficient as the NetWare or Windows NT Networks, they don't provide many of the extra feature like network security, and although on a single computer basis it may be cheaper if you have over 20 computers the difference is not significant (Lowe, 1996).

Because of its ability to handle both DOS and Macintosh systems equally well most schools find the best choice to be Novell's NetWare. Because of this it is the one that will be examined in more detail when the discussion the software installation is addressed. Even if the school is all Macintosh most libraries receive their information from a DOS system and sooner or later you will likely need to connect to a DOS computer. This is not to say NetWare is the best choice for everyone. Simply, that this is currently the most popular choice. So that is the one that will be used for the more detailed installation explanation.

After selecting a NOS, next decide how the servers will be set up. It has already been stated that if you decide on NetWare then you must dedicate a server while LANtastic, Windows 95 and Windows for Workgroups or any peer-to-peer network do not need a dedicated server. If at all possible, the network will run more smoothly when a server is dedicated to just running the network.

Some things to keep in mind once you have decided a dedicated server is the way to go. Most networks will quickly run out of disk space no matter how much you start out with so your network manager will need to keep a close eye on this. Train your users that space is not infinite and must be used wisely. Remember a server computer will be doing just that so it does not have to have a top notch monitor, but when it comes to the processor chip, memory, and disk drive the better you have the better your network will work. Finally if you will be doing a great deal of printing on your network you may consider dedicating a separate server just to handle that task.

The server can be located almost anywhere as long as it is clean, dry, has electrical outlet, and can be accessed if need be. And another thing that should definitely be included is a UPS or uninterruptible power source. This can be a life saver if for some reason, and "some reasons" usually happen, the power goes out. A UPS can prevent losing data, and provide time to get users logged off the network and shut things down in a orderly fashion. This will make it much easier to restore things with the least amount of difficulty when the power returns .

Now that a NOS and server arrangement have been decided upon it is time to decide how the network will be connected. The most common of which is Ethernet briefly explained earlier. Ethernet is the method in which the computer listens to see if the line is clear. If it is the information is sent. It then listens to see if a collision occurred. If it did then it will try sending the information latter. This is called CSMA/CD or carrier sense multiple access with collision detection. Token Ring and ARCnet both have their own merit but since Ethernet is the most common it is the one that will be explored when it comes to cabling.

Network topology

There are three basic ways that a network topology or layout can be set up. The *bus* network in which the computers are connected in a straight line one to the next. This is the simplest method with the drawback of a line break anywhere and the entire network will be down.

The *ring* is similar to the *bus* with the exception of connecting the last computer to the first forming a continuous loop.

Finally the *star*. In this arrangement all computers are connected to a central point called a hub. This requires more cable but if one line is broken the other computers will still be able to function. You need to decide what will work best for your situation and budget. The decided on layout or topology should then be carefully mapped out including where the server will be located, where hubs are,

and what computer will be hooked in where. Ideally this will be part of the well organized inventory and kept up to date when any changes are made.

Now for the actual computer to computer connection, which up to this point is usually done with some type of cable, although wireless connections can not be to far way. For the present there are three common cable choices. Thick coaxial cable is rarely used because of its cost. It is also difficult to work with, and requires a particularly difficult connection. On the positive side it resists interference from outside sources well and it works over greater distances than the other two, up to 500 meters per segment (Lowe, 1996).

Thinnet or thin coaxial is the second choice it is less expensive and much more flexible than the thick coaxial. Unlike the thick coaxial which is attached to the computer on one long line thinnet runs separately to each computer with a special terminator attachment required at the end. A single section of thinnet can be up to 185 meters long and connect as many as 30 computers.

Unshielded twisted-pair or UTP is currently the most popular choice for network cabling. It is cheaper than thinnet, and many buildings are already wired with it as it is the same wire used for modern telephone lines. UTP is wired in a star arrangement connecting to a hub allowing you to connect as many as 24 computers. UTP wire is graded 1 through 5, the higher the number providing greater protection from electrical interference. A rating of at least three is recommended but a 5 is ideal. UTP allows for a connection of up to 100 meters.

The current thinking on cabling seems to be go with the cheapest you can get by with for your current needs. Wireless connections look very promising for the future (Weinstien, 1996).

The computers will also need a Network Interface Card, or NIC. This allows the computer to communicate with other computers over the network. As already mentioned, Macintoshes already come with network capabilities called

Apple Talk. For those computers that do need a NIC you need to be certain that the NIC can be connected to the type of cable you select and can be installed in your computers (Lowe, 1996).

Time to Install.

You have planned, planned, and planned some more, now it is time to start putting that plan into practice and begin installing the hardware and software of your network. Even this process can be improved with a little more planning.

If the goal is simply networking a lab, it is a job that might be accomplished without an expert, but if a district has a need to cable an entire building or several buildings it will at the very least need to hire people to pull wires. Depending on the comfort level and expertise of the technology coordinator a networking specialist, at the very least as a consultant, will likely be needed as hardware is installed. It will be much less expensive in the long run to fix the problems while the cable is being put in than having to go back and rewire an entire building later (Lowe, 1996).

Before beginning the process the installer will want to have a basic computer tools set. This should include screwdrivers and wrenches that can open all the computers in the system and allow for installation of the NIC's. The kit should also include wire cutters, wire strippers, and a crimping tool to attach the connectors to the cable. If cable is going to be run through walls you will also need a hammer, a method for drilling or cutting through walls, a ladder, flashlight, and fish tape which allows you to pull the wire through long thin openings. Some hints on working with cable; leave some slack in the wire, try to avoid items that might cause electrical interference. If the cable is on the floor protect it. Label both ends of all wire, and wire tie cables together when a bunch of them come to a common point.

As mentioned earlier the computer will need a NIC. These can be installed fairly simply by opening up the computer and placing it in the correct location. The difficulty comes in configuring the NIC to work in the computer. Configuring usually requires you to set switches called DIP switches or moving a jumper block. DIP switches are fairly small and can be set using a small straight piece of metal like a bent paper clip. To set a jumper block you move a plug from one set of wires to another, again this is a fairly intricate process. If your cards do not have DIP switches or jumper blocks you may be lucky because it means your NIC's are configured with software. Also many NIC's are default configured right out of the factory and may work with out any additional configuring. This will still need to be checked individually (Lowe, 1996).

After the card is properly configured installing the card is fairly straight forward. Turn the computer off and unplug it, remove the cover, find an expansion slot not being used, remove the slot protector, insert the NIC, connect it with the screw you removed from the slot protector, put it all back together. As always be organized and record the NIC configuration in your well organized inventory/map binder.

For the most part the cable and the NIC's make up the hardware of the computer now comes installation of the software. Software installation is becoming more and more user friendly every day. All networking programs come with manuals that provide step by step instructions on how they are to be installed. Simply read the manual and do what it says.

Network software then needs to be installed at the work stations. A properly configured NIC should already installed . NetWare works under a protocol system called IPX or Internetwork Packet Exchange which manages the routing and flow of information on the network. This is called the network driver. The second part of the software system is the net work shell called NETx which

customizes the network to work with a particular version of DOS (Rains & Palmer 1994).

Remember this process is being updated and improved regularly, always follow the manual directions and keep the manuals handy in case things go bad later.

Ways to properly protect your server from nasty viruses, simple steps you need to do to make certain things keep running smoothly, and more, can be found in much greater detail in the manuals provided by NetWare.

Keep it Working.

Now that you have everything up and running don't begin to think that your job is finished, actually now is when it begins. A network is like a living breathing organism and is in constant need of attention and management.

One of the most important and often over looked aspects of keeping your network running smoothly is to train the users. Give your users some basic information of how the network works. The established security measures, the importance of security, and how it will be maintained. How the printing works and why they should not keep sending a document to be printed ten times merely because it didn't print the first time. That occasionally the network will be down, this will be announced to warn them in advance, if possible, but disasters do happen. The safe guards that should be taken to assure that your system is not infected by a virus, especially by your own users. If you want the users to use the network properly, they need to be educated on some important do's and don'ts. Please do not let this part slip through, education is the single most important aspect of getting the most out of the network. Be a good listener, some times the users may have a good idea (Lowe, 1996).

The need for organization skills previously mentioned is an aspect that can not be stressed enough. It is usually suggested to begin with a three ring binder

that will become the managers "bible" of the network. This binder should include a detailed constantly updated map of the network ,including what computer are on the network, there capabilities serial number, cost etc. (Lowe, 1996).

Regularly backing up the network, checking for viruses, and cleaning off files that are no longer used is also a job for the manager.

Another important role of the network manger will be deciding how much security the network will need. For instance setting up user IDs and passwords. Looking for ways to protect the networks resources, and ways to make the network more easy to use by assigning user groups (Lowe, 1996).

After the network is up and running one job the manger will need to do is regularly check to make sure it is and continues to run smoothly. The manger should regularly check for bottlenecks which are usually caused by the CPU in the file server, the memory of the server, or the NIC. This can usually be done with software that monitors the network (Lowe, 1996).

Plan for a disaster so that if all else is destroyed the network can quickly be restored. A rotation for regularly backing up the network should be in place.

When you buy the NOS you will receive some manuals, keep them in a place that they can be easily located. Also keep track of people and services you consult. Record how helpful the resource was and make notes if the resource should or should not be tried as a resource in the future. Subscribe to computer magazines and be on the look out for things that will fit to and improve your system (Lowe, 1996).

In summary properly train your users. Keep and organized library of all manuals. Keep a detail list of all those that you have and can call for help including notes of just how helpful they really are. It is always handy to have at least a few excuses ready just in case.

CHAPTER THREE:

Conclusion

Education is communication. If schools are going to provide the best possible education then schools need to be able to communicate in the best manner possible. Networks are currently one tool that can provide for that means of communication. Students of today live in a world where exchanging ideas and information is a way of life. To live effectively in that environment the skills to exchange those ideas and information should be taught. Networks can provide an efficient and effective way of exchanging those ideas and information. Although some will resist the change and the awkward beginnings of using a network, or anything new, the potential benefits will eventually be realized, far outweighing those initial apprehensions.

This research has provided a set of basic steps and information for setting up a network in a school setting. Networking is not a complicated concept but its implementation can be cumbersome. When a district looks at the potential benefits of sharing information, resources, and programs that networking can provide it will likely recognize a need to get involved with networking. As the paper has pointed out the key to making a smooth transition into the world of networking includes a well organized plan for implementing that change.

Details discussed included the following steps: assessing your needs, setting goals, getting organized, making your plan, installing the system, and managing the network once it is installed. Following these steps will make the transition of networking a school more effective. Everything you need to know about network installation is not what this paper is about. Networks, what they can do and how they work best, like all technology, are rapidly changing and improving so although the informational details on specific networks may change it

is the process that you go through in implementing the technology that ultimately determines its degree of success.

Schools are often criticized for being out of touch with the "real world" and networks can be a critical tool in reducing this problem. With the speed and range of connectivity networks can provide they have become an integral part of society and need to become an integral part of the schools preparing students for that society. Although setting up and installing a computer network is a time consuming and initially expensive endeavor, it is a step that schools must be willing to explore. By following the steps outlined in the paper the likelihood that a school system or district will successfully implement a network system that will meet its needs will be dramatically increased. A network system that will work for the present and allow for growth and expansion in the future and beyond should be a part of that goal.

Putting in a computer network is not a decision that should be taken lightly. It is a decision that each district should examine with the input of many people, people that have been previously mentioned. Each district must take inventory of where they currently are in terms of technology and education, and where they would like the district and its students to be in the future. Schools should not get technology just so they can say they have it. This is a mistake that many districts have made in the past. By carefully examining goals of the district the district will increase its chances of selecting a system that will best fit its individual needs and the needs of its students and teachers. When it comes time to purchase technology the district goals are often lost in the shuffle. If these goals remain the focus and the reason for implementing the technology addresses those goals the technology has a much greater chance of doing what it is intended to do, improve education.

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