Smart Valley Schools Project
Technical Guidebook for Schools

January 30, 1996

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Preface

From the Smart Valley Board of Directors

December 10, 1995

Dear Reader:

Nowhere is the gap between classroom teaching and workplace requirements more pronounced than in Silicon Valley. For this reason, Smart Valley, Inc. launched the Smart Schools Project in February of 1994, to accelerate the integration of the Internet and information technologies into education in Silicon Valley schools.

We quickly realized that schools were in need of unbiased, technically sound information about networking capabilities and strategies. Silicon Valley's high-tech industry has the technical expertise and experience our educational institutions need to make the transition into the information age. Acting as a neutral broker of information, Smart Valley pooled the knowledge of over 50 individuals from 25 high-tech companies to develop technical guidelines for schools. This guidebook seeks to make that information available to schools in Silicon Valley and beyond.

A primary concern of the guidebook was to offer educators practical networking strategies that would allow schools to support increasing numbers of users and add new capabilities over time, without expensive hardware replacement. Industry has learned that spending a little more time in careful planning, and investing a little more money up front on equipment purchases, can save thousands of dollars over time in operating expenses and upgrades. The information in this guide is designed to help the educational community make decisions that will allow them to get the most out of their networks now and into the 21st century.

We welcome your comments on the Smart Valley Technical Guidebook for Schools, and we wish you success in your network planning and implementation.

Sincerely,

John Young

Chair, Smart Valley, Inc.

Eric Benhamou

Chair, Smart Valley Technical Committee

Acknowledgments

Considerable time and effort were spent identifying, studying, and addressing the needs and concerns of the people responsible for implementing networking solutions in schools. Smart Valley wishes to thank those involved in this project for their efforts and results.

PART I About school networks

Chapter 1 — Using the Guidebook

The decisions you make about the network you want in your school, between campuses, within the district, or between districts are part of one process. Just as the network will connect a variety of locations and equipment types, your networking plan should intertwine the needs and expectations of all participants with the capabilities of the technology — resulting in a well thought-out, well-designed program. This must include an emphasis on both your curriculum goals and your future needs, to allow the network to grow alongside advances or changes in technology, educational aims, and program size.

This guide is designed to help you:

- **Decide how your school will use the computer network. (Chapter 2)**

  The network design process begins with identifying what it is you want to do with your network, and deciding how to best implement technology to achieve your curriculum goals. Examining the desired educational use for the network will help you avoid either buying equipment that will not support more complex networked assignments, or buying unnecessarily advanced equipment that is not appropriate for more basic curriculum goals. Chapter 2 examines the different capabilities you may want to provide over your school's network:

  — Internet Access (for example, research, World Wide Web investigation)

  — Multimedia (for example, lesson generation, student projects)

  — Video conferencing (for example, distance learning, guest lectures)

  — Remote access (for example, home dial-in access to e-mail, the Internet)

- **Decide which computer network options fit your school's needs. (Chapter 3)**

  Depending on the type of activities you plan to support, your school will utilize different network variations. Chapter 3 provides network design guidelines and explains the differences between the available types of networks. LAN and WAN service options are provided, as well as a discussion of the functions and limitations of various types of cabling you will need to connect your network. Additionally, sample network implementations are provided, to give you an idea of the kinds of equipment needs each network type entails. This chapter will enable you to draw up general requirements of your network, before you make final network design decisions with a vendor, consultant, or contractor. It includes:

  — Local-area networks (LAN)

  - Baseband and broadband networks

  — Wide-area networks (WAN)

  — Internet-capable networks

— Multimedia-capable networks

— Video conferencing-capable networks

— Remote access-capable networks

- **Create your networking plan. (Chapter 4)**

  As a conclusion to the Guidebook's networking discussions, Chapter 4 offers network planning suggestions. Equipment choices are only the tip of the networking iceberg. Chapter 4 deals with the many hidden items that can ensure smooth network design and implementation, or unnecessarily stall your technology project. This chapter offers you guidlines for the following elements of your technology plan:

  — New equipment and operating budgets

  — On-going technical support

  — Security measures

  — Facilities electrical assessment

  — Physical plant evaluation

The industry guidelines and suggestions in this document represent the minimum equipment specifications for typical school network capabilities. Because schools vary in size and use of technology, the guidelines and suggestions are designed to offer schools maximum flexibility for adding users and capabilities.

NOTE: This document does not evaluate or compare systems and equipment from competing vendors and manufacturers. For example, decisions about whether to purchase an Apple Macintosh, IBM PC, or a computer system by other vendors are left to the schools.

Who is the Guidebook for?

The Smart Valley Technical Guidebook for Schools is a resource for educators who are looking for a general understanding of networking technologies and are planning to set up a new network within their school or school system. It provides guidance about which technological approaches allow for a network that will be flexible and easily enhanced in the future, and will also be able to work with many different technologies and systems. It supplements the *California Department of Education K–12 Network Technology Planning Guide*, written by the California Department of Education.

The *California Department of Education K–12 Network Technology Planning Guide* sets statewide networking standards and discusses general network implementation, including:

- Background information about networking and the Internet
- General information about network servers, support, and security
- Training plans and resources
- A glossary, including definitions of Internet and networking terms

The material set out in the *Technical Guidebook for Schools* will complement that knowledge by helping you:

- Identify the activity options that fit your needs (Internet access, access to the World Wide Web (The Web), multimedia / production, video conferencing, and remote access).
- Choose the network design an equipment that supports your desired capabilities.
- Design a migration path that requires a minimum of design changes as you expand your network and add further users and capabilities.
- Create a networking plan including on-going technical support, security and budgeting measures, to ensure the success of your network

Chapter 2 — What you can do with a computer network

Computers used as stand-alone devices are limited in resources — bound by the hard disk space and memory available. Networks, however, can provide shared resources, in addition to remote computer maintenance and diagnostic capabilities.

A network transforms stand-alone computers from productivity devices used for a single purpose, such as word processing, into information communication points accessible to a number of users inside and outside the school. Networked computers become an interdisciplinary device allowing students to utilize more than one information source in their study and class preparation.

Basic Network Capabilities	
Application category	**Potential uses**
General	• E-mail • Information access (Internet, Web access, Gopher) • Computerized instruction • Computerized testing • Interactive communication • Shared resources - application software, CD-ROM tower, printers, scanners, faxes, additional storage locations

As an educational tool, networks change the focus of the teacher's role from one of an information provider to that of a skill provider — helping students acquire the skills they need to find information, evaluate its content for relevancy to their assignments, and complete assignments using processes that prepare them well for the world beyond the classroom.

The majority of the capabilities discussed in this guidebook require a communication network. This network can be as simple as connecting several computers within a single classroom to provide e-mail and Internet access. The network grows more complex as you provide service to more than one classroom; communication between schools, district offices, and information providers. This chapter details the activities that can be performed over specific network types, to give you a general idea of the type of network you require.

There are two basic types of networks, Local-Area Networks (LANs) and Wide-Area Networks (WANs).

- A LAN can be described as a network configuration that provides connectivity between computerized workstations within a localized area. The workstations connected could be located in a single room, multiple rooms in a single building, or within several buildings in close proximity. In a simple configuration, one LAN can connect a school.

There are size (the number of workstations), network resource (servers, printers, etc.) and distance (the length of the cable) limitations to LAN technology.

- A WAN is a network configuration that provides connectivity between separate LANs or computerized workstations over longer distances. Multiple schools in a district, or several districts may be connected over a WAN. In complex cases, a WAN can connect several floors within a large building or several buildings on a large campus.

This chapter will describe the potential uses of both LANs and WANs, and will also detail the capabilities offered by systems that support Internet access, multimedia, video conferencing and remote access (off-site access to your network) applications.

LAN uses

Basic

LANs enable you to tap into a variety of network benefits, the most fundamental of which is the ability to share resources. This can include network-wide access to software and hardware, shared files used by multiple parties (for example, students teamed on a class project accessing their report from different computers at different times), and centralized locations where information is stored (for example, a central grading database that can be updated by teachers from their desktop workstations).

LANs provide the ability to connect different kinds of workstations — for example, Apple Macintosh or IBM-compatible computers — and allow them to communicate with one another. LANs can also link these workstations to network server software so that files can be stored and shared. Hardware resources such as scanners, CD-ROM drives, printers, multimedia laboratories, video centers, and modem pools can also be attached to the LAN and shared.

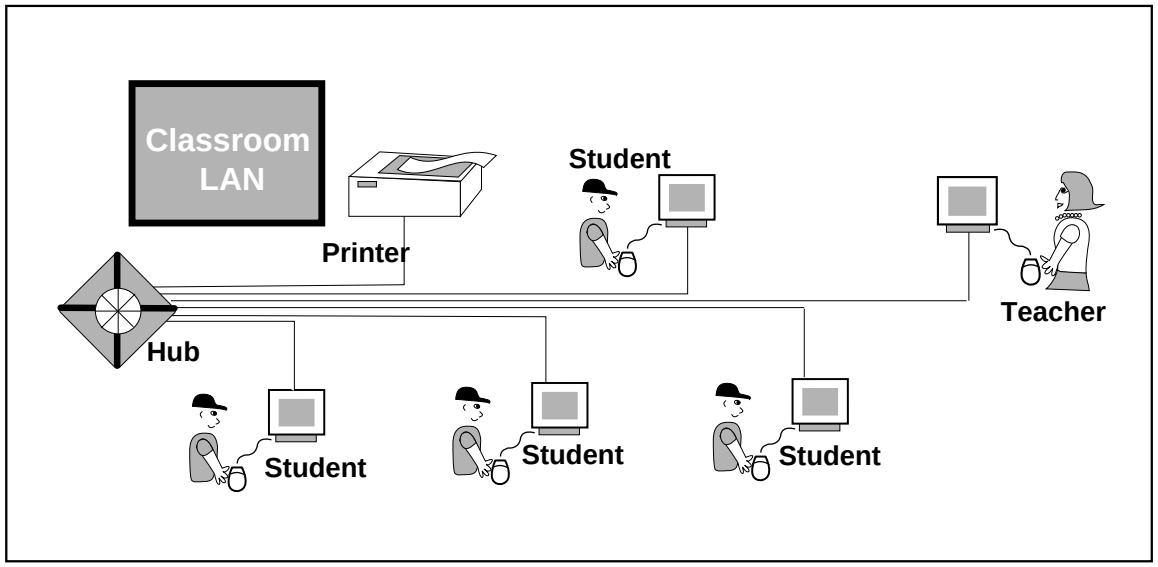
A network set-up is particularly beneficial for a scenarios involving multimedia tools, so all workstations connected to the network (i.e. systems located physically apart in a classroom, lab, and library) can share expensive equipment (for example, a color printer for multimedia production). Therefore a network allows a school or district to effectively manage the benefits provided by technology and to have a greater reach than is possible in each specific physical location.

LANs enable you to enhance the educational environment with the following basic activities:

Basic LAN capabilities	
Application category	**Potential uses**
District/School	• Inter-administrator communications • Access to school record databases • Access to other administrative and informational databases, including accounting, county, and city records as necessary • Back-up emergency notification or district-wide announcements
Teacher	• Electronic attendance • Electronic grade submission • Access to networked instructional resources (hardware and software) • Campus server access to class agenda, class assignments, and shared information (accessible from home or on campus) • Inter-school and inter-district communication for general notification, curriculum enhancement, brainstorming, etc.
Student	• Assignment sharing • Access to server-based class agenda • Access to assignment listings • Access to teacher selected information (accessible from home or on campus)

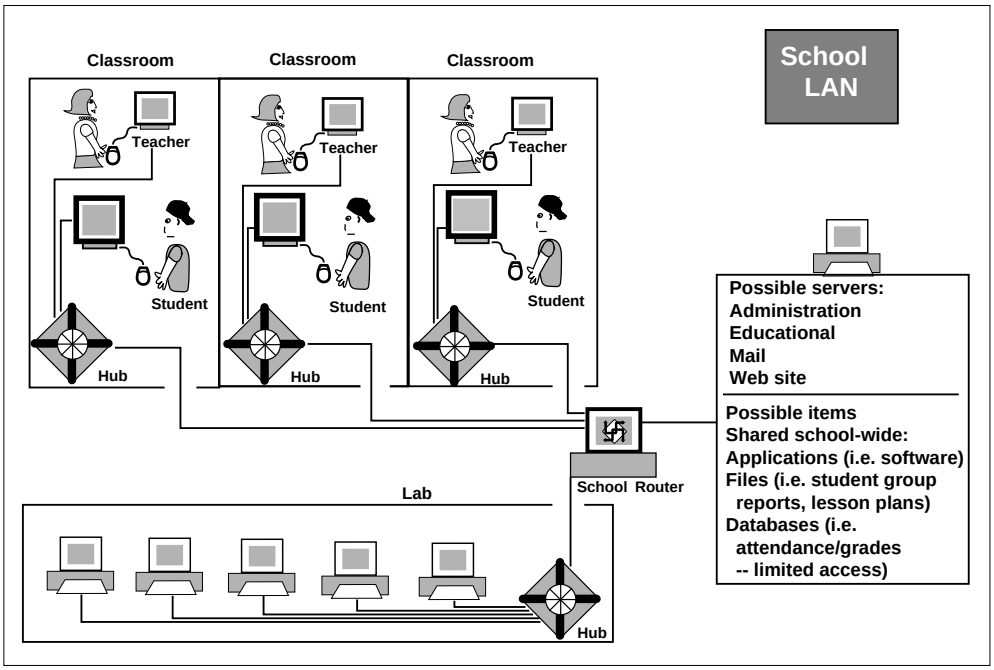
As evidenced by the preceding examples, LANs can also go beyond bringing equipment and technology resources to the many workstations connected to your network — but can similarly bring members of your educational community together, joining at the electronic school network. Through basic applications like e-mail, communication channels are broadened. Through file sharing, students in different physical locations can work together, practicing skills that are necessary in the workplace today.

How do these LAN uses fit into a network plan for your school? A simple configuration might be a computer lab facility in an elementary school connected to the classrooms, guidance, administrative, and office computers by a file server. Resources, such as shared printers for the school office and perhaps in the computer lab, may also be provided through connection to a print server (which can be simply a workstation running print-server software). It is up to you to decide which uses you want to include in the educational environment of your school or district, and to construct your network with your goals and needs in mind.



Advanced

A simple LAN configuration can be expanded (i.e. with a fiber-optic cable connection) to join different sites in a district that are in close proximity — containing an elementary school, a middle school (junior high), and a high school. These participants in an extended school environment can communicate, collaborate on projects, view classes, and share resources (e.g. a CD-ROM database) that would otherwise be limited to use in one library at one school.



An example of advanced LAN usage might be student or teacher-created educational multimedia projects residing in a central media center, that are accessible to students participating in a tutoring program.

Advanced LAN activities that can improve your curriculum include:

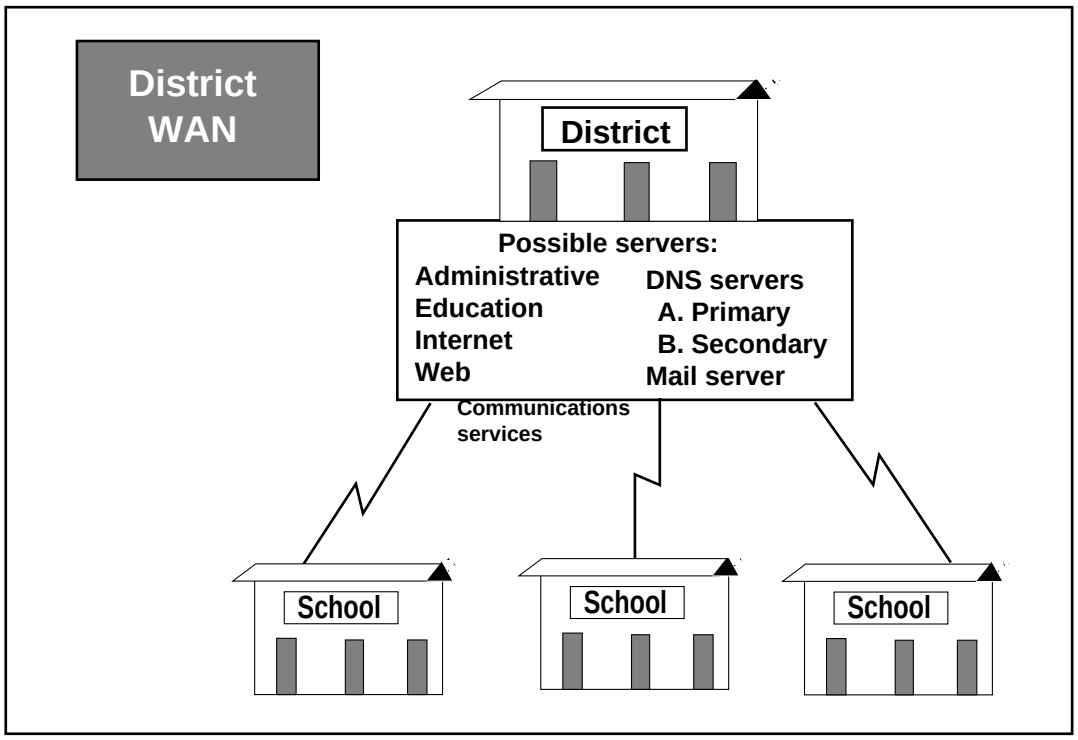
Advanced LAN capabilities	
Application category	**Potential uses**
Teacher	• Lesson creation - teachers create course materials utilizing multimedia tools. Course work can be customized to meet the needs of specific levels of student capabilities and subject orientation. Different levels of instruction can be provided to allow students to progress at an individual pace • Audio/video recording sessions • Lectures presented to multiple classrooms or multiple desktops via video conferencing • Lectures presented to individuals at home (or in another private setting) via video conferencing • Collaboration involving two groups or many groups via video conferencing • Cable TV and satellite program access
Student	• Access to taped lectures, presentations, lab experiments, and public-access stations through TV and satellite networks • Instruction in multimedia production • Student-centered teaching - students create lesson plans and instructional materials • Interactive individualized learning • Access to an extended library utilizing CD-ROM-based information • Student team projects — student groups develop reports involving graphics, sounds, illustrations, and potentially Quick Time video

WAN uses

WANs can connect different kinds of workstations and server-based resources just like a LAN — but a WAN expands the scope of your network to information resources located outside your school. Simply put, a WAN takes the physical borders of your school and expands them to include home-based students, students and teachers at other schools, individuals outside the classroom environment, and outside resources. At the same time, it allows others to access those resources you want to share.

Basic

How do WAN uses fit into a network plan for your school? Students, teachers, and administrators can travel within the Internet's virtual world, communicating and interacting with each other without leaving their desks. Using WAN technology, students can have access to a richer learning environment that includes worldwide resources.



In an instructional setting, WANs can be used for all of the items listed for LANs, in addition to the following:

Basic WAN capabilities	
Application category	**Potential uses (includes all LAN uses, as well as the following)**
General	• Worldwide e-mail • Direct Internet access and research • Use of World Wide Web resources • Use of Archie, Gopher, Jughead, Veronica and other information resources for student and teacher research • Transfers of information using FTP file transfers (to obtain large documents or software from other locations) • Network-based collaboration between district, school, classroom, and industry participants • Parent-teacher interaction on homework assignments, help sessions, parent-teacher conferences, school announcements, and PTA meetings • Remote access • Access to teaching bulletin board systems (BBSs), College and University BBSs

Advanced

By providing access to individuals and resources outside the school or district, WANs provide an almost infinite expansion of tools and resources available for use.

Advanced WAN capabilities	
Application category	**Potential uses (includes all LAN uses, as well as the following)**
General	• Interaction with local, state, and national government for educational purposes • Distance learning, remote instructional sessions • Community enrichment — Web page creation to inform community of school activities and programs. Create home page locations allowing access to learning units and tutorials for the entire community, enriching parents and students, and inviting widespread participation. • Provide worldwide access to an on-line school newspaper, teacher profiles, school events, and facility hours. • Video conferencing and distance learning (video, text, audio), featuring both passive (one-way, teacher-to-students) and interactive (two-way) communications. • Collaborative work and support — sharing of documents/files for team projects in real-time over the network.

Internet capabilities

The most highly touted benefit of a WAN is that it can connect your school or district LAN to the Internet. With the Internet and the World Wide Web, instead of merely connecting to your school's library, you can connect to libraries worldwide. While a LAN lets you access software shared among your school's workstations, the Internet allows you to sample software developed around the world.

Via the Internet, your WAN can let you communicate with professionals, scholars, teachers, and students who would not normally be accessible from your fixed school location. Worldwide e-mail allows individuals on your network to talk with individuals not physically located in the school environment.

The Internet and its capabilities are explored in studies on TV, in professional talks, in magazine articles, and over the Internet itself. The Internet as a learning tool warrants a volume all to itself (much like the intricacies of computer-based teaching and multimedia development) and will only be summarized in this Guidebook to provide a basic understanding.

Multimedia capabilities

Multimedia elements highlight the potential of computer-based learning by expanding the two-dimensional text-based world of traditional textbooks and written information to include a more compelling mix of media. The term multimedia is used to describe any program, workstation, network, and activity that supports the use of sounds, graphics, and video.

Multimedia systems allow students to go from a spectator role to one where they can choose the material they view, the sounds they hear, the movies that play on their computer screen, and therefore the educational content that is presented to them. From there, students and teachers can even move into the authoring role with more advanced systems, creating their own programs and projects using sound, graphic, and video tools. Networked multimedia systems create opportunities for team projects, collaboration, and the widespread and more cost-effective use of technology.

With hypermedia software tools and learning system software, computer-aided education can be tailored to suit a particular student, a group of students' needs, or specific teacher goals. Teachers can guide and customize a student's learning path. Varying levels of instruction can be defined, allowing students to move to more advanced levels as they progress.

Basic

At the most basic level, multimedia systems can consist of a computer equipped with a CD-ROM drive, running encyclopedia-type CD-ROM offerings enhanced by graphic images, sounds, and video clips. Examples of the elements that can be used to make up your multimedia system are provided below, and will vary depending on the level of complexity of your needs and your planning constraints (some of the items presented refer to the use of networks, to be discussed later).

- Multimedia data

  Any text, audio, or visual image that can be stored, manipulated, and retrieved by a multimedia system. Traditional magnetic storage devices, such as high-density floppy disks and large capacity hard drives, are used for text and graphics. Audio, animation, and motion images are usually stored on laser videodisks or CDs.

- Multimedia software

  Uses one or more multimedia elements (other than regular text). It comes in many forms, from complete packages that provide tutorials, learning systems, and reference materials, to tools that facilitate the creation of presentations, learning units and Web pages. This book does not provide guidelines for multimedia software. However, there are many technical papers and discussions of this subject on the Internet.

- Multimedia equipment

  One or more of the following: a CD-ROM player, a videodisc player, a microphone, a voice synthesizer, an audio digitizer, a digital or analog video camera, a color printer, a digital scanner all connected to a workstation.

- Multimedia communication systems

  LAN and WAN networks that facilitate the storage or retrieval of multimedia information on a single workstation, multiple workstations within the classroom, multiple workstations in remote classrooms, or servers located in other schools.

Advanced

Advanced WAN applications allow schools to provide all the benefits of multimedia-enhanced learning previously mentioned, with the additional capabilities provided by wider access to tools and project participants. Multimedia offerings designed in your school can include presentations on a networked computer via video conferencing applications, utilizing technologies and tools drawn from anywhere your WAN has access. The World Wide Web and the Internet provide a wealth of software tools, research content, and multimedia applications which can be incorporated in classroom activities through the WAN.

Advanced activities including the benefits of graphics, sound, and video to complement traditional text include:

- Student-centered teaching

  Rather than the teacher being the provider of information, this new learning technique gives the student the opportunity to create presentations, learning units, or tutorials that are then viewed by other students for critique and comment. This new student-centered way of learning provides more than just a new and dynamic way for students to explore and learn a new topic.

  With the student selecting the information, collecting the information from a variety of reference sources, and preparing the presentation, a student can learn more about a particular subject while acquiring highly marketable decision-making, research, and technical skills. Presentations can include different multimedia elements — graphics video, and sound — created using different technologies, such as laser disks, CD-ROM images, camcorders, and digital cameras. Several successful examples of student-based teaching are available on the Web.

- Student team projects

  Similar to student-centered teaching, this technique focuses on a group of students who become the providers of information, creating a presentation as a class project and presenting the project to other groups of students for comment and critique. For example, project teams in a science class can be set up to create presentations about each system in the human body. This approach promotes student-centered learning and builds team skills.

- Lesson creation

  Multimedia software can be used to create learning units and tutorials, allowing teachers to focus on particular areas of instruction not covered in text books or traditional lesson plans. Teachers can also enhance their instruction with visual and audio elements to more fully engage students.

  Teachers can revise curricula to match their students' needs in selected areas and to reuse information from one term to the next.

Multimedia projects executed over a WAN allow:

- students to employ a wider range of media and technology tools

- teams to include heterogeneous participants from different classrooms, age levels, and cultural groups
- projects to mimic workplace demands, based on the need for problem solving, critical thinking, collaboration, planning, revision, and reflection from team members in distant locations.

Collaboration and team-building skills are stressed in this environment, as participants contribute to group projects from their desktops — storing or presenting graphics, ideas, or other pieces of information on the topic at hand on the network. The incorporation of sounds, graphics, and animation, as well as the resources of the Internet and the wide-area network motivate students to perform more thorough research, to think more deeply about their audience to select the appropriate research findings, and to more actively question and critique others' contributions.

By learning through participation, students generate writing, comprehension, and critical thinking skills. Additionally, distance and team challenges create opportunities for students to strengthen their ability to successfully convey thoughts, making their ideas more clear and concise.

Video conferencing capabilities

The connection of technology participants in different physical locations also introduces the need for real-time, visual links between parties. Video conferencing spans the spatial differences of network participants, allowing users to see what their partners and teachers are doing in another room, lab, library, or building.

In a traditional video conferencing set-up for educational purposes, a monitor is located at the front of the classroom, along with a camera and a video "codec" that allows analog video signals to be digitized and transmitted over the phone lines. A monitor shows the image from the remote location. Some configurations also have a second monitor that shows the local room — allowing participants to see what is being transmitted to the other location. In the past, video conferencing was limited by the cost and size of the equipment required to transmit visual images.

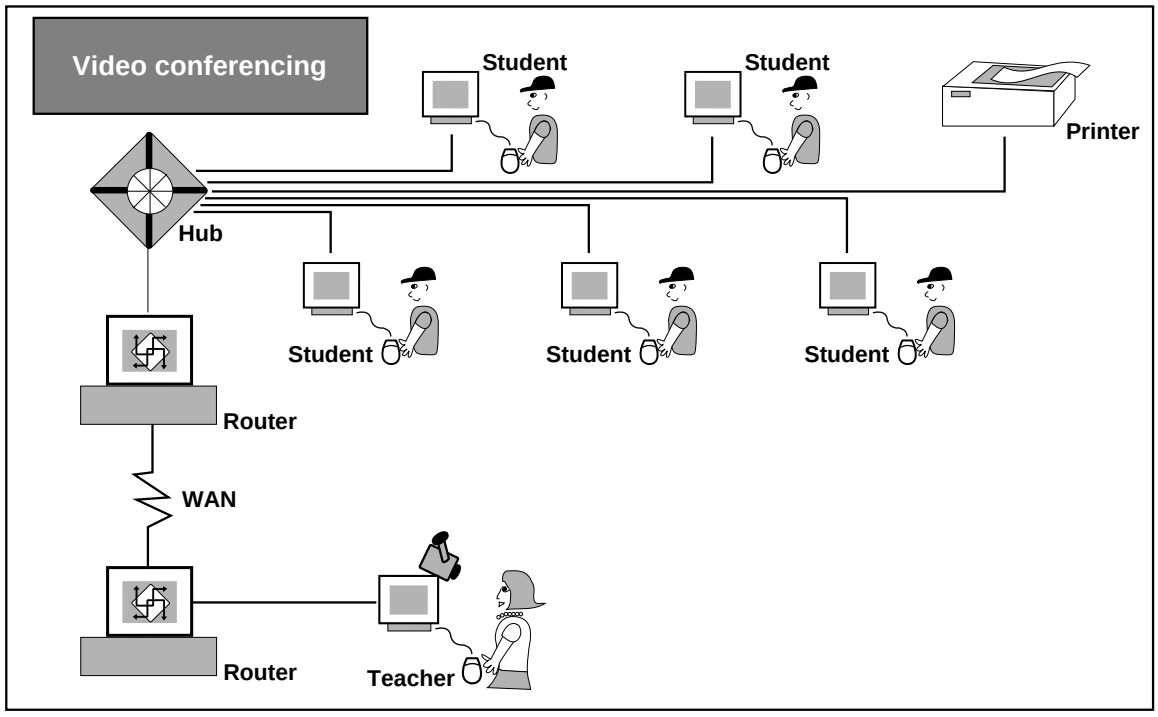
With technology developments lowering the size and cost of video conferencing equipment, it is possible today to send a video image to a student's desktop. Desktop conferencing systems located at the workstation are similar to traditional video conferencing, but with the camera and codec equipment connected to an individual workstation.

Basic

Many desktop conferencing systems focus on collaborative computing tools that allow a student to share applications with remote users. Video conferencing allows human resources to be shared effectively and efficiently, an important point when it comes time to consider the yearly budget.

Video conferencing is especially applicable for distance learning applications. Early distance learning systems relied mainly on audio to communicate between sites. Video conferencing eliminates limitations of a purely audio approach:

- Maintaining students' attention by supplementing audio communication with other methods.
- Providing ease in communicating information. The visual component allows information to be conveyed in multiple ways, as opposed to only explained with words.
- Ability to convey important visual cues, such as raising a hand to ask a question, thereby making student participation easier.



Basic video conferencing capabilities	
Application category	**Potential uses**
Passive distance learning	• Home participation by sick or disabled students • Access to quality instruction by students in remote locations • Project collaboration • Virtual tours and field trips • Teacher and staff training • Special events programming and enrichment programs • Public service workshops • Guest lectures from individuals in off-campus locations, eliminating travel and lodging expenses • Cultural arts presentations • Extended curriculum in subjects like foreign languages, computer instruction, and other offerings that might not be available at a particular school

Advanced

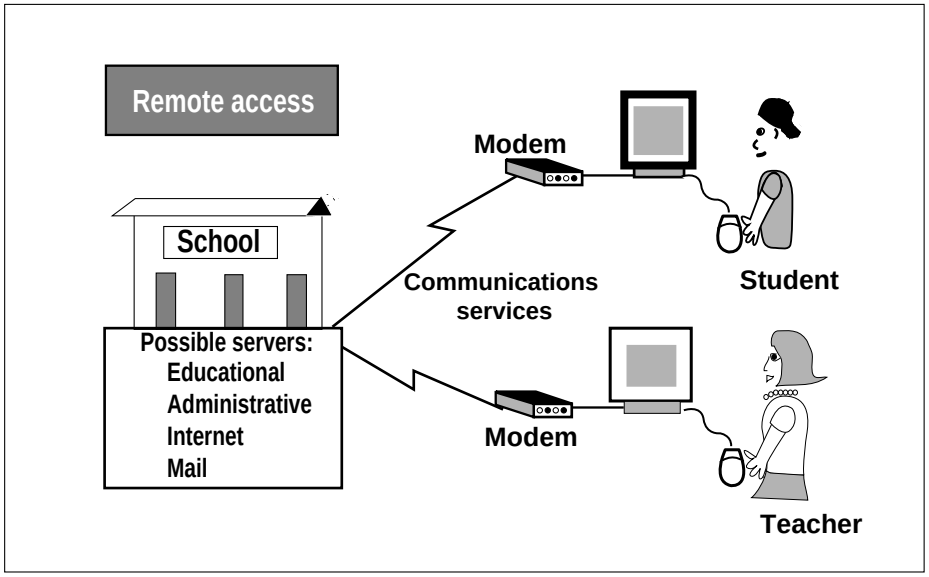
Schools have found new and creative ways to share information by use of video conferencing technology. Benefits of video teleconferencing include improved communications between students, teachers, parents, and the community, as well as lower student absentee rates and consequently higher test scores. Technology today can bring these benefits to the desktop, the classroom, an auditorium or the town hall.

Video conferencing over WANs provides real-time, visual contact with an extended group of users connected to your wide-area network. Specifically, video conferencing enables schools to provide distance learning to students and teachers who would not otherwise be incorporated in the school environment.

Advanced video conferencing capabilities	
Application category	**Potential uses**
Interactive distance learning	• All uses included under passive distance learning • Interactive access to classrooms from off-campus locations. Students can ask questions and respond to teacher questions on-line. Similarly, teachers in off-campus locations can instruct student classrooms on different campuses, fielding questions on-line. • Specialized instruction, including virtual student help sessions and instruction in native languages for ESL students • Project collaboration • Interaction between students from differing social, geographical, economic, and cultural backgrounds • Personalized contact with scientists and other experts • Seminars and interactive lectures by remote experts such as scientists, historians, or politicians for improved subject coverage

Remote access capabilities

For students who cannot easily leave home or who need extra tutorial assistance in their studies, remotely connecting to a campus or resource center designed specifically to meet their needs can be crucial. Parents who need to follow student progress or want to regularly communicate with school administrators and teachers can use the network. Remote connections — allowing off-campus / off-site users to access school networks via the Internet or a modem — broaden the geographical reach of the educational environment, incorporating off-campus locations in a larger, virtual school, made possible through the network.



Through remote access connections, users can execute the following activities from off-site locations:

- Obtain assignments from teachers at school.
- Exchange e-mail for progress reports, questions about assignments, and for delivery of finished assignments.
- Access on-line databases and news groups on the Internet to research information on specific subjects.
- Engage in passive distance learning
- Conduct a class (a single teacher or several teachers) from an off-campus location.

Remote access allows teachers, administrators, and students to perform school-related work from any location, as long as access to a computer, a modem, and a telephone-line, interactive cable, or other high-speed connection to the school network is available.

Chapter 3 — How to choose the right computer network

Once you have figured out what you want to do with your network, you can examine the different technology options available to achieve your goals. This chapter describes various LAN and WAN options, sets out suggested guideline criteria for your network, and provides basic equipment suggestions for the actual implementation of your network, focused on access to the Internet and the World Wide Web.

The following types of networks or applications are presented:

- LANs
    - — Baseband networks
    - — Broadband networks
- WANs
- General school Internet networks (broadband and baseband)
- Video-conferencing networks
- Multimedia networks
- Video-conferencing networks
- Remote Access networks

Different levels of implementation are offered to provide you with the necessary information you need to achieve different networking and curriculum goals.

Note: Baseband and broadband networks are discussed here under the LAN heading. WAN options for baseband and broadband capabilities are often determined by the capabilities offered by schools' local access service provider (telephone companies, cable TV companies).

LANs

Local-area networks connect on-campus workstations and can be constructed in a variety of designs, with different cabling options, and with different levels of potential uses. LAN choices also include connection to the Internet, the World Wide Web, and to WANs.

This guidebook suggests the following LAN infrastructure options:

- Start with a baseband Ethernet network with a star topology
- Category 5 (copper) cable to classrooms and workstations. Pull three four-pair Category 5 wires to each classroom, terminated on RJ-45 jacks.
- RG-6 75-ohm coaxial cable for broadband to classrooms. Pull two for current use (one for incoming video and two-way data; one for outgoing video), terminated on F connectors.
- Multimode (fiber-optic) cable -- Pull one six-strand cable terminated, and one six-strand cable unterminated for network backbone and to any current or anticipated computer labs.
- Singlemode (fiber-optic) cable -- Pull two six-strand cables unterminated for backbone (from main to intermediate distribution frames) and to any present or anticipated computer labs.

All LAN options presented in this section are geared toward robust access to the Internet and World Wide Web. This section covers the following LAN infrastructure issues:

- Quantity — How many cables to install.
- Type — What kind of network capabilities to implement (baseband or broadband).
- Cabling options — What kinds of cable to install.
- Toplogy — Which network topologies to use.

LAN cabling quantity

The suggested minimum for network cabling is based on the computing technologies used, or likely to be used, in schools and the network requirements for those technologies. Although not every type of suggested cable can be used at the same time, it is generally less expensive to install the full complement of cables initially than to install additional cables later.

Two main reasons justify this approach:

- It is less expensive to purchase extra cable and install two or three additional cables during the initial installation than it is to install additional cables later.
- Cable installation through conduit is usually only possible the first time. Subsequent attempts to install additional cable through the same conduit are often difficult or unsuccessful.

LAN type (baseband vs. broadband)

Within a network, you may utilize one or both of the following network technologies, depending on your requirements.

- Baseband digital networks — all communications are in digital form and share the use of a single cable. One signal is transmitted over the cable at a time.
- Broadband networks — signals may be either analog signals — such as those used in broadcast television — or digital signals. Multiple signals can use the same wire simultaneously.
- Wireless networks — radio signals are transmitted via transceivers that communicate by infrared light, microwaves, or the spread spectrum and replace the need for physical cable.

  NOTE: Currently, wireless wide-area networks are still in development and have only been deployed in certain geographic locations. Today's wireless technology also has significant bandwidth limitations which may make it inappropriate for school use. For more information about wireless technologies, contact your local wireless provider.

The network type you use depends on the requirements of your class curriculum and the capabilities you need to support that curriculum. The following table illustrates the uses for baseband and broadband networks.

Type of network	Use	Benefits	Drawbacks
Baseband	Network (typically Ethernet) connecting computers and other network equipment (printers, scanners, faxes). Transmit data, computer, sound, picture, and video files.	Equipment has been standardized, based on widespread use. All data is transported in a common digital format.	Less bandwidth than broadband.
Broadband	Network connecting computers and other network equipment. Distribution tool for transporting information-intensive signals that require greater bandwidth. Transmit large data, computer, sound, picture, and full-motion video files. Maintain electronic libraries with video, pictures, audio, and text for school-wide access.	Greater bandwidth. Allows for full interactivity.	Relatively new technology is not standardized, allowing for potential equipment compatibility problems. Much greater LAN cost in comparison to baseband.

Some capabilities are easier to provide over baseband networks and some over broadband networks. The final choice depends on the specific application for which the network is being designed. For example, transmitting high quality video is most effective over a broadband network.

For baseband networks, the following technologies are suggested:

Suggested LAN technology

Network Technologies:

Ethernet **10baseX**	• 10 Mbps bandwidth • Suggested for all new installations. • Suggested for basic Internet usage
Fast Ethernet **100baseT or VG**	• 100 Mbps bandwidth • Suggested if users will be sharing software on server(s), accessing CD Towers, etc. • Effective bandwidth limited by WAN service speed for Internet use.

In this document, LAN guidelines and configurations are based on Ethernet use. Ethernet is a baseband network cabling and signaling specification. Although other LAN protocols may be available, Smart Valley suggests IEEE 802.3 standard Ethernet as your school's LAN protocol because of its almost universal acceptance among hardware vendors and the relatively low cost of supporting hardware and software.

Ethernet signaling and cabling specifications follow this format:

<signaling speed><type of network><type of cable>

Different types of Ethernet include:

- 10BASE-T —10 Mbps Ethernet running over unshielded twisted-pair (UTP) copper cabling
- 10BASE-F —10 Mbps Ethernet running over fiber-optic cabling
- 10BASE2 —10 Mbps Ethernet running over thin, 50-ohm baseband coaxial cable (10BASE2 is commonly referred to as thin Ethernet or Thinnet)
- 10BASE5 —10 Mbps Ethernet running over standard (thick) 50 ohm baseband coaxial cabling (10BASE5 is also called Thicknet)

LAN cabling options

LAN performance is directly effected by the type of cabling you choose. "Bandwidth" is a term that frequently goes hand in hand with talk about Internet and Web access, because many of the new, exciting applications developed for networks require powerful LANs and WANs with lots of "bandwidth." One of the greatest determiners of your networks' bandwidth is the type of cabling you use: twisted-pair (copper), coaxial cable (coax), or fiber-optic cable (fiber).

The following tables demonstrate the basic differences between different kinds of copper and fiber cabling:

Unshielded twisted pair (copper) cables		
Type of cabling	Benefits	Drawbacks
Twisted Pair Category 5 (CAT 5)	• Less expensive than fiber-optic cable. • More desirable than other copper alternatives for high-speed networks. • Signal attenuates less quickly than CAT 3 (another copper option). • Less crosstalk than CAT 3 (another copper option). • Requires less wire than other copper options to run Fast Ethernet.	• Maximum cable run distances much shorter than fiber.

Fiber-optic cables		
Issue	Singlemode fiber	Multimode fiber
Network uses	• Higher performance • Longer distance • More expensive • Mostly WAN usage (can provide direct connection to workstations for high-performance applications)	• Mostly LAN, campus usage • Limited to 1 to 2 km in length
Bandwidth vs. Distance	• Higher bandwidth per distance	• Cannot transmit similarly high bandwidths over a given distance
Termination costs	• Four to five times more expensive (this is expected to change with future technology advances)	• Less expensive termination
Associated equipment costs	• Equipment for use with singlemode fiber is more expensive (this is expected to change with future technology advances)	• Less expensive equipment
Cable costs	• Varies, based on inside or outside use • Less expensive than multimode fiber for outdoor use	• Depends, based on inside and outside uses • Equivalent to singlemode for indoor use
Industry trends	• Will increase in use over the long term	• Will decrease in use over the long term

Note: You can also investigate coaxial cable as another higher-bandwidth LAN cabling option, but be aware that coax has a different set of requirements and specifications. Contact your local cable system operator for more information on coax cabling and potential designs. Coaxial cable (two types include Thinnet and Thicknet) is a less typical LAN cabling option for the delivery of analog video and, in the future, data. Thinnet can be used in very small Ethernet networks. Thicknet is a physically large, outdated technology which requires more expensive connectors than other Ethernet networks.

Singlemode and multimode fiber differ in their associated hardware and capabilities. Installing both singlemode and multimode fiber whenever possible gives the most flexibility, is the most conservative choice, and is the suggested approach, even though it is more expensive.

Category-3 copper wiring is also available as a wiring option, but is not suggested because it offers deficient bandwidth capabilities for most of the activities discussed in this book.

The following table lays out the limitations and uses of different cabling options.

Suggested LAN cabling

LANS

Cable	Distance Limitations in Meters	802.3 Standard	Bandwidth	Guidelines for schools with no current infrastructure	Guidelines for schools with existing infrastructure
Unshielded Twisted Pair (UTP) Category 5	90 + 10	10baseT 100baseX	10 Mbps 100 Mbps	Use for hub to workstation and for backbone where distance permits. Implement 10baseT as standard. Implement 100baseX where need is indicated.	Use Cat 5 today to extend network where needed. Implement 100baseX today where need is indicated. If pulling wires to vicinity, pull three four-pair Category 5 unterminated to classrooms for future use.
Multi mode fiber optic cable 62.5/125 um	1000-2000	10baseF 100baseX	10 Mbps 100 Mbps	Use today for backbone where distance does not allow UTP Category 5. One six strand cable unterminated to classroom for future use as resources allow.	Use today for backbone if needed and distance dictates. One six strand cable unterminated to classroom for future use as resources allow, or use as backbone.
Single mode fiber optic fiber	very long distances	10baseF 100baseX	10 Mbps 100 Mbps	One six strand cable unterminated to classroom for future use as resources allow.	One six strand cable unterminated to classroom for future use as resources allow.
RG-6 75-ohm Coaxial				Pull 2 to each clasroom for future use as resources allow.	Pull 2 to each clasroom for future use as resources allow.

LAN topology

The physical relationship between nodes on a network is called the network topology. There are several ways to set up a local-area network (LAN) topology. This guidebook suggests the use of the star configuration for school environments.

A small network may need only a single segment of cabling to connect all its stations. Larger networks can be configured by connecting these segments to each other, through a central point, in a hierarchical star topology (also called an inverted tree). The star topology is a logical configuration as well as a physical configuration. When designing a network, this logical configuration must be maintained, but the physical location of the connected segments can be determined by the location of the stations to be serviced.

Star topology	
Description	**Use**
A star topology consists of a central control, usually a hub, that links all other devices to form the network. This central hub controls all switching and routing of network message traffic. Devices communicate with each other by going through the hub. The star-wiring scheme uses relatively inexpensive and flexible twisted-pair copper wires connected to media access units (MAU).	The star topology allows different "legs" of the star to connect those areas of the school that are ready to be networked. New "legs" can be pulled from the central hub and router, to grow with the expanding needs of your network. This topology can be used to connect student workstations to an instructor's workstation in a class or laboratory situation. Ethernet can be used to configure star topologies.

Additional LAN topologies — the point-to-point connection, the bus, and the ring — are not suggested by this Guidebook for use in schools, due to flexibility and scalability issues.

WANs

The wide-area network or WAN is a broadcast network interconnecting a group of LANs. The LANs can be in the same geographical area or in geographically distant areas like separate campuses. WANs are connected by communications services, complemented by physical equipment such as bridges and routers, which provide the physical connections between separate LANs — to allow the individual networks to function as a large virtual network.

WANs use many technologies, but typically can be characterized by point-to-point and the less direct cloud technologies — cloud technology is so named because a connection between any two points appears transparent to the devices connected to the cloud. The cloud itself is really a complex network of switches and trunk lines which deliver the incoming messages to the correct destination.

WAN communications services

Choosing a WAN service is an important decision because this service will be one of your largest on-going network-related costs. There are three basic types of WAN services available in the San Francisco Bay Area:

- ISDN
- Frame relay
- Leased line services, such as T1
- ATM
- SMDS

These options involve different ways of delivering and charging for data services. When choosing a WAN service, consider the numbers of current and anticipated users, types of use (for example, how much bandwidth is required), and the location of your networked facilities in relation to your Internet Service Provider (ISP).

The following table provides suggested guidelines for WAN communication services — speeds, user numbers, and locations. A WAN speed of at least 384 Kbps is suggested for Internet and Web connections. Options that can provide this speed are dedicated T1, fractional T1, T1 frame relay, multiple BRI ISDN lines, or a PRI ISDN line. A 1.5 Mbps WAN service is suggested for those schools that can afford it. More bandwidth to accommodate incoming traffic may be required if your school hosts Web sites.

These guidelines are driven not only by cost-benefit issues, but by typical growth patterns of bandwidth needs. Keep in mind that lest-costly alternatives can be short-sighted, limiting potential for future curriculum advancement and incurring higher costs in the future when needs may dictate the installation of a new, higher-speed communications infrastructure.

Suggested WAN services

WANS

Technology	Bandwidth	Guideline typical	Implemented per school's requirements
Modem	28.8 Kbps step-down	Use for 1 user remote access from home to school network	Suggest that dial-up/remote access is only through centralized site, such as district office, COE, or ISP. Not suggested for Internet access.
ADN or X.25/PPS or Switched 56 Leased Lines	to 56 Kbps		Suggested only for schools that expect fewer than 5 simultaneous users accessing the Internet.
ISDN BRI (2 B+ D channel)	112 to 128 Kbps	Use at elementary, schools with a small number of users	Suggested for 5 to 10 simultaneous users accessing the Internet. Also incorporated into network as required by school's technology (example: video conferencing).
ISDN PRI (23 B+D channel)	to 1.544 Mbps	Elementary, middle school, high school	Can be used to handle aggregation of "switched digital" access in a district office
T1 Fractional T1 leased line	to 1.544 Mbps (fractions at 128 Kbps, 384 Kbps)	Suggested at: 384 for elementary Full T1 for middle / high schools	
Frame Relay Fractional FR	to 1.544 Mbps (fractions at 56 Kbps, 128 Kbps, 384 Kbps)	Suggested at: 384 for elementary Full T1 for middle / high schools	
T3	45 Mbps	High schools	For use where traffic demands bandwidth
SMDS	155 Mbps	High schools	Requires many-to-many connectivity (mesh networks rather than star LANs)
ATM	155 Mbps (to 2.5 Gbps in future)	High schools with advanced networks	

Some types of data lines can be scaled to provide larger bandwidths. Others offer only a set bandwidth and must be replaced with another line when more bandwidth is needed. When you choose a WAN service remember that the related network equipment must support that type of WAN service, and switching service in the future will most likely involve installation charges and additional equipment costs.

ISDN— Each ISDN line provides the user with two B lines and a D line which allow for multiple connections over the same ISDN line. However, ISDN can only run at 128 Kbps, may not have the bandwidth to handle a large network, and may result in bottlenecking. ISDN lines have a nominal monthly rate, in addition to a per usage fee. Centrex ISDN lines provide the user with an internal network within which usage is billed at a lower than normal rate. Outside the network, usage is billed at the regular rate for that distance and time of day (much like a long-distance telephone call). In some areas, special flat-rate tariffs are offered to schools.

FRAME RELAY— Frame relay connections are more expensive than ISDN lines, but offer greater bandwidth. . Frame relay connections can be made at 56 Kbps, 128 Kbps, 384 Kbps, or a T-1 line at 1.5 Mbps. The user pays a flat monthly rate which varies, depending on the bandwidth used. It is also possible for the user to only pay for fractional amounts of frame relay lines if extra bandwidth is repeatedly available. It is possible to install T-1 frame relay lines and use and pay for only a fraction of the service, later to upgrade as required without new installations or equipment.

LEASED LINE (T1)— These services provide high speeds (i.e. T1/1.5 Mbps) for a fixed rate. While ISDN lines are billed for actual calling time, like a regular phone line, leased lines do not incur these charges and eliminate budget uncertainties that could arise from usage variations. Leased lines are available in various bandwidth options.

NOTE: An ISP or network integrator will be a crucial partner with you in the areas of WAN equipment specifications and capabilities. Issues such as signaling type, physical interface specifications, scalability, security features, and quality standards should be addressed with a reputable ISP or network integrator.

WAN hardware

Internetworking devices and infrastructure elements provide communication between LANs over the wide-area network.

Suggested Networking Equipment

Network Equipment

WAN connectivity equipment	• Choice primarily dictated by WAN service • ISDN BRI: NT1 and bridge where cost effective else, NT1 and PC card. Internal and external Terminal Adapters. • Frame Relay and T1: CSU/DSU and router.
Routers	• Use to connect LAN to WAN • Will also need to connect different physical LANS at school
Bridges	• Consider scalability for future expansion
Hubs and switches	• Standard guideline is non-switching hubs. • Switched hubs suggested if specific areas demand dedicated bandwidth.
Servers	• Suggest UNIX servers at district level, COE, etc. • Suggest Macintosh and PC based servers for schools, school labs, shared files and print services.
Network interface cards	• Install appropriate device in workstation to connect to local-area network.

Connection equipment options offer your wide-area network practical connections to the Internet. WAN connection equipment varies, depending on the service you utilize (ex.: LAN bridges for ISDN lines, or EtherFRADs for frame relay lines, both of which are available from a number of manufacturers).

Bridges and routers

- Routers —allow interconnection of different network types and improve traffic flow control between interconnected LANs (for example between Ethernet and Token Ring networks).

  When choosing a router, consider the following features and issues:

  - Scalability to accommodate future expansion.
  - The ability to add or change WAN or LAN interfaces, if there is a possibility that the WAN service or LAN interface will change in the future.
  - Software features that help minimize WAN service charges.
  - Protocol support features. We strongly suggest TCP/IP as the network protocol running over Ethernet. Several options are available for networks involving multiple protocols:

    -A multiprotocol router.

    -A converter box that converts other protocols to Ethernet before they enter the router.

    -Software packages that encapsulate other protocols (such as AppleTalk) to run over IP.

- Maintenance and technical support requirements:

  Some schools find that it is more economical to have a larger, scalable router at the district office and smaller routers at the school sites that will support a single Ethernet and primary WAN connection. In this scenario, a school would likely have to replace its router if it changes WAN services, for example, switching from ISDN to frame relay.

- Bridges — connect two LANs of the same type and provide boundaries that localize LAN traffic (for example, bridges are used between two Ethernet networks).

Network centers focus on critical resources such as servers, routers and intelligent hubs located in a centralized and secure location.

The network backbone developed out of the need for LANs to connect greater numbers of users. At first, all members of departments were connected to departmental LANs, but as companies grew, they needed to connect the separate LANs to a common network. The backbone network offers this structure, by providing one central connection media supporting many separate attached networks. This guidebook suggests the use of fiber-optic cable in the school backbone (singlemode or multimode).

Key characteristics of the backbone network are:

- Access to the backbone is possible by any user
- Internetworking devices link networks
- Traffic within a LAN stays local
- Traffic on the WAN uses shared backbone media
- Utilizes a star wiring topology

The primary characteristic of a backbone network initially was the common transmission media. The backbone network concept has now changed to reflect how the different LAN segments are interconnected. Two backbone network types are typically used, the collapsed backbone and the distributed backbone.

Collapsed backbone network — provides access to centralized resources from any attached workgroup. You can design a collapsed backbone network with workgroups on each floor, linked to a central router through the network center concentrator. The router interconnects the individual LANs, establishing logical network boundaries and providing a point for managing backbone traffic and configuration. In addition, the router links to wide-area connections or to a campus (distributed) FDDI backbone.

Key characteristics of the collapsed backbone include:

- All routers are located in a network center
- The entire backbone remains within the network center
- File servers and shared resources located in network center

Distributed backbone network — provides flexible configuration for growing organizations with complex network management issues. Distributed backbones are useful when a network serves a large number of users in multiple sites and is generating increasing network traffic. In a distributed backbone design, routers and other support equipment can be located outside the network center.

Hubs provide a means to create group-oriented networks, supporting one or more network segment and providing an easy interface to inter-networking devices. Workgroup concentrators and wiring hubs can be used by the network planner to improve network performance by breaking single large segment LANs into multiple smaller segments.

General school Internet networks (baseband and broadband)

Baseband networks

In baseband networks, a single channel is used for communication across a physical medium, such as a cable. Only one device can transmit at a time. Each device on a baseband network can use all of the available bandwidth for transmission. Baseband is analogous to a single phone line on which only one person can talk at a time. If more than one person wants to talk, each one has to take a turn.

The most familiar form of baseband digital network is an Ethernet network. An Ethernet network can be used to connect groups of personal computers with each other and to other devices such as a printer or scanner in a LAN. The information transmitted over the network can include data files, computer files, text, sound, pictures, or even video.

Since all data on the baseband network is in a common digital format, the network does not have to change to support new capabilities. However, digital transmission can be a limitation when converting to a common format to support special tasks — or with new application software for which the standard digital format is inappropriate.

Baseband networks — sample implementations

The following pages include suggestions for the implementation of a baseband network that will fulfill your school's needs for Internet and World Wide Web access:

- Level 1: Library (single workstation)
- Level 2: Computer lab (for 15 to 25 networked workstations with Web site hosting)
- Level 3: School (100 or more networked workstations)
- Level 4: School (high-bandwidth uses)

These descriptions are incremental — a workstation described for Level 1 can be used for Level 2. A Level 3 lab can be used in the Level 4 school network.

Baseband Networks
Workstation for Internet/Web activities

The following tables discuss the suggested guidelines presented in this chapter (excluding multimedia). These suggestions will give you a general idea of the types of workstations that will allow you to benefit from the Internet, World Wide Web, and other information-intensive applications.

Suggested Basic Computer Configuration

Desktop Clients - PC

Equipment	Guideline new purchase minimum for schools' general use	Minimum to accept as a donation	Min. to Upgrade and Network
Processor	Pentium 75 MHz	486	386 / 25 MHz
RAM	16 MB	8 MB	8 MB
Hard Drive	540 MB	340 MB	120 MB
CD ROM	4 X	2 X	
Laserdisc			
Monitor	15 inch		
Video card	256 SVGA 1 MB video RAM		
Sound Card	sound card		
Audio	speakers or headphones		
Network capability	Ethernet card		

Desktop Clients - Macintosh

Equipment	Guideline new purchase minimum for schools' general use	Minimum to accept as a Donation	Min. to Upgrade and Network
Processor	Power PC 601 66 MHz or equiv speed	68040	68030 processor
RAM	16 MB	8 MB	8 MB
Hard Drive	540 MB	340 MB	120 MB
CD ROM	4X	2X	
Laserdisc			
Monitor	15 inch		
Video card	Built-in	Built-in	Built-in
Sound Card	Built in		
Audio	Speakers or headphones		
Network capability	Built-in		

Level 1:
Single workstation connected to Internet

WAN connection equipment:

- For a single user only, an internal PC card that connects your computer directly to the WAN service.
- External terminal adapter (NT1)for an ISDN line (easier to install than an internal PC card connecting to the WAN). Other devices for non-ISDN WAN service.

Internet access software:

- A suite for e-mail, gopher, whois, etc., plus a World Wide Web browser.
- Check the software for the exact amount of disk space required; at least 9 MB is typically required.

WAN services for Internet:

- At least a 56 Kbps (switched or dedicated) circuit, such as ISDN Basic Rate Interface (BRI), 56 Kbps frame relay, or 56 Kbps leased line.

  ISDN BRI data lines cannot be upgraded to faster speeds. If you plan to add more simultaneous users (approximately five or more) to this WAN connection, WAN connections at fractional T1 speeds or frame relay are suggested choices.

Baseband Networks
Level 2:
Computer Lab with Web Site Hosting
(~15–25 Networked Workstations)

WAN connection equipment:

- WAN connectivity equipment must match your WAN service. For T1 or fractional T1-based services, you will need a CSU/DSU with B8ZS and ESF capability. (This equipment may be provided by your Internet service provider.) For ISDN lines, an NT1 network terminator device (sometimes integrated with the bridge or router) will be needed instead of a CSU.

WAN service:

- 256 Kbps is suggested (a dedicated T1, fractional T1, T1 frame relay, multiple BRI ISDN lines, or a PRI ISDN line). A 1.5 Mbps WAN service is suggested for those schools that can afford it. More bandwidth to accommodate incoming traffic may be required if your school hosts Web sites.

Router:

- A low-end router and a CSU/DSU for frame relay or leased lines, or a low-end router and a NT1 for ISDN lines.
- A higher-end router, if your school plans to move quickly to advanced levels (CDDI/FDDI, ATM, or 100 Mbps technologies).
- Evaluate different interfaces available on routers, and options for modularity/adding LAN and WAN interfaces over time.

Server:

- Required if your school or district wants to host a Web site. A server can also be used to provide Gopher, FTP, and e-mail services (these can also be provided by the school's Internet service provider, however).

  NOTE: You may want to consider preconfigured Internet servers available from a number of vendors.

  TIP: It is a good idea to connect the server directly to the switch rather than to a hub port.

Hub:

- A modular hub with 24 ports (must have one port for each connected workstation) or two hubs with 12 ports. Add more 24-port hubs to support additional users.

  TIP: If you plan to add many users in the future, consider purchasing a switching hub, as described in Level 3, for adequate bandwidth.

Workstations:

- Level 1 workstations

Baseband networks
Level 3:
School
(100 or more networked workstations)

WAN connectivity equipment:

- Same as Level 2.

WAN service:

- If you need greater WAN bandwidth, ATM, SMDS, or other high-speed (greater than 45 Mbps) services are available. These are high-speed but expensive and complex network services. Your WAN service provider is the best resource for information about implementation specifications and configuration details.

Router:

- Same as Level 2.

Servers:

- A larger server might be needed at this point; for example:
  - — Multiprocessor server
  - — 1 to 4 GB hard drive
  - — Switched 10 Mbps or greater LAN interface

Hubs:

- Enough hubs to accommodate end-user workstations. There should be one hub port for each networked workstation. Hubs can be stacked in a central site or located in individual classrooms and connected by hub crossover cables.

  Tip: Consider switched Ethernet hubs. A switched Ethernet hub allows for allocation of LAN bandwidth and can be desirable for the main distribution room, to provide better speed to your classrooms. Most switched hubs offer the advantage of being upgradable to higher-speed FDDI and ATM networks. We suggest evaluating the cost-effectiveness of an upgradable switched hub. Two options include:

  - — Option 1: One switched Ethernet hub in the main distribution room and regular hubs in the classrooms.
  - — Option 2: One switched Ethernet hub in the main distribution room and switched hubs in classrooms or labs, if dedicated bandwidth needs to be allocated at the workstation level.

10BASE-T, 10BASE-F, 10BASE2, and 10BASE5 all operate on a switched Ethernet hub. If you start with Option 1 and later migrate to Option 2, some recabling might be required. Also, if all workstations are generating a lot of Internet-based traffic, Option 2 might not solve the total performance problem, because bandwidth is limited to the speed of the Internet connection.

Workstations:

- As many as needed; same configuration as Level 1.

Baseband networks
Level 4:
School
(High-bandwidth Software)

If you plan to use advanced, high-bandwidth digital video — such as real-time video transport or integrated voice, data, and video — on a single network, consider higher-bandwidth WAN and LAN technologies such as FDDI, CDDI, 100VG, 100BASE-X (Fast Ethernet), or ATM. This level provides equipment suggestions for several of these technologies.

FDDI (fiber) and CDDI (coaxial)

Router:

- An FDDI or CDDI model is requires. If you have an upgradable router, an FDDI or CDDI module can be added. Otherwise, you will need to buy a new router.

  NOTE: FDDI/CDDI is not suitable for isochronous services such as video and audio transport.

Server:

- A large UNIX-based or other high-end server might be required; the server should have ample storage and an FDDI or CDDI LAN interface.

Hubs:

- Dual-attachment FDDI or CDDI concentrators are required to connect other single attachment devices to the network.

Workstation:

- Same as Level 1 (higher-performance workstations should also be considered, depending on expected use).

  Only dual-attachment workstations with optical bypass switches should be attached directly to the backbone ring. Therefore, either dual-attach workstations can be used or single

attachment workstations can be connected with a dual-attachment hub.

100VG and 100BASE-X (Fast Ethernet)

Router:

- A 100VG / 100BASE-X module is required. With an upgradable router, this module can be added; otherwise, you may have to buy a new router.

Server:

- A 100VG / 100BASE-X interface is required.

Hubs:

- 100VG / 100BASE-X hubs are required.

Workstation:

- Same as Level 1.

ATM

Router:

- An ATM interface is required.

  TIP: Not all upgradable routers support ATM, so check with the vendor first.

Server:

- A large UNIX-based or other high-end server with an ATM interface.

Hubs:

- If you are using switched hubs, you can simply add ATM interfaces to your existing hubs. Special ATM switches are also available.

Workstation:

- ATM or TAXI (Transparent Asynchronous Transceiver Interface) interfaces are required in your workstations.

Broadband networks

With planning and careful selection of a design that allows for a migration to increased capabilities, a broadband network can provide the following:

- Electronic libraries of video, pictures, audio, and text that can be networked to allow on-demand access to stored material from anywhere in the school.
- Students and teacher access to community and nationwide multimedia databases. This requires external public networks capable of providing two-way communication.
- Access to the Internet, inter-school data transfer, and access to other data services — made possible by wide-area packet communications over the network.

- Extension of inter-school broadband communications supporting the virtual classroom to multiple schools. Teachers with expertise in specific areas can conduct classes electronically in several schools, thereby allowing a greater choice of subjects for students. Teleconferences and teacher in-service training materials can be made available throughout a district.

- Parent and teacher access to school resources from home. This enables parent, teacher, and student-teacher meetings, as well as home access for sick or disabled students, specialized tutoring, and home access to campus electronic libraries. This requires two-way communications to be provided over the public network to homes, which is not yet developed in most areas.

In broadband networks, physical cabling is divided into several different channels which have their own frequency. Special techniques allow these different frequencies to be combined onto the network cabling in a way that allows multiple simultaneous transmissions to take place (network devices tuned to one frequency do not "hear" signals on other frequencies).

Cable television is an example of a broadband network. With cable television, multiple channels are transmitted simultaneously over a single physical cable; the viewer selects a channel that corresponds to a broadcast frequency that carries the requested selection.

Recently developed technologies have made possible the transmission of electronic data over broadband networks. Although baseband networks have become relatively standardized for data transmission over the last few years, broadband networks are new, and the equipment associated with them is not yet standardized. Also, two-way broadband service is not yet available in all areas. Broadband WANs (between buildings or to a service provider) are becoming more affordable, but broadband LANs are still costly.

The following broadband guidelines and suggestions are fully compatible with the design standards now being constructed by both local cable television companies and Pacific Telesis. The broadband network supports:

- Two-way transmission of video generated in-school, throughout the school complex (classroom-generated video, virtual classrooms within schools). A broadband or video distribution network is a tool for transporting information-intensive signals — i.e. television, video, and high-speed data — throughout a school complex. A broadband network can support one or two-way video between different points on campus.

  Locally generated video can be inserted into the network at the hub and distributed throughout the school. Locally generated video can come from a single VCR signal that can serve many classrooms from one location. This configuration allows program viewing in several classrooms simultaneously. A classroom could establish a one-way or two-way link with other rooms. A broadband network with this capability allows the creation of virtual classrooms as needed, and also allows the sharing of resources anywhere in the school

- Transmission of data among classrooms.

- High-speed Internet access (if available from the service provider).

In recent years, cable systems have begun upgrading to provide full two-way capability and high-speed data services. Trials are now underway to provide connections to the Internet and other on-line services at speeds up to 10 Mbps.

With some capabilities, the best current combination of performance and cost is achieved by the simultaneous use of both cable and telephone networks. Some cable companies are providing Internet access by transmitting packets to the user at very high-speeds over their one-way cable, and then having the user send packets to external locations via telephone modem. Other cable companies are providing two-way communications over cable, with 10 Mbps download speeds and 100 Mbps upload speeds. For certain users, such as students doing research, large files, video, and graphics are downloaded very quickly. The upstream traffic is not hindered by the slower transmission rate, since it consists mostly of keystrokes that require very few bits and are transmitted almost instantaneously.

Distribution of up to 110 channels of television programming from external suppliers (Cable in the Classroom, satellite programming, Educational Television Fixed Service). Cable television operators provide television programming targeted specifically at schools. In addition, most communities have one or more Educational Access Channels set aside for exclusive use by schools. These channels can be used for vocational training, transmission of school calendars to the community, off-campus college classes, or other forms of education. Programs can be scrambled for reception only by selected receivers, to make virtual classrooms, in-service training, and similar uses more practical.

Educational Television Fixed Service (ETFS) is used by junior colleges to share programming and transmit it to local cable companies. It is also used by the Stanford Instructional Television Network (SITN) to transmit vocational programming directly to companies that provide classrooms for employees who wish to take classes. There is interesting ETFS material at the K–12 level. Contact your county office of education for information about ETFS for your school.

Satellite programming often contains material of interest to schools. Today, three types of satellite antennas support three different types of subscription services. Although much of the available programming parallels that available from cable companies, some of it is unique. It is common to find a full-time NASA feed of video from manned space shots, for example.

Transmission of data and video to and from other schools and locations (if available from the service provider), such as video conferencing, video-on-demand. Until the telephone or cable companies upgrade their systems to allow full two-way video capability, interactive video interconnections to external locations will almost always be accomplished by converting the video signal to digital form, converting the data stream to its most efficient form (digital compression), and then transmitting the final data stream through a standard data network, where the whole process must finally be reversed. The conversion process costs more, and the video quality is limited by the speed of the transmission system.

High-speed digital connectivity is often available from the primary carriers and competitive-access providers (CAPS, alternative telephone companies).

Broadband networks — sample implementations

Five technology levels are presented here for broadband networks (although Level 1 is the usual starting point, implementation can begin at other levels).

- Level 1: Low band, single broadband, video RF supplier.
- Level 2: Local origination at hub, or second channel external source.
- Level 3: Video or data (modulated) originated from classrooms (broadband can function as a LAN).
- Level 4: Mixed RF multichannel external suppliers.
- Level 5: Videodata to outside carrier (two-way cable systems).

(Alternative implementations could include):

- Starting with Level 1: add Level 2, Level 3, or Level 4.
- Starting with Level 4: add Level 2, Level 3, or Level 5.
- Starting with Level 5: add Level 3 equipment.

Consider these factors when choosing a broadband level:

- Capabilities of external video service supplier(s).
- Construction of a standardized distribution network in accordance with Smart Valley specifications.
- Provision of add-on modules to support desired functionality.

Broadband networks
Level 1:
Single Broadband (low), Video RF Supplier

Specialized equipment:

- Television receivers
- Workstation with Ethernet card (same specifications as baseband)
- Telephone line to each inter-networked classroom (or an Ethernet LAN)
- Amplifiers
- Hybrid modems and telephone lines for Internet access
- Ethernet network for connecting workstations
- Notch filter, one for each cable channel you want to filter out

Uses:

- One-way real-time video
- Internetworking between classrooms using hybrid systems

Broadband networks
Level 2:
Local Origination at Hub or Second Channel External Source
(High-bandwidth Software)

Equipment:

- Equipment from Level 1
- Local video origination hardware (cameras, VCR, laserdisc, CD-ROM, authoring tools).
- Video server (optional).
- Reception hardware, such as ETFS receiver, satellite dish.

  NOTE: For each additional channel or source, such as satellite or internal sources, you will need a modulator and directional coupler. A group of directional couplers forms a combining network.

Uses:

- In-school originated one-way video.
- One-way limited video-on-demand (analog or digital) from hub only.
- Multimedia production.
- Importing a one-way external single channel and second video source (for example, cable ETFS).

Broadband networks
Level 3:
Videodata from Classrooms
(Broadband as LAN)

Equipment:

- Equipment for Level 2
- Multimedia origination equipment.
- Data server or data / video server.
- Duplexer.
- Two-way amplifiers.

- Cable modems for each group of workstations (3 to 4 on the broadband network.

Uses:

- Two-way virtual classrooms within the school.
- Multimedia origination from anywhere.
- Creation of RF LAN / packet communications within the school.
- LAN-based video conferencing.
- Full video-on-demand within the school (two-way).
- Processor for each locally originated channel.

Broadband networks Level 4: Mixed RF Multichannel External Suppliers

Equipment:

- Total number of channels (15) is limited by downstream capacity of the network.
- Channel processors for each external service provider, such as cable or telephony provider.

Uses:

- Increased options for externally received video.
- Two multichannel external video sources from which to choose channels; for example, 10 cable channels and 10 telephone broadband channels.

Broadband networks Level 5: Video/data to Outside Carrier (Two-Way Cable Systems)

Equipment:

- Level 3 components.
- Packet enabled cable headend.
- Two-way external supplier offering bandwidth channels.

Uses:

- Additional duplexers for each external service receiving signals.
- Video or data processors designed either for data or video, but not both.

- Inter-school data and video network.
- External two-way video.
- Home access to school data and video.
- Multi-school (home) distance learning.
- School-originated material broadcast through external service providers.

Multimedia — sample implementations

Multimedia can be defined as a combination of visual and audio information stored or presented in a computer-based format. Multimedia uses require more powerful computers and some key accessories —to fully capitalize on the benefits of sound, video, and graphics. Considerations when designing your multimedia system:

- It is important to determine the kind of software your school will run when choosing your networking and multimedia hardware. In some cases, the software might require a specific processor, require a specific amount of RAM, use unexpectedly large amounts of disk space, or have other requirements that need to be considered.
- Workstation memory should be upgradable. Multimedia software upgrades typically require increased memory and available disk space.
- The advanced authoring system requires expensive multimedia production hardware and software that should be considered if your school is planning a special program in multimedia production.

Note: multimedia systems are differentiated between viewing — passive participation of created multimedia applications and materials — and authoring systems— actual creation of multimedia applications, software, and materials.

The following tables offer suggestions for acquiring workstations that will be used for multimedia viewing and production.

Suggested Basic Multimedia Workstation

Multimedia Desktop Clients - PC platform

Equipment	PCs Multimedia Viewing Basic	PCs Multimedia Viewing Advanced	PCs Multimedia Authoring Basic	PCs Multimedia Authoring Advanced
Processor	Pentium 75 MHz	Pentium 100 MHz	Pentium 75 MHz	Pentium 100 MHz
RAM	16 MB	24 MB	16 MB	24 MB
Hard Drive	540 MB	1 GB	540 MB	1 to 5 GB
CD ROM	4 X	4 X or best avail	4 X	4 X or best available
Laserdisc				Education Player
Monitor	15 inch	17 inch	17 inch	17 inch
Video card	256 color SVGA 1 MB video RAM	256 color SVGA 2 MB video RAM	256 color SVGA 2 MB video RAM	256 color SVGA 2 MB video RAM
Sound Card	22 kHz, 16 bit playback, stereo	44 kHz, 32 bit playback, stereo	22 kHz, 16 bit playback, stereo	44 kHz, 32 bit playback, stereo
Audio	external speakers	external speakers	external speakers	external speakers
Microphone				for recording digitized voice
Printer			color laser, 300 dpi	color laser, 300 dpi
Scanner			color, 600 dpi	color, 600 dpi
Camera			camcorder	camcorder, digitized camera
VCR			VCR	VCR with digital tracking, jog control
Software				Multimedia video editing suite
Software			Video capture card: 30 fps in grabbing full screen (640 x 480 pixels)	Video capture card: 30 fps in grabbing full screen (640 x 480 pixels)
Network capability	Ethernet card	Ethernet card	Ethernet card	Ethernet card

Suggested Basic Multimedia Workstation

Multimedia Desktop Clients - Macintosh platform

Equipment	Macintosh Multimedia Viewing Basic	Macintosh Multimedia Viewing Advanced	Macintosh Multimedia Authoring Basic	Macintosh Multimedia Authoring Advanced
Processor	Power PC 601 66 MHz or equiv speed	Power PC 603 66 MHz or equiv speed	Power PC 601 66 MHz or equiv speed	Power PC 603 66 MHz or equiv speed
RAM	16 MB	24 MB	16 MB	24 MB
Hard Drive	540 MB	1 GB	540	1 to 5 GB
CD ROM	4 X	4 X or best avail	4 X	4 X or best avail
Laserdisc				Education Player
Monitor	15 inch	17 inch	17 inch	17 inch
Video card	Built-in	Built-in plus extra 1 MB video RAM	Built-in plus extra 1 MB video RAM	Built-in plus extra 1 MB video RAM
Sound Card	Sound capability built in	44 kHz, 32 bit playback, stereo	Sound capability built in	44 kHz, 32 bit playback, stereo
Audio	external speakers optional	external speakers	external speakers optional	external speakers
Microphone				for recording digitized voice
Printer			color laser, 300 dpi	color laser, 300 dpi
Scanner			color, 600 dpi	color, 600 dpi
Camera			camcorder	camcorder, digitized camera
VCR			VCR	VCR with digital tracking, jog control
Software				Multimedia video editing suite
Software			Video capture card: 30 fps in grabbing full screen (640 x 480)	Video capture card: 30 fps in grabbing full screen (640 x 480)
Network capability	Ethernet card	Ethernet card	Ethernet card	Ethernet card

Video conferencing — sample implementations

A wide range of capabilities are available through interactive video-conferencing equipment. The kinds of technologies and hardware needed depend upon the requirements of the application being provided for the institution. Video quality, in terms of lack of blocking, depends on both the choice of hardware and the network bandwidth selected. Low bandwidth networks are easy to implement and are relatively inexpensive. However, low bandwidth networks also yield the lowest video quality, which might not be acceptable for your activities.

While higher bandwidth networks can be harder and more expensive to implement, they can deliver near-television quality video that your school may require. When you have determined the bandwidth available for your video conferences and have determined the quality needed or available budget, the hardware should be selected to match that bandwidth. Some hardware delivers low quality, regardless of the network bandwidth. Therefore, it is important to consider both the hardware and the local-area network when designing your video-conferencing network.

When planning video conferencing systems, you need to consider how you would like the communication to work. It is important to consider whether computer-to-computer capabilities (collaboration, file sharing, annotation, etc.) are your main curriculum goals, or whether face-to-face interaction is the primary impetus for use of this application.

Note: Video conferencing can be done over point-to-point or multipoint networks.

Point-to-point networks connect different sites through a dedicated communications line between two specific points. Point-to-Point networks can be privately owned; they are often leased by long-distance carriers. Point-to-point videoconferencing allows two users or two groups of users seated in rooms equipped with videoconferencing facilities to communicate using audio and visual elements. This is useful for tutorial sessions or one-on-one discussions, such as teacher-to-teacher collaborations, and district-to-school administrative meetings or individual training programs.

Multipoint networks connect three or more sites that are participating interactively. Migrating from a Point-to-Point Network to a multipoint Network, a Multipoint Control Unit (MCU) is required. The MCU hardware is an audio/video bridge which allows all sites to be heard by all other sites. The audio/video bridge switches the video of the dominant speaker, for example the teacher, to be seen by all sites in real time.

The MCU must be accessible from all sites. If all sites use Integrated Services Digital Network (ISDN) or SW56 access they would simply dial into the bridge in much the same way you would dial from your telephone into an audio conference bridge. If the existing network is a dedicated backbone, the MCU must reside at the hub in a star configuration. If the backbone network is not designed in a star configuration, network redesign must be considered.

Several vendors offer MCU bridging services, which allows a school to avoid the expense of purchasing the MCU hardware. If you use a service provider rather than purchasing the equipment, you must schedule your conferences ahead of time with the provider.

The following tables list the basic guidelines to follow to make decisions about your video-conferencing networks. These tables also provide information about the hardware you can utilize for each situation. For maximum flexibility, designing a network using ISDN or SW56 technologies is greatly preferred if future growth to multipoint use is desired.

Video conferencing alternatives		
Type	**General use**	**Considerations**
Traditional	Classroom-to-remote-location applications utilizes a monitor in the front of the classroom, a video camera, and a video "codec" that allows analog video signals to be digitized and transmitted over the phone lines. The monitor shows the image from the remote location, which is equipped with a similar set-up to transmit and receive video images. Some configurations have a second monitor that shows the local room — allowing participants to see what is being transmitted to the other location.	Most useful for face-to-face applications. Especially applicable for distance learning applications, allowing video-enhanced campus-to-off-site interaction. Eliminates the limitations of a purely audio teleconferencing approach. Not appropriate for collaboration-oriented activities.
Desktop	Allows workstation-to-workstation video conferencing, enabled by special software, connecting local and wide-area network users via ISDN. Frame-by-frame video with audio provided by the telephone. Can be offered over several types of inter-LAN networks (for example, packet switched and synchronous networks).	Most useful for computer-to-computer applications, such as collaboration, file sharing, annotation, etc. Fully interactive desktop video requires a digital, circuit-switched, synchronous telephone network (which is not generally available). Not appropriate when pure face-to-face interaction is the main curriculum goal
Internet	With the necessary equipment and software, any user with an Internet connection can communicate and share ideas, presentations, and learning techniques over the existing telephone networks. Virtual field trips and tours, with the addition of full audio and video connections to off-campus locations. Classes can visit museums and other educational sites, via a remote camera, with the ability to converse with other museum visitors. CU-See-Me is another Internet video conferencing option, but is limited in the number of concurrent users.	Poorer quality than dedicated video conferencing systems Allows teachers, students, and interested parties to collaborate on projects and develop curricula from a variety of resources. Demonstrated in the National Science Foundation (NSF) funded Learning Through Collaborative Visualization Project (CoVis). This includes experiments with project collaboration and distance teaching using Internet resources, putting students in direct contact with practicing scientists and scientific tools

Implementation levels

This section presents suggestions to implement the following levels:

Level 1: Interactive distance learning: classroom to classroom (group system; point-to-point)

Level 2: Teacher-to-teacher collaboration / school district meetings (point-to-point)

Level 3: Teacher-to-student; student at a remote desktop video system (point-to-point)

Level 4: Interactive distance learning / classroom-to-classrooms; (three or more classrooms linked interactively to a teaching site) (multipoint)

Level 5: Teacher-to-teacher collaboration / school district administrative meetings (multipoint)

Level 6: Teacher-to-students: students using remote desktop video systems (multipoint)

Level 7: Desktop video conferencing (point-to-point)

Level 8: Internet video conferencing (a selection of Internet video conferencing options)

Each level lists applications, network options and hardware, teacher hardware, and makes bandwidth and other suggestions.

NOTE: If different systems desire to "talk" together, they have to use the H.320 CCITT standard, in which case some quality and features may be lost.

Video conferencing
Level 1
Interactive Distance Learning; Classroom to Classroom (Group System; point-to-point)

Tip: For maximum flexibility, designing a network using ISDN or SW56 is greatly preferred if future growth to multipoint networks is desired.

WAN options:

- Best with high bandwidth network, 336 to 384 Kbps minimum, 672 to 768 Kbps is optimal.
- ISDN BRI
- ISDN PRI (lowest cost)
- SW56
- Dedicated T1

Network Hardware:

- Inverse multiplexer with ability to multiplex at least six channels (336 Kbps).
- WAN connectivity equipment appropriate for WAN service (ex.: NT1 and power supply for each BRI).
- 30 fps codec with 480-line resolution. Video codec must support CCITT standard and higher quality modes.

Teacher/Student Hardware:

- Integrated Room System must support classroom peripherals such as extra cameras, multiple microphone environments, wireless microphones for instructors, speakers, monitors, control system and video codec.
- Alternatively, can build a custom (but costly) system.

Video conferencing
Level 2:
Teacher-to-Teacher Collaboration/School District Meetings (Group System; point-to-point)

Network Options:

- Network bandwidth from 112 to 384 Kbps. If 112 Kbps selected, standard, G.728 audio minimum required.
- ISDN BRI (lowest cost)
- SW56
- Dedicated T1

Network Hardware:

- Terminal adapter, NT1 or dual DSU, or inverse multiplexer depending on overall bandwidth desired (112 Kbps-384 Kbps).
- 15 to 30 frames per second codec with 240 to 288 line resolution. Video codec must support CCITT standards.

Teacher/Student Hardware:

- Integrated room system with camera(s), microphone(s), speaker(s), monitor(s), control system and video codec.
- No need for custom system.

Note: Easy-to-use, turnkey system best for this application.

Video conferencing
Level 3:
Teacher-to-Student;
Student at a remote desktop video system
(Group to desktop system; point-to-point)

Network options:

- Network bandwidth of 112 to 128 Kbps.
- ISDN BRI (lowest cost)
- SW56

Network hardware:

- Terminal adapter, NT1 and power supply, or dual DSU

Student hardware:

- Turnkey Mac or PC desktop video system with microphone, camera, and software.
- Speakers (headset instead of speakers may be used for person-to-person conferencing).
- Collaboration software for application sharing.
- Telephone

Teacher hardware:

- Turnkey desktop PC or Mac video system with camera and software.
- Collaboration software for application sharing.
- Classroom system as described in Level 1 or 2

NOTE: Currently, a second ISDN or telephone line is required for data sharing. This can also be done using an IMUX, but this can be very costly.

Desktop System - video conferencing (as an example, not the exact specifications)

Equipment	PC	Macintosh
Processor	Pentium/75 MHz	Power PC 601/66 MHz; 68040/ 33 mHz is acceptable, e.g. Quadra 800/900 series
RAM	16 MB RAM	16 MB RAM
Hard Drive	540 MB hard drive	540 MB hard drive
CD ROM	CD-ROM drive 2X	CD-ROM drive 2X
Monitor	15-inch color monitor	15-inch color monitor
Video card	Video card: SVGA capability (1024x768x256 color), 1 MB video RAM	Built in
Sound Card	Sound card: 8 or 11 Hz, 16-bit playback, full duplex sound	Built in
Audio	Audio: external speakers	Audio: external speakers (optional)
Camera	Camera: color, 320x240 at 30 fps, still-picture and motion capability	Camera: color, 320x240 at 30 fps, still-picture and motion capability
Video capture	Video input card	Video input card
Sound capture	Microphone	Microphone

Video conferencing
Level 4:
Interactive distance learning/
Classroom-to-classrooms;
Classrooms (three or more) linked interactively to teaching site
(Group System; multipoint)

Network Options:

- ISDN BRI
- ISDN PRI
- SW56
- Dedicated T1 (must be star configuration). If service is chosen over purchased MCU (multipoint bridge), T1 is not needed.

Network Hardware:

- MCU should include required network hardware. Must be able to multiplex a PRI or T1 network, as well as provide internal inverse multiplexing capabilities.
- MCU should support as many sites as you have classrooms. Forty sites is the maximum for a single MCU, but meetings with more than ten sites can be unwieldy.
- Each classroom site needs to have Level 1 equipment.
- Alternatively, a multipoint bridging service can be used in place of purchasing MCU equipment.

Teacher/Student Hardware:

- Same as Level 3.
- Chairperson control software should be added to point-to-point system for maximum functionality.

Video conferencing
Level 5:
Teacher-to-Teacher collaboration/
School district administrative meetings
(Group system; multipoint)

Note: This level uses the same equipment as Level 1 in addition to the MCU specifications of Level 4.

Video conferencing
Level 6:
Teacher-to-students;
Students at remote desktop video systems
(Group to desktop system; multipoint)

Group Network Options:

- ISDN PRI (lowest cost)
- Dedicated T1, (must be star configuration), or none if service is chosen over purchased MCU (multipoint bridge).

Desktop Network Options:

- ISDN BRI (lowest cost)
- SW56

Network Hardware:

- MCU should include the ability to multiplex a PRI or T1 network. No inverse multiplexing is needed for 112 Kbps networks.

Teacher/Student Hardware:

- Same as Level 3.
- The point-to-point desktop system must support CCITT video standards.

Note: This requirement will likely be eliminated by 1996.

Video conferencing
Level 7:
Desktop-to-desktop video conferencing (point-to-point)

Network Options:

- ISDN
- LAN (Ethernet, Token-Ring, etc. using TCP/IP, NETBIOS, or Novell IPX)

Network Hardware:

- ISDN interface card or LAN interface card plugged in PC. ISDN may require NT1 adapter. Multipoint may require MCU device.

Teacher/Student Hardware:

- Same as Level 3.
- Audio amplifier may be required for large class rooms.

Note: Multipoint over LAN will become available by mid-1996.

Note: For multipoint whiteboard (data) sharing, UNIX workstations are required.

Internet video conferencing

Note: Video conferencing over the Internet is a rapidly changing and expanding area. As the industry progresses, this book will be updated.

This segment lists some of the software available for video conferencing over the Internet and the hardware configuration each type of software requires. For many packages, the hardware required is too costly to consider for school use. However, if the larger, more expensive equipment is available, or can be obtained at a reasonable price, many of the packages listed in this section are free of any software charges.

Note: The inclusion of actual hardware vendors should not be taken as an endorsement of one particular vendor's product over another vendor.

CU-SeeMe

CU-SeeMe allows multiple users from different locations to point to a particular reflector and virtually meet. A reflector is a Unix computer, running the reflector program, that allows multiparty conferencing with CU-SeeMe. A CU-SeeMe reflector enables multiparty conferences using CU-SeeMe software on the Internet. Without reflectors only point-to-point connections connecting two CU-SeeMe users are possible at this time. However, CU-SeeMe reflectors provide the ability to send multicast, but not to receive.

CU-SeeMe only accommodates point-to-point conferencing with video, text, and sound. In contrast, Mbone broadcasts can be picked up by multiple people all over the world (multicast). CU-SeeMe can also function world-wide, but all users must be pointed at the same reflector to converse (unicast). Currently, sound-only is supported for the Mac platform.

Note*:* Multicast CU-SeeMe-like video conferencing is not yet readily available, but some products are currently in development.

Desktop Requirements:

See Level 3 video conferencing

WAN Requirements:

- For one site pointing at an external reflector (without others using any bandwidth): 128 Kbps minimum (2 B channels bonded)

  This bandwidth can be provided by WAN connections such as ISDN BRI or fractional T1. Anything slower than 128 Kbps will reduce audio and video quality.

- For multiple simultaneous users at one site (to an external reflector):

  Must have a high speed WAN connection such as T1, ISDN PRI, etc. A dedicated T1 will allow approximately 12 simultaneously transmitting users to point at various external reflectors. Once again, if other users attempt to run other Internet applications concurrently with the 12 CU-SeeMe users, the transmission quality degrades.

  It is possible to connect to a reflector without transmitting audio/video; this cuts the bandwidth requirements in half (~64 Kbps). If only one person is transmitting, 22 others can "lurk" (receiving video but not transmitting) from the same school site to the external reflector with a T1 connection.

Becoming a reflector site:

To become a reflector site, you have to set up your server with the CU-SeeMe reflector software available at: http://cu-seeme.cornell.edu

The server could be a UNIX machine or a PC (running UNIX) loaded with the reflector software. Keyboard and monitor are not required if the UNIX machine is being controlled by a dumb terminal.

Server Requirements

- 486, 33 MHz minimum (currently, there is no version of UNIX for the Mac that will run the reflector software)
- 16 MB RAM
- 200 MB hard drive (server software requires at least 100 MB)

NOTE: If this server is also functioning as your Web server, then the video conferencing will be much slower.

There are several advantages to setting up a local reflector. First, it allows more local users to simultaneously teleconference over the LAN, since the functional bandwidth is not limited by the WAN connection. However, once an external user such as a parent attempts to connect to the internal reflector, the quality of the transmission diminishes.

An internal reflector can also be configured to point to a specific external reflector which will then allow many more local users pointing to the internal reflector to simultaneously connect to an external reflector. This method will accommodate approximately 150 simultaneous users with a T1 connection.

If both groups are pointing to the same external reflector, this will now allow students, teachers, and administrators to video conference with other students, teacher or parents while still maintaining an acceptable quality transmission.

The CU-SeeMe software can only display eight transmitting connections at the same time, but the reflector software can support approximately 30 connections (the actual allowed number is determined by the reflector set-up). This allows others to watch the eight conversations and lurk in the background, receiving video but not transmitting. By linking reflectors, you can increase the maximum number of lurking connections.

Other video conferencing systems

Mbone is a free multipoint video conferencing alternative available by anonymous FTP from ftp://zenon.inria.fr/rodeo/ivs. It supports the UDP/IP and IP Multicast protocols; uses PCM, ADPCM, and VADPCM audio encoding; and utilizes H.261 video encoding.

INRIA IVS—The INRIA Video conferencing System (IVS) is a video conferencing tool for the Internet available in the public domain.

Note: This system will soon be available on PCs or Macs.

WAN requirements:

Server requirements:

- Sun SPARCstation, HP9000, DECstation 5000, SGI Indigo.

Desktop requirements:

- A UNIX workstation.
- Multi-host conferences require kernel support for multicast IP extensions (RFC 1112).
- Video frame grabbers supported are VideoPix, SunVideo or Parallax boards for SPARCStations, RasterOps board for HP workstations, IndigoVideo or GalileoVideo boards for SGI IRIS Indigo and Indy workstations, or the VIDEOTX board for DEC workstations.
- Camera compatible with the video board.

NV (Network Video)

NV is a multipoint video conferencing option that uses UDP/IP and IP Multicast protocols to provide video over the Internet. NV, VAT, and WB are all free and available by anonymous FTP:

It is commonly supplemented with Visual Audio Tool (VAT) and WhiteBoard (WB) for full-featured video/audio conferencing and collaboration. It is offered by Xerox/PARC.

Platform requirements:

- Sun SPARCstation, DECstation 5000 and Alpha, SGI, HP9000, IBM RS6000.

Desktop requirements:

- All platforms require a camera compatible with the video capture hardware. Sun/SunOS 4: Parallax, PARCVideo, VideoPix, X11. Sun/SunOS 5: SunVideo, VideoPix, X11. DEC 5000/Ultrix: PIP, X11; DEC Alpha/OSF 1: J300,X11; SGI/Irix 5: SGI VL (Indy, Galileo), X11. HP9000/HPUX: VideoLive, X11. RS6000/AIX: IBM VCA, X11.

- NV: ftp://parcftp.xerox.com/pub/net-research
- VAT: ftp://ftp.ee.lbl.gov/conferencing/vat
- WB: ftp://ftp.ee.lbl.gov/conferencing/wb

NOTE: NV, VAT, and WB are tools commonly used with MBONE.

Remote access (Dial-up) — sample implementations

We strongly urge you not to implement dial-up or remote access at the school level. To avoid problems with security and abuse of dial-up access, such access should be handled at a centralized site — for example, at the district office, county office of education (COE), or through a system integrator or ISP.

Dial-up access permitting users outside the school to access a server through a modem pool and telephone line connection can be added to any implementation levels described in this chapter, except Level 1. To add dial-up access, you need the following equipment.

Analog System

- Remote access terminal server
- Modem pool (28.8 Kbps step-down)
- Telephone lines

Digital System (ISDN)

- ISDN terminating equipment
- ISDN bridge / router (dial-up ISDN can be a built-in part of some routers)
- ISDN telephone line

NOTE: If your school plans to use dial-up access for remote LAN access or e-mail, keep the following in mind: to run programs remotely on dial-up, your school needs a remote access server to control a locally attached workstation. No major files or programs should be sent across the line. For simple access such as e-mail and FTP, your school can use a remote access server without an attached workstation.

PART II Creating school networks

Chapter 4 — How to create a technology plan

Technology plans and networks can be designed in a variety of ways, depending on the goals you wish to achieve and the realities of your budget. It is up to you to decide which level of technology and network capability makes sense, keeping your present and future curriculum goals in mind. Although schools may begin at any implementation level described in this document, the key to a successful technology project starts with a good planning process.

Getting started

Creating a technology plan is an iterative process and requires a team effort for success. Anyone in a school or school district can manage the planning process— but you must assemble your team from the right people to determine the following:

- educational and administrative requirements and priorities
- corresponding technical solutions to meet those requirements
- school building infrastructure changes (electrical, air conditioning, security) required or desired
- staffing level required and desired to support the system once it is in place
- operating processes and security measures that will provide for a high-quality, secure system
- capital (new purchase) budget required to buy equipment and software
- operational (on-going costs) budget required to sustain the system after implementation
- migration plan for future growth of your network — to be followed if all items are not to be purchased and implemented at the same time.

The importance of a plan

Planning is key to the creation of a network that will be successful and practical today, as well as in the future. The development of a plan provides perfect timing for your school to map out overall school goals for technology incorporation into the educational process. To become acquainted with proven and emerging technologies, you can investigate technology options to decide what kinds of equipment and software features will lead to the fulfillment of those goals. Finally, you can determine which network features can be included in which phases of the network creation —during the primary construction of the network, or perhaps a few years down the road — based on budgetary, space, and other resource considerations.

In designing a plan that will give your school the most technology for its money and effort, you must focus on the following four key concerns when dealing with technology choices and decisions:

- Flexibility — can your network adapt to new curriculum focus areas, growth in class size, demands for different kinds of applications and activities, and the incorporation of new technologies?
- Longevity — will your equipment physically last for a long period of time? Will this technology be appropriate in the future?
- Upgradability — can you add new features and equipment to your network to keep up with ever-increasing speeds and performance standards that will arise in the next several years? Can the network you install keep pace with technology — with reasonable equipment and software additions — or will you have to discard some of today's purchases to make way for tomorrow's technology developments?
- Scalability — can the equipment you have now be efficiently utilized if you expand your network? Will you be able to incorporate all its elements into a larger future network?

Proper planning is critical in developing a well-designed network that will be able to make a smooth transition to increasing levels of capability. Although you may not expect to expand your network for several years, your current planning will impact the ease and costs of future additions. A future network should incorporate current network elements, require some speed and power upgrades, and utilize new equipment to meet new requirements —without having to replace purchases with totally new equipment to meet the needs future network expansion.

Assembling your team

One of the first steps in creating a technology plan is to identify and assemble a team to create the plan. Different players need to be involved at various phases of the project, and it is best to identify key players at the beginning of the process. Involving all the necessary players from the beginning and keeping them informed of the planning process and progress from start to finish will bypass potential communication difficulties later.

The following list suggests the individuals needed for a successful planning team.

- Sponsors, or persons in positions of authority or budgetary power. This could include principals, district superintendents, school board members, financial or business managers, or business partners that will be ultimately responsible for, or contribute financially to, the support of the plan. These individuals should be present at the kick-off of the project and should be included in the final decisions of plans or phases. Individuals who are not interested in keeping abreast of details should be kept generally informed of the progress of the project through open communication channels.
- People who will be directly affected by what is implemented. This includes all users of the system — teachers, students, administrators and computer systems staff. Obviously, not all those to be affected need to be on the team, but all groups should be represented. If you might network a lab or library, be sure to include the lab teacher or librarian. Be sure to include a member of your computer staff, a technology resource instructor, and some general education teachers.
- Facilities manager, or a delegate. These individuals will be needed to help with the required changes to your school's physical infrastructure (i.e. upgraded electrical, air

conditioning, and room security systems, as well as the installation of conduit for electrical and network wiring, etc.)

- Experts:
  - — You will need a networking architect to create a sound networking plan and a well thought out migration plan.
  - — You will need someone who can install the network if the network architect does not perform that job.
  - — You will want need to include someone from your school and or district who is assigned the responsibility for running the system once it is up and running.
  - — You might consider including individuals with experience in the introduction and integration of technology into classrooms, curriculum, and schools — if your teachers and staff would like some assistance defining this step.

Not all players need to be fully participating members of the team at every phase of the project. They will all, however, be needed or affected at some point. Your goal should be to get all key individuals involved early enough to identify their requirements and concerns, to address these issues, and to therefore allow the planning project to run smoothly from start to finish.

Defining your requirements

After assembling your team, the next step is to begin defining your team's requirements — what you want to do with the technology. It is important that these requirements be documented, to achieve widespread agreement and buy-in among the educational community. Documented requirements will also be important to your network designer, as certain requirements will heavily influence network design.

These requirements can be constructed by one person, to be reviewed/revised by the team or collected at group brainstorming sessions where administrators, teachers, students and business partners come together to sketch out their ideas. A successful requirements list will represent the needs, expectations, and goals of all users of the system, and will be agreed to and understood by all planning participants.

Some questions to be answered during the requirement-collection phase are included below. Remember to break down your answers by grade or level, as your answers will probably differ accordingly.

You may not be able to answer all of the questions laid out in this chapter, but be as thorough as possible to give your network architect a more complete picture of what you are looking for in your network. The more your architect can "guess-estimate," the better. It is understood, however, that you can only reasonably provide estimates of the frequency of use, number of users that will simultaneously use the network, and the information/equipment/applications you would like to be accessible over the network.

The following provides you with some fundamental questions you must answer at the outset of project planning:

- What do you want to be able to do with your computers?
- How often will people be using them and for how long each time?
- How many people do you want to be able to be using them simultaneously?
- Where do you want the machines to be?
- What do you want to share within your school?
- Do you have data files you want to share with others?
- Do you want to keep some software in a common place?
- Do you have CD towers (on-line collections of CD-ROMs) in your library that you would like to access from each of the classrooms?
- Do you want teachers to keep attendance or grades in an on-line database?
- Do you want students to do particular subject lessons on the computer each day (ex.: math lessons where the student interacts with special math-focused educational software)? Would you prefer that students do this simultaneously as a class?
- Will you have computer classes?
- Do you currently have a computer lab available for entire classes to use? Do you need another lab for this type of use?
- Are you using, or will you need to use, any special software that can only run on special machines? What is the software and what are the machines needed?
- What do you want to share (i.e. files, databases, applications) with users outside of your school?
- Do you want to continually share data files or resources with certain outside schools? With your district? With your county office of education? What do you want to share and with whom?
- Do you want to have electronic mail (e-mail)? For each teacher? For each class? For each student? For members of the greater educational community?
- Do you want Internet access? For whom? Can you estimate the amount of time and number of people that will be using the Internet? How many will be simultaneously accessing the Internet? How many users will be simultaneously accessing off-campus networks of other schools, districts, or areas outside of your school?
- Will you be doing multimedia tasks over the network? Video conferencing? Will you utilize Cable in the Classroom's commercial-free cable TV programming?
- What items on your network do you want to be accessible to whom (ex.: Teacher / administrator-only access to grading databases; student access to group project files for collaborative efforts between students in different classes)? What files / applications are confidential and require extra security protection?
- Do you want teachers to be able to have access to the network of the Internet from home? What do you want them to be able to do from home? What about students? What about parents?

- Can you prioritize all these requirements?
- Are there items that you know you want to do in the future but have not listed here?

Defining your technology needs

Once you have defined your requirements, you and your network architect can start translating them into the technical equipment, etc. necessary to support your needs. The following sections introduce the key areas of attention for your network architect, and will give you some sample requirements that will affect the technology plan and network design.

Translating requirements — workstations

Depending on your needs, you can have varying workstation plans. Key questions include:

- how many workstations you need
- where the workstations should be located
- how the workstations are going to be used

Keep in mind the migration plan you will follow to meet future needs. Also, you must determine how you want to divide up workstations between classrooms, libraries, and labs. Take a look at what makes sense for you — educationally. With planning, a satisfactory solution can be pinpointed.

Workstation requirements for classrooms

Currently, many schools plan on having one computer and a TV (to be used as a monitor for the whole class to view the computer screen) for each teacher in each classroom, as well as one computer for every five to seven students. Schools typically plan to hook all these computers up to the school LAN. The key factor in the pace of the future growth of your network (referred to as your "migration plan") is often determined by budget factors.

Economically, schools are faced with a trade-off between trying to improve older computer equipment through upgrades — or simply buying new computers. Schools can invest a lot of money in adding new CD-ROM drives, more memory, bigger hard drives, and faster video cards to older computers, but the expense does not necessarily pay off if the computer has an older-version processor that is too slow to allow users to benefit from the upgrades.

In a number of cases, schools connect only new equipment to the school LAN, and use older equipment as stand-alone (not connected to the network) workstations — which can run different programs, but cannot share network resources. Over time, older equipment can be retired and all workstations will be connected to the school LAN. Schools who have fairly new workstations (i.e. 486 machines) usually connect them to the network.

Workstation requirements for labs

In addition to providing workstations in the classrooms, schools typically plan for computer labs which have enough computers in them for every student in an average-sized class, allowing different teachers' classes to rotate through the labs. For example, some schools use labs for computer class, as well as basic research (utilizing local library and Internet resources), math classes using interactive software, and/or creation of class assignments. The number of labs you create depends on the number of periods per day/week that entire classes will be using the facility. Many elementary and middle schools plan to offer one to three labs, while many high schools plan on three or more. Be sure to anticipate future needs, especially if you expect technology adoption and integration into the curriculum increase.

Translating requirements — LAN design

A local-area network (LAN) provides connectivity between computers within a localized area, defined here for simplicity as one contiguous piece of land with one school or one school and a district office on it.

Again, you have to make sure to investigate all your current and future requirements:

- What do you want to do with your LAN?
- What items (equipment, software, files, etc.) do you want to share?
- Do you want classes to access equipment in other parts of the school? What equipment? Where will this equipment be located? How often do you think it will be used? By how many people simultaneously?
- Do you want a server where people can store files centrally?
- Do you want to access or share multimedia files across the LAN? Will these files be located on your LAN or off-campus? How frequently will you use this feature? How many people will use this feature simultaneously?
- Do you want to use color printers in multiple locations around your school? Where?
- Do you want to do video conferencing over your LAN? To where? How often?
- How many workstations are to be placed in the classrooms and lab(s)? How many workstations will be located in the Library? How many workstations will be located in the school office and where will they be? How many workstations will be located in the teachers' room? What about the nurse's or counselor's rooms? What about the book or other inventory storage areas? Do you want one computer for inventory control? (Look at every spot on your campus and decide if you want computers there today or if you might in the future)

Physical LAN design

Now that your basic LAN requirements have been determined, you can begin to lay out the physical design of your network. If you have typical school requirements — desiring good network performance and capacity today, with growth potential for the future and eventual connection to most of the rooms in your school — it will be pretty straightforward for the network architect to design your system.

This guidebook suggests that architects follow the basic "star" topology (design), which is described in further detail in Chapter 3. The star topology provides for good network response, future flexibility, and simple growth. In the star topology, your network will have the following basic features:

1. Networked classroom workstations are connected to a remote hub (as an example, one remote hub could manage all of the computers in one classroom, with each classroom in a school served by its own hub)
2. Each of your remote hubs are connected to one central hub (this is the "star" topology)
3. The central hub is connected to your school router
4. Your router and a CSU/DSU or Network Termination Adapter (equipment used to connect the local school network to a wide-area network) are connected to the main telephone line entering your school

In finalizing your school's physical LAN design, you must decide where to put specific pieces of network equipment. Specifically, you must find the optimal place for your router, central hub, remote hubs, server(s) and any other key network equipment (such as CD towers) that have not yet been assigned a location.

Note: All of this network equipment has to be placed in secure, weather protected areas and have adequate electrical power supply.

Network migration plan

As part of the planning process you must also determine your wiring priorities — whether you are going to pull network wires to the whole school at this time, or if you are going to just wire one or two labs, classrooms, and or library. Your wiring priorities and network goals will be combined to produce your network migration plan.

Pulling wire

If you plan to provide wiring to more than one room or one contiguous area of the school, it is suggested that you wire each room of the wing you are wiring, or wire the whole school. Any group of rooms that would eventually be connected by the same bundle of wires or conduit pipe (a hard casing that surrounds wire to protect it from damage) should be wired at the same time (this may include one or two or more wings of a school that follow the same leg of your "star").

It is not advisable to exclude rooms that will eventually be connected to your network from your initial wiring effort:

- it will be a lot more expensive to go back and pull more wires to the same area. For example, you may plan to connect some rooms in one hallway immediately to your network. Other rooms on the same hall will be hooked up eventually, but not initially. In most cases, it is cheaper in the long run to pull the wires to each class in the hall at the same time, leaving some wires dormant until they can be utilized. The cost involved in pulling extra wire is usually much less than is involved in launching a new installation effort to connect the remaining classrooms with wire to your network.

- if you are pulling fiber, it is best to pull it all though a given piece of conduit at the same time. Overpulls (pulling more fiber-optic cable through conduit after some is already inside) can damage the glass fibers, cause problems for your network and be costly to repair.

Even if you have wired an entire wing, hallway, or your whole school, you do not necessarily have to connect hubs or workstations to the wires you have pulled. The wires can be left safely unused until you have the budget or resources to do further networking in the wired areas. Pulling sufficient wire now will save you money in the long run, and will significantly speed up your future ability to further expand your network. Be sure to reference Chapter 3 for a discussion of different cabling options.

Translating requirements — WAN design

A wide-area network (WAN) expands the scope of your local-area network and enables you to connect to virtually any other network in the world that is open to you.

The following are some basic questions you can brainstorm about your WAN.

- What do you want to do with a WAN?
- What do you want to be able to access?
- What do you want to share?
- Do you want to access or share resources and files with other schools in your district? In your county? Do you want to do this as easily as looking for a file on the hard drive of your computer?
- Is there any other school, institution or business group you want to share resources with and be closely and easily linked to?
- Do you want to be able to utilize the Internet?
- Is your district or county office of education going to provide your school Internet access? Will they pay for that access?
- What does your district or county office of education want to share with your school? What do they want you to be able to access? What do they want to be able to access from your school?
- How often will users perform any of the above sharing activities? For what duration of time each use? What items will they be accessing — text files, multimedia applications, etc.? How many people will be doing this simultaneously?
- Do you want educational cable TV? Do you want it to be accessible from all classrooms?
- Do you want to do video conferencing? From where, how often, and with whom?
- Do you want to broadcast your own videos? From where, how often, and to whom?

Physical WAN design

Once you have pinpointed your WAN requirements, it is time to consider the physical design of your WAN. The current national public communications infrastructure is not set up to provide inexpensive high-speed Internet access. Schools will have to consider advanced communications services to get the quality of service necessary to achieve some curriculum goals. This can be expensive, and therefore your network design team must be careful in choosing its WAN design and an Internet service provider.

First, it is helpful to look for potential economies of scale. Will your district office or county office of education provide you Internet access and service? If so, this is probably the best option, as long as it can provide you with a powerful network. Optimally, the district or county office of education would obtain services for a flat fee, which would eliminate per-use charges. This is usually the most economical option for a large group, and gives schools and districts a fixed amount that can be included in their budget. Flat fees eliminate the hassle of huge variable-cost bills, like your phone bill, arriving in the mail. If this is not possible for your school, shop for Internet providers smartly to obtain your cost points and service needs.

Next, you must look at how closely you want to be coupled with your district, other schools in your district, and/or your county office of education. At this time, you must decide how much of your LAN you wish to share with these outside parties, as well as what part of others' LANs you would like to utilize. Your network architect and technical staff can make sharing items located on your district's network as easy as opening a file on your own computer's hard drive. In order to have an easy to use system, you must lay out the capabilities and levels of access you would like to set up between your LAN and other LANs in your district or county. Server arrangement, levels of access you have to off-campus LANs, and levels of access off-campus users have to your LAN have a direct impact on the technical staffing, support, and security of your system.

Finally, you have to select the type(s) of communication service(s) your school is going to use. This Guidebook recommends dedicated, permanently installed, communication circuits. You must consider the number of users and the quality of service your activities require. For example, ISDN imposes less of an economical strain than Frame Relay service, but is considered adequate only for approximately five to 10 simultaneous users. ISDN lines utilized by too many users simultaneously will cause your network to slow down, an effect which worsens still when users are exchanging large (i.e. multimedia) files. As another option, your local cable providers might be able to provide less expensive, reliable 10 Mbps capability.

Translating requirements — servers

Servers are machines that make certain resources available to a number of other machines on the network. For example, a file server allows other machines on the network to utilize centrally stored files, such as a grading database, group projects, etc. The file server can be set up so that each class, each user, or different subjects have their own folder or area that can be accessed from machines around the network. These folders or areas can store items with which they are working. Different servers set-ups allow you to share software, files, equipment resources (printers, scanners, etc.) from locations around the network.

Once again, it is necessary to answer the following questions to determine how servers fit in your technology and networking plans.

- Do you want files on a server to be shared? Shared by whom? Inside your school? Your district? Your county office of education? Others?
- Are students and teachers going to house their work on a server? How many items will they house there? How big will these items be? How long will they keep them on the server?
- Are teachers going to start keeping electronic portfolios for students (containing information on student attendance, class work, grades, etc.)? How many items will be included in a portfolio? Will some contain images? Video clips? How long will they keep them (ex.: one year or longer)? Who will have access?
- Do you want to locate shared software on servers? What kind? How much will the software be used and by how many individuals at the same time?
- Are you going to have electronic mail? Who will have accounts?
- What administrative records do you want to house on a server? Who do you want to have access to them?
- What servers do you currently have? How are they being used? How are they working?
- Do you plan on hosting a World Wide Web site?
- Are you going to allow remote users (teachers, students or parents) to access information on your servers from their homes? Access e-mail accounts? Access the Internet?

These questions should be understood when you are defining the role you want servers to play in your technology plan, and when designing where the server(s) will be placed on your LAN or WAN. Multimedia items that will be heavily used (ex.: interactive encyclopedias), commonly used software, and other shared local files with high-usage are typical items that could reside on your LAN server.

If your curriculum goals include heavy e-mail and Internet/World Wide Web usage, it might be practical to have your district our county office of education house your mail server and Web server(s) on their LAN. It is suggested that one "postmaster" staff position be provided for supporting each 1000 e-mail accounts.

Additionally, dial-in access from home to e-mail accounts and the Internet may be done most practically at the county or district levels. Your district and county office would typically then need to provide you with Internet "Domain Name Service" (DNS) — a required feature for Internet use that would usually be provided by your Internet service provider. As an example, you could house a primary Domain Name Server at the district office, and have a secondary DNS at the county office of education — for back-up in case of server problems or heavy usage. It is suggested that one "hostmaster" staff position be provided for each 2000 to 3000 network devices.

Translating requirements — Hubs

Hubs are an integral part of a network, and the distribution of hubs in your network design will greatly affect your wiring scheme and future flexibility. Every computer on a LAN with the suggested "star" topology is directly linked to a hub. Those hubs are then connected to the central hub (which is usually a switched hub for better performance). You will need to determine where you want to locate your hubs.

A generic networking approach would put one hub (usually a 12 to 24-port hub) in every classroom, a configuration that allows for future growth, flexibility, and simplified school-wide network architecture. When you are looking at wiring administrative offices, teachers' room, nurse's room, storage areas, etc. you will probably need to look at how you will share hubs across rooms.

Providing one hub for each classroom gives you flexibility in the initial wiring efforts, because if you have smaller goals you can first hook up computers directly to your wiring, later to be replaced by hubs that connect to numerous computers. When pulling Category 5 wiring (see wiring suggestions in Chapter 3), the second set of available wires can be used to connect another hub to accommodate a network printer and more computers. (The same flexibility exists if you pull multimode fiber to the classroom, but connecting it directly to a single computer is expensive. In most cases you would opt to connect the fiber to a hub first, and then start connecting your computers to the hub.)

Taking stock at mid point of your planning process

We have discussed some questions to ask in defining your requirements and have looked at how requirements can relate to the physical equipment aspects of your LAN and WAN design. At this point in the planning process, there are a number of other tasks, or paths, that should be pursued:

- Identify associated physical infrastructure requirements:
    - — Physical storage of equipment
    - — Electrical requirements
    - — Air conditioning requirements
    - — Furniture requirements
- Define system security plan
- Define technical support plan
- Define general training plans
    - — For teachers
    - — For technical staff
    - — For students

- Define budgets
    - — Capital, or new purchase budget
    - — Operations budget

Assessing your infrastructure

A number of infrastructure items need to be considered when creating your LAN/WAN design and technical plan.

- Where are you going to store all the equipment (consider each item separately)?
- Are your rooms big enough to add the computers you anticipate?
- Do you have enough rooms to house the number of labs you would like to have?
- Will your equipment be secure?
- Do you need to bolt down the equipment? For theft reasons? For earthquake reasons?
- Should routers, the central hub, and servers be in closets or rooms that are inaccessible to non-specified personnel?
- Should the remote hubs be in cabinets or up on shelves out of reach (ex.: near the ceiling) in the classrooms?
- Do the rooms (especially the labs) need to be air conditioned?
- Is there proper electrical supply? Who will determine what electrical needs to be upgraded? (This is to be done after placement of equipment is decided.)
- Do you have power surge protectors, line conditioners and/or a UPS (uninterrupted power supply) for your equipment?
- What is being done to make sure the system is properly grounded? Is there a common ground between buildings?
- What will it take to wire the school? Who will draw and write specifications (both electrical and network) for wiring the school?
- Do you have desks/tables for the new computers? Are they ergonomically correct?

These issues need to be resolved at the beginning of your network design process, to avoid future planning risks. The location of your network equipment has to be decided before the LAN and WAN designs can be completed. Placement of the central hub is the most crucial decision, because all network wires to remote hubs will emanate from that location. If you decide to move the central hub in the future, all the wiring will have to be moved, as well, at significant extra cost.

Electrical equipment

Electrical problems can cause costly damage to sensitive electrical computer equipment. Surges and power outages can cause you to lose data on computers and servers. We suggest that you take a look at a number of factors in designing your electrical system:

- Electrical surges can cause your computers and servers to lose your data. Unexpected power outages can likewise lose your data. In the worst case scenario, overloaded circuits can cause fires.
- The electrical requirements (amps) for all your equipment need to be counted. In a classroom you will typically have computers, monitors, speakers, a printer, maybe a scanner, a laserdisc player, a TV, an overhead projector, and a hub. Make a chart that lists all your equipment, detail the individual electrical requirements, and have an electrician list how many circuits and amps you currently have in the classroom (**note:** some rooms share electricity with other rooms). Many computers with monitors and speakers use about 6 or more amps. If circuits provide 20 amps, you can safely plug in only three computers per circuit. Ensure that this analysis is done.
- Analyze the following factors in designing your electrical system. Can you keep computer equipment on separate circuits? Can you place surge protectors on all computers? Can your servers be placed on circuits with line conditioners and a UPS? Servers are particularly important to protect if you store a lot of data on them.
- Electrical wiring can add up to a significant portion of your total technology costs.
- You must be specific in your desired outcome. If you do not specify what you want (such as what type of conduit to use, where to put the conduit, what type(s) of wires to pull and use, where to put the equipment, where to cut holes in your building, where to put new electrical outlets) you may not get the job completed as you would like. If you put a well-defined job out to bid, you will be able to better understand differences in responding contractors' proposals. If you do not have a wiring plan that dictates how you are going to label both ends of each wire, you will have a costly problem the first time you have to change something and cannot determine which wires are for what purpose.

It is helpful to determine your needs and put your wiring task up for bid among several contractors, in order to get the desired end results. Contractors should help you address the following questions:

- what type of conduit to use
- where to put the conduit
- what type(s) of wires to pull and use
- where to put the equipment
- where to cut holes in your building
- where to put new electrical outlets.

Environmental and safety considerations

Equipment and cables are sensitive to environmental conditions. The following lists some items to consider when planning your school's system:

- Adequate, dedicated electric power
- Air conditioning (must be considered for a room with 20 or 30 computers)
- Appropriate kinds of conduit for pulling network cables (depending on the kinds of elements they are exposed to)

Physical safety

The physical safety of your equipment is a self evident concern.

- Earthquakes are a fact of life in some areas. Physically securing the equipment both protects expensive equipment from being broken and protects individuals from being seriously hurt by heavy equipment.
- Theft and vandalism can jeopardize your equipment and network wires. Bolting down equipment and utilizing door locks, window bars, metal pipe for outdoor conduit, and alarms are some options.

Classroom space and furniture requirements

Classroom space and furniture may sometimes overlooked or left unaddressed. Be sure to look at the true needs of your school:

- Should a plan be put in place to try and address classroom size or lack of rooms for new labs that are needed?
- Do you need new furniture for the computers and other equipment?
- What is your school's position on ergonomics? Industry has addressed these needs for adults, but they have not been addressed for school children.

Defining your security plan

Security is a key element in the success of your network creation and implementation. Your security plan should focus on the following three areas:

- Network security
- Host security
- Application security

Network security may be defined as the procedures and controls you set up to protect your network equipment and data from accidental, unauthorized, intentional, or malicious modification, destruction, disclosure or thievery. Host security is a similar protection of your e-mail, Internet, and outside entry points, while application security covers software programs. Tight security results from incorporating protective measures in your network plan and design, and implementing those measures when you install the network.

Security is an important issue to Internet Service Providers, network system administrators, Web server implementers, and general users. One Industry working group, the Site Security Policy Handbook Working Group, produced the *RFC 1244 Site Security Handbook*, which provides current, state-of-the-art information on security and a variety of networking subjects. News-group discussions, implementation suggestions, and information regarding security can be found in abundance on the Internet. For example the *comp.security.misc* news group is dedicated to security issues. Security information is also available on the Web and can be found using search programs and indexes such as Yahoo, Web Crawler, and Lycos.

Security policy requirements

Each campus has different security needs.Schools, districts, and administrative offices each have special requirements that must be considered when forming a security plan. Therefore the procedures you implement must conform to the particular needs of each campus. However, when you are in a networked environment, you must also take a look at the integration of all the procedures into a larger district or county-wide plan.

Before formulating a security policy, try to answer the following questions:

- What are the school / district / county's expectations as to proper system use?
- What are you trying to protect? Assets? Information? Other?
- What are the associated risks or costs if the network is not protected?
- From what and / or whom do you think you need to protect these items?
- How likely are these threats to your system? Internal threats? External threats?
- How severe are these threats? What are your priorities for protection?
- Who will set security policies?
- Will policies be imposed at the county, district or the school level?
- How cost-effective are the measures you are implementing?
- How often will your security process be reviewed? Who will review it?
- How quickly can you improve your security measures when a weakness is found?

Security risks and threats

Here are some of the issues schools need to consider:

- Equipment may be constantly switching locations to accommodate new users or to accommodate rearrangement of your school facility. Inventory and tracking of what is owned can prevent the loss of computers and peripheral equipment.
- Hardware needs to be protected from theft and destruction — keyboards, terminals, workstations, personal computers, printers, disk drives, communication lines, terminal servers, routers, etc.
- Supplies need to be protected from theft: ribbons, magnetic media, paper, forms, etc.
- Equipment needs to be protected from tampering.
- Software must be protected — licenses, source programs, object programs, utilities, diagnostic programs, operating systems, communication programs, etc.
- Network must be protected from loss or denial of service to your network users.
- Network must be protected from unauthorized access to system or data.
- Files must be protected from copying for unauthorized use. Data could be copied from on-line storage, off-line archives, back-ups (copies of network files that are recorded at intervals and kept on disks or tapes), audit logs, databases, during execution, or in transit over communication media.
- Data must be protected from manipulation or falsification.
- Computers must be protected from viruses which may corrupt data or cause network interruption.
- Users need to be protected from unauthorized use of passwords or tampering with user accounts.
- Network must be protected from intruders on your system or broadcasts to your system.
- Student Internet access policies must be created.
- System support must not be reliant on only one person — in the absence of that person other qualified personnel must be able to solve problems.
- Proper documentation must exist and be safely stored for programs, hardware, systems, and local administrative procedures.

Threats must be assessed according to their severity and likelihood — and priorities for protection must be determined. For example:

- Severity may be considered high if the threat or risk stops your entire network. Risk can be considered low if the threat only affects a single computer or directory of non-critical data.
- Severity may be high if the threat includes access to highly confidential information but low if it is access to a student's work assignment.

Choosing security measures

The following list offers typical goals for your network's security plan:

- Enabling user convenience, to encourage all participants in the network to be productive and eager to join in.
- Ensuring student, teacher, and administrator privacy for:
  - e-mail messages
  - personal and personnel files
  - work files
  - test results, test answers and grades

  Security considerations can be extended for privacy within groups, allowing limited access between students or groups of students in a classroom, but allowing teacher access to all.
- Developing a high level plan that determines and assigns access levels for administrators, teachers, students and parents. Detail what they can access: computers, servers, directories, software and resources such as the Internet, etc.
- Developing a high level plan that determines and assigns access levels — plus grants and controls access to the network and its resources for your technical support staff.
- Clearly articulating your security policy objectives. Stating on-going plans for evaluating your policy's success.
- Developing a system of recovery procedures which can be rapidly deployed in case of a security breach or other problem. Backing up data and software on a regular basis, and implementing a regimen of problem-reporting procedures should be key items of your system recovery plan.
- Understanding that no single technology can fully protect a network. Many network designers recommend taking a systemic approach that uses multiple, overlapping security measures.
- Choosing a set of controls that will enable you to protect your network but allow the flexibility your network requires to allow users access to the resources they need.
- Identifying which security measures are not automated. Consider implementing breach of security consequences within the rules and regulations of the school and the district.
- Identifying which personnel are required to implement your security plan. Your school may require a full-time system administrator for security and network functions, or a security working group to help with security administration.
- Incorporating security costs in your school's capital and operational budgets.
- Realizing that for security purposes you do not want to disseminate the security configuration or measures for your network (akin to announcing that your house key is under the front door mat).

Protecting the computer system

- Keep regular backups and storage of data in a secured, off-campus location as a mandatory part of protecting the information located on your network.
- Physically secure your network systems. Keep expensive equipment in a secure room. Bolt hardware to desks or floors.
- Put school property numbers on hardware and establish and maintain inventory.
- Limit access for users to critical network components. You can lock critical network components in equipment closets, or physically lock the system from user access and secure all wiring closets.
- Set up firewalls (a computer which denies unauthorized access and activity) to protect the system from outside intrusion.

  Unauthorized users typically enter a network through available access points. Links between networks can allow access to many of your network resources. Each service your network offers can be compromised.

  If dial-up line configurations allow access to a log-in port on a single system, your network can then be accessed by an unauthorized user connected to a terminal server. Because terminal servers may not use an authentication scheme for access, or are configured for Telnet access to the network, intruders may use terminal servers to disguise their actions.
- Set up procedures for detecting unauthorized network activity.

  You can set up a system of monitoring tasks which can be performed by the system administrator. Some easy-to-implement tools for monitoring your network (such as establishing activity log files) can be set up using standard operating system software or software from third-party vendors.

  You can also use software designed specifically for network monitoring. Automatic monitors can scan the entire system to detect security breaches. They can trigger an alarm when a breach is detected to ensure that breaches are quickly identified, located and dealt with.
- Identify software bugs.

  Bugs in the software, especially those bugs that are publicly known, may allow an unauthorized user to access your network. As soon as you find a software bug, you should report it to the vendor so it can fix the problem.
- Run check programs to find evidence of changes.
- Maintain a journal of sources and times of data changes.
- If your systems have not been configured properly, access to your network may be simplified for a knowledgeable intruder.
- Install secure hubs that automatically disconnect unauthorized addresses (DUA).
- Guard against insider threats.

Users with direct access to portions of your network and its hardware components are at an advantage in accessing restricted areas.

Protecting student and administrative records

The information your network contains is one of the most important assets you must protect. However, the way we use information makes it the hardest to secure. Information is constantly being accessed, modified, and moved within a network. Controlling the authorization of access to information on your network is an on-going task.

NOTE: Privacy of on-line student records should be comparable to other methods of maintaining student records.

The following suggestions will help you develop a plan for maintaining the information contained in student and administrative records:

- Create separate administrative and educational networks and install a firewall between them.
- If you have one network, install a firewall between the administrative and educational areas.
- Have one network, but have separate administrative and educational servers.
- Isolate administration records, especially counselor and medical files, tests, test answers, grades and other sensitive files.
- Install an eight-character password system to limit access to administrative-only software applications and databases, as well as other sensitive information.
- Educate users about good password choices. For example, do not use the name of a favorite pet, a maiden name, a date of birth, or a social security number. A good password choice is a combination of upper and lowercase letters, numbers, and symbol.
- Implement password aging — a mechanism whereby a password becomes obsolete after a given number of days, or on a particular date.
- Enforce good password procedures.

  One user with a poor password can leave your system open to unauthorized access.
- Encrypt individual passwords for teacher access to administrative information.

  Information that is in transit over your network may be intercepted. Either hardware and software encryption methods. can provide secure links within your network. However, if you are using the Internet to pass data from site to site, you must remember that the Internet cannot provide secure links between every point and you may want to consider an end-to-end encryption technique for your system.
- Deny access from certain workstations to certain servers. For instance, allow only teacher workstations to access the server which contains student grades.
- Designate an individual or group of individuals responsible for making changes to administrative files. Others (i.e. your principal) should have read-only access to the

files, meaning they can bring the files up on the computer screen, but will not be allowed by the software to modify the files

- Specify times for access to data files.
- Scramble signals for broadband transmission to avoid unauthorized access.
- Secure or lock the room housing the computer with access rights to private records.
- Implement automatic timed log-out on computers with password access. This disconnects password-connected computers after a specific period of inactivity.

Ensuring privacy

To operate your network successfully, you must have certain information about your users — who they are, their addresses, and their phone numbers. To protect this information you can:

- Encrypt e-mail and other documents and communications (requires encryption software).
- Consider a privacy enhanced electronic mail system. Additional information on privacy enhancement is available from the Internet Activities Board Privacy Task Force which has drafted a standard for a protocol that can be used for privacy-enhanced mail (Refer to RFCs 1113, 1114, and 1115 or the current edition of the IABB Official Protocol Standards for information about standardization and status of these protocols [http://www.cis.ohio-state.edu/hypertext/information/rfc.html]).
- Implement password systems.
- Store sensitive information about your network's users, whether in hard copy or electronic form, in a school safe to prevent unauthorized access.

Preventing software piracy

- Use appropriate licenses and protection measures by sending in registration cards.
- Store original software disks and licensing information (software serial numbers) in a secure place.

Detecting and preventing viruses

Protect your system from viruses by doing the following:

- Install virus detection software on every computer and make sure it is set to run automatically.
- Read and react to virus alarms.
- Install CERT (Computer Emergency Response Team) patches so that virus detection is announced properly and action can be taken quickly.

Security layers

Different security measures are implemented at various points on a system. The following items are organized to give you an understanding of how and what different measures are implemented at different points in the system.

- Keep workstations secure
  - — Lock and alarm rooms that contain workstations.
  - — Secure workstations for earthquake safety.
  - — Run virus software in the background on each workstation.
  - — Run screen saver software with password protection on all staff workstations.
  - — Ensure that all machines connected to the network time-out. Consider a five minute time-out for staff workstations and a 15 minute time-out for student workstations .

- Keep servers secure
  - — Locate all servers in locked rooms or areas not accessible to students or other non-authorized persons.
  - — Password protect all servers. Change the passwords on a routine basis.
  - — Run virus software in the background on each server.
  - — Password protect all staff directories, on both administrative and educational servers.
  - — Deny student access to the administrative server.
  - — Password protect student directories on educational servers and / or workstations
  - — Use encryption for all e-mail.
  - — Back up files nightly and store them on-campus. At weekly intervals, send backups off-campus for storage.

- Keep hubs secure
  - — Locate all hubs in locked and weather resistant spaces.
  - — Use address filtering at the hub level to limit access to certain server(s). For example, only staff workstations should have access to the administrative server where grades are kept.
- Keep routers secure
  - — Locate all routers in locked areas.
  - — Set up a firewall on the router connected to the Internet to keep unwanted off-campus traffic off your network.

— Attach a monitoring station to the router to track traffic and attempted accesses.

— Deny incoming Telnet access from the Internet. Telnet access allows individuals to access their e-mail and the network from off-campus locations via the Internet. This, however, also provides an entry point where outside users can attempt to hack your system. Other methods of off-campus access or filtering techniques (access lists) can be utilized to allow only designated individuals to enter the network from off-campus locations.

- Keep applications secure

  — Require user passwords for e-mail and other applications, like attendance and grading

  — Use passive FTP software to prevent anonymous and unauthorized FTP requests.

- Keep remote access secure

  — Define your policy regarding the purposes for which remote dial up is to be used.

  — Use access lists to restrict access.

- Keep overall network secure

— Implement network management software and use it. The type needed will depend upon your network. A big sophisticated network will need a robust network management tool-set, which can be expensive. If you have network management in place at the county office, you can probably use a less expensive solution at the district and bypass your school. However, all network devices at all levels should be network manageable and have compatible SNMP modules included.

— Have contiguous TCP/IP addresses. They are easier to administer and therefore more secure than non-contiguous numbers.

— Carefully decide who will work on certain aspects of your network, such as access list updates, network configurations, as well as network management, hostmaster and postmaster tasks.

Sample security plan - Proactive measures

This sample plan presents security support measures for a K-12 group of approximately 10 schools in two districts. The Group of Schools plan will implement a modest, five-workstation Phase I LAN in each school, followed by a more robust Phase II LAN connecting all the rooms in each school. Technical support measures are presented as initial Phase I measures (as indicated), as well as later measures to complement the more rigorous demands of the groups' overall goals.

Workstations:

- (Phase I) Rooms with workstations will be locked and have alarms.
- (Phase I) Workstations will be secured for earthquake safety.
- (Phase I) Virus software will run in the background on each workstation.
- (Phase I) Staff workstations will have screen savers
- Machines connected to the network which are not being used will time out. Staff machines will time out after 5 minutes. Student machines will time out after 15 minutes.

Servers:

- Administrative servers at schools, the district servers, the Group of Schools server, and the county office of education (COE) servers will all be physically located in locked rooms or areas that will not be accessible to students or other non-authorized personnel.
- All district, Group of Schools, and COE servers will be password protected. Passwords will be changed on a routine basis.
- Virus software will run in the background on each server.
- Staff will have directories on the schools' Administrative and Education servers that will be password protected.
- Students will have directories on the school's Education server and/or workstations that will be password protected.
- Students will not have access to the Administrative servers.
- Password files and e-mail messages will be stored in an encrypted format.
- Server files will be backed up weekly at a routine day/time when the network is scheduled down. The back-ups will be stored in the firesafe at the District Office. The weekly back-ups will be kept for 5 weeks and then the tapes will be reused. Tapes will be thrown out and replaced according to life expectancy.

Hubs:

- (Phase I) All hubs will be located in locked and weather resistant spaces.
- Address filtering will be done at the switch level for access to certain servers (ex.: only staff workstations will be able to access the Administrative servers).

Routers:

- (Phase I) Routers will be located in locked areas.
- (Phase I) Firewalls are located on the COE router connected to the Group of Schools and on the router to the COE network.
- (Phase I) Telnet access will only be allowed at the COE level during Phase I.
- Future Telnet access down to the District and School levels will be decided on a district by district basis.
- (Phase I) Access lists will prevent unauthorized users from traversing the schools' networks.
- (Phase I) A monitoring station will be connected to the router for the network technician to use to track traffic and attempted accesses.

Applications:

- (Phase I) E-mail accounts and certain other applications, yet to be defined, will require user passwords.
- Passive FTP software will be used to prevent anonymous and unauthorized FTP requests.

Remote Access:

- (Phase I) A modem pool connected to the COE switch is used primarily for remote mail access and Internet services.
- (Phase I) Access lists will be used to restrict access.

Other network details:

(Phase I) COE will apply for a Class B TCP/IP address block (approx. 16,000 addresses), as one contiguous group of numbers is easier to administer and more secure than non-contiguous numbers.

- A hierarchy of network management software will be used:
  - (Phase I) HP Open View with SNMP (UNIX) at the county office of education
  - HP Open View with SNMP (UNIX) at the Group of Schools level.
  - DOS-based SNMP at the district level.

(Phase I) Only network personnel (no students) will be able to update access lists and perform network configuration, network management, hostmaster, and postmaster tasks.

Defining your technical support plan

Putting together a network is tricky enough, but keeping a network running can be even trickier still. Careful planning, design, and implementation of proactive monitoring and maintenance measures can help head off network problems before they occur. Equally important is a staff of technically trained people to lead technical support during all phases of network implementation and operation.

This section will provide suggestions for proactive measures that can be implemented at the staffing, network, workstation, server, and software levels. The three basic areas where astute technical support is needed make your network easy to use are:

- **Network set-up (formally known as configuration management) -** This area can be best understood as designing your network to operate smoothly. Your tech support staff will determine, and change as necessary, the set-up of your network, the different mechanisms for system status reports, and the naming of different elements in the network.

- **On-going network observation and modification (performance management)** - This area is defined as the continual evaluation of the behavior of different elements of your network. It includes capabilities for gathering and logging reports on network performance.

  Technically trained administrators will be needed to monitor its operation. Knowing how the network operates when it is healthy will help those who maintain the network pinpoint problems when they occur. A formal logging procedure might also be established to note both normal activities and problems. Having descriptions of all types of network activity will help anyone coming in at a later date understand how the network should operate and how to solve any problems that arise.

- **Troubleshooting (fault management)** - This area deals with the detection, isolation and correction of abnormal network operation. This includes notification of problems throughout the network, tracing of those problems, diagnostic testing to pinpoint what is causing the problem, and corrective action to alleviate the problem.

  The high cost of diagnostic tools and software is a difficult issue. In a large network, it will be nearly impossible to isolate problems without the assistance of diagnostic tools. When planning your network, investigate tools or software that will help you maintain the network, or at the very least, consider anti-virus programs that will check each device on the network. In larger networks, software-based diagnostic tools can test whether a networked device is operating correctly or is perhaps incorrectly terminated.

  When selecting staff for system administration, try to find individuals that are technically astute, practical, and eager to continually learn new aspects of technology. Other considerations might include ensuring your network technical support staff is properly trained on simple troubleshooting techniques and techniques for improving network operation. For example, loose or disconnected wiring can cause problems in networks, but can be easily remedied. Unterminated or improperly terminated cables are another source of problems but, again, careful planning and mapping of the network before network implementation can help alleviate these problems. Also, simple improvements in network operation can be obtained by adding memory (RAM) to

printers to speed up their acceptance of printing requests, or by using faster hard drives or file servers.

Proactive measures:

Each school should have a technical support plan that outlines who is going to perform which roles. Clearly defining the roles of the county office, district office, administrative staff, teaching staff, students, volunteers, industry partners, and parents in the plan. Some functions, such as hostmaster positions, may be centralized in a district or county office or given to certain individuals at a school. Other roles, such as computer support, will most likely require on-campus personnel.

The technical support plan and/or its accompanying policies and procedures should also elaborate on what preventative measures will be taken to keep the systems' components in good working shape — as well as the levels of escalation users should follow when they encounter problems with the system. Below are some suggestions as to what areas and items may be contained in a technical support plan.

Proactive staffing measures:

- Ensure that you hire qualified professionals to implement and support your school's technical capabilities.
- Students and volunteers should only be used to supplement hired professional staff.
- The number of professional staff will depend upon your school and population size. We suggest you consider the following minimum staffing levels:
    - 1 network manager at the county office
    - 1 network manager at the district
    - 1/2 network technician at each school
    - Students, teachers and volunteers at the school level to supplement need.
- All technical staff should be adequately trained on an on-going basis.

Proactive network measures:

- Considering purchasing as much equipment as possible with built-in network management software and tools. This may be initially more expensive but can save costs and time in the long run.
- Designate who is/are the network manager(s). All network tasks should be done by these individuals.
- Choose router, switches and hub network devices that can be remotely managed.
    - Have a monitoring station with network management software loaded.
    - Use utilization and error statistics for devices and the network as a whole.

- To detect problems

- For capacity planning

- Establish levels of escalation for problems.
  - Have well-trained people monitoring the network or available for impromptu consultation.
  - Phone support from each equipment vendor .
  - Purchase a maintenance contract for network hardware with stipulations that broken hardware will be replaced overnight (or within a time frame you can tolerate).
- Determine what network operating system software you will use.
  - Ensure you have a maintenance contract to receive software updates and bug fixes.
  - Ensure you will have help via telephone support.
- Determine what e-mail system(s) you will support (standardizing on one mail system is recommended). Determine how many people will have e-mail. Determine where the e-mail server will reside — at the county, district, school, Internet provider, etc.
- Designate who will fulfill the following roles:
  - Password management.
  - Postmaster for your e-mail system.
  - "Hostmaster" controlling your DNS (Domain Name Service). This function has to appropriately handle:
    - Equipment moves, adds and changes from the network perspective
    - IP address administration
    - Updates to the hostmaster database on the domain name server

Proactive server measures

- Obtain a maintenance contract for your server(s). Be sure it includes 24 hour replacement (or however long can you tolerate having the server down).
- Determine who will be the support managers or technicians, and who will be in charge of backups. These roles must be filled for each server you maintain. You might consider that only hired staff touch servers with teachers' files and that school technicians do not alter district or county servers, etc.
- Determine your escalation plan for problems and ensure it is communicated to users and technical support staff.
- Determine who will:
  - perform routine disk management
  - monitor available space

- monitor CPU utilization
- monitor network utilization
- create all directories for staff and students
- ensure routine backups, with appropriate off-campus storage, are completed

- Ensure that virus software is running and checks files created / updated.

Proactive workstation measures

Determine who will be the computer support technician(s) for staff machines and student machines. These individuals will:

- Configure machines
  - work with "Hostmaster"
    - set up Host's name
    - set up IP address
    - set up address for name servers
    - set up the IP network mask
  - set file / directory security
- Determine who will maintain staff and student workstations
  - attend to user or equipment malfunctions
  - maintain privileges to load software
  - perform routine disk management
  - conduct scheduled physical inventory and reporting for workstation status
- Determine what will be done for virus checking (for example, load software on each machine that checks at machine turn-on and / or at creation of any file)
- Determine what will be done for disk management
  - Where students will store their files— on disk, workstation, server, etc.
  - Will students files have security
  - Will backups be done for workstations
- Determine if there will be an "acceptable use" policy and how will it be enforced
- Determine escalation paths and communicate where users should go for help if they have problems with hardware, software, get a message that a virus has been detected, etc.

Proactive software support for users

- Determine training plans for teachers, students and technical staff. Training is the best defense against having network problems.
- Determine escalation paths for user software problems.
    - for teachers in the process of conducting a class
    - for general software questions

    Investigate offering at least one person in each school to provide software phone support for users.

Sample technical support plan —Proactive measures

This sample plan presents technical support measures for a K-12 group of approximately 10 schools from two districts. The Group of Schools plan will implement a modest, five-workstation Phase I LAN in each school -- connected via a WAN to a cingle County Office of Education server -- followed by a more robust Phase II LAN connecting all the rooms in each school, adding multiple LAN servers in each school, and a WAN server in each district. Technical support measures are presented as initial Phase I measures (as indicated), as well as later measures to complement the more rigorous demands of the groups' overall goals.

Staff:

Professionals will be hired to implement and support the schools' technical capabilities. Students and volunteers will be used to supplement hired staff. Staffing plans at full implementation of Phase II are as follows:

- (Phase 1) 1 network manager at the County Office of Education, funded by the COE.
- (Phase 1) 1 network manager at the Group of Schools, funded by the Group of Schools.
- 1 network manager at each district, funded by each district.
- 1/2 network technician at each of the schools, funded by each school.
- Students and volunteers at each of the schools, at no cost, or ROP students if use funded by school.

(Phase 1) All technical staff will be adequately trained on an on-going basis to do their jobs.

Network:

(Phase I) All routers, switches, and hub network devices will be managed.

- Monitoring stations will have network management software.
- Utilization and error statistics for devices and the network as a whole will be used.
    - used to detect problems.
    - used for capacity planning.

(Phase I) Levels of escalation will be established for use when problems occur.

- Will have trained people in the loop.
- Will have phone support from vendor.
- Will have a maintenance contract for network hardware, including replacement/fixes within 24 hours.

The following network operating systems will be used:

- (Phase I) UNIX/Solaris on the COE Sun server.

- UNIX / Solaris on the Group of Schools and District Sun servers.
- NT or Netware on each of the schools' Pentium Administration servers.
- AppleShare on each of the schools' Mac Student servers.
- (Phase I) All servers will have current NOS software licensing / maintenance contracts for software updates, bug fixes.
- (Phase I) Technicians will have help via telephone support.

(Phase I) One e-mail system (Pop mail, client / server). It will reside on the COE server. Approximately 5 staff members per school will have accounts.

- It will be recommended that all schools continue to use the same e-mail system on an on-going basis. It is anticipated that all staff members will have e-mail accounts and that elementary and middle school classes will share accounts. High school accounts to be determined. During Phase II, e-mail will start to migrate from the COE server to the Group of Schools server.

(Phase I) The network manager will be:

- The postmaster for the e-mail system.
- The hostmaster controlling the DNS (Domain Name Service)
- The persons responsible for password management.

(Phase I) The systems / network will be secured (Detailed in security plan).

Servers:

(Phase I) The COE network manager will support the COE server.

The Group of Schools and district managers will support the Group of Schools and district servers.

The district manager and half-time school network technicians will support the schools' servers. (Under no circumstances will students be able to access the Administration's server.)

(Phase I) The managers / technicians will:

- Perform routine disk management.
- Monitor available space.
- Monitor CPU utilization.
- Monitor network utilization.
- Create all directories for staff and students.
- Ensure routine back-ups, with appropriate off-site storage, are completed.

- Back-ups will be taken after school, once per week, during scheduled downtime.

(Phase I) All servers will have virus software running to check files created.

(Phase I) All servers will have a maintenance contract, including 24-hour replacement.

(Phase I) Escalation paths and back-ups will be determined and communicated.

Workstations:

(Phase I) The COE and Group of Schools network managers in Phase I and the District network manager working with the half-time School network technician from Phase II will:

- Configure machines
- Work as "Hostmaster"
    - Set up Host's name
    - IP address
    - Address for name servers
    - IP subnet mask
- Set file / directory security
- Perform routine disk management on staff workstations

(Phase I) The network managers will:

- attend to user or equipment malfunctions
- load software
- conduct scheduled physical inventory and reporting of all workstations' status
- perform routine disk management on students' workstations

(Phase I) Virus checking will run on each machine and check for viruses at the creation of files.

(Phase I) Students will sign an acceptable use policy on a yearly basis. School enforcement / discipline measures will be communicated.

(Phase I) Workstation escalation path will be determined and communicated.

(Phase I) No workstation back-ups will be taken. This will be communicated to students and staff so they understand that back-ups are conducted only once a week and only for servers.

Software for end users:

(Phase I) Training plans are being established for the teaching staff.

(Phase I) Escalation plans for user software problems will be determined and communicated.

(Phase I) One member per school will have phone access to a software support service. One District rep will have phone support for Internet software.

Developing your training plans

We suggest that you seriously consider developing training plans at the same time as your technology plan — including teacher, technical support staff and student training.

Teachers

Teachers will determine the rate at which computer technology is integrated into your school's curriculum. Their training should be a key focus area. Your plan should look at the base competency level which you would like all teachers to have; determine how far your teachers are from that goal; and put a plan in place to close that gap. We suggest that your plans not only include basic skills, but also specific training for the effective use of technology in the classroom and for the effective incorporation of technology into the curriculum.

We also suggest you provide on-going training, not only for new individuals, but to enable all your teachers to advance their skills and more effectively utilize technology to meet their teaching goals.

Methods for teacher training vary. They range from summer classes, weekend classes, afternoon classes, one-on-one tutoring with volunteer parents, and train-the-trainer sessions — to week-long classes during the school year when teachers are replaced by substitute teachers. Your school has to determine what combination will work for you.

Some schools and training institutes have been able to reinforce the teacher's training by giving them a workstation upon completion of their class(es). It is important that teachers have adequate access to computers after training, or training will not be retained.

Be sure to keep associated training costs in mind:

- Do you want to build a district training lab?
- Who will teach your classes?
- Will you send teachers to outside classes?
- Will you have to pay substitute teachers

Remember to include all these costs in your capital and operating budgets.

Technical staff

Technical staff training is vital — your system will only be as good as your staff. You should hire people that are technically quick and astute and then you must ensure that they are trained to handle all aspects of your current system. Technical staff must know how to fix the system themselves or who to call in a timely fashion to get the help they need. Your staff must stay abreast of new versions/releases of software that they should be learning and adding to your system. At least one key member of your technical staff must be aware of the general technology changes that are being introduced so that your school's long and short-term technical strategic plans will be kept up to date.

The training methods for technical staff are also varied. These range from:

- self teaching
- peer teaching
- vendor seminars
- visits to observe technical staffs at other schools, the district office or industry
- regular technical classes at schools

Be sure to allocate time and funding for training. We suggest approximately $1500 per person each year as an average starting point. Be sure to encourage your staff to teach each other what they have learned. It's a great way to reinforce learning and to effectively pass on training, while keeping your costs down. Again, training takes time. It is up to management to place priority on training and to effectively communicate that to the staff.

Students

Last but not least, student training can be best determined by examining what your benchmarks are for student technology success. These goals should drive a good part of your technology plan. We suggest you list the computer skills you expect for the K-12 levels in your technology plan. This gives you a focus point to help map the rest of the plan to your expectations.

Having a technical curriculum and classes established in schools will help narrow the gap between those children who have computers at home and those who do not. Also consider special tutorials for student training, above and beyond computer classes, to bring those students who are unfamiliar with computer and network fundamentals up to speed. Again, take a look at all the associated costs and be sure to add them to the budget.

Creating your budgets

Your technology plan will need to include both capital and operating budgets.

- Start with an inventory of what hardware and software your school currently owns and determine how you are going to upgrade, supplement and/or replace it.
- Create an equipment specifications list which covers all the major specifications of the equipment you wish to purchase. This will help avoid purchasing equipment that is not really what was intended.
- Corresponding to these lists, your plan should include its capital (new purchase) budget which list the one time cost of buying equipment and software.

  Note: Industry, or taxable corporations, cannot buy software under "capital" as software does not have the same tax status as depreciable equipment. However, for tax-exempt schools this is not an issue and new software purchases can be combined with capital budgets.
- Create an operating budget. This includes all of the costs that are considered on-going (rather than one-time) costs. Typically costs are figured either on an annual basis, such as staff salaries, maintenance contracts, software licensing, etc. or they are figured on an event basis, such as software upgrades that appear with each new software version.

Examples of both capital and operating budgets are given here. The items and prices listed are only estimates to give you a rough estimate of what you can expect to find.

Sample Capital Improvement Budget

WIRING MATERIALS		Estimte	Total
Quantity	Description	Unit Price	Amount
0	12 Strand Riser Rated MultiMode Fiber Optic Cable	$ 2.00	$ -
0	12 Strand Riser Rated Single Mode Fiber Cable	$ 3.00	$ -
0	CAT 5 UTP (1,000 FT. ROLLS)	$ 85.00	$ -
0	COAX (1000 FT. Rolls)	$ 40.00	$ -
0	RJ-45 Connectors	$ 0.18	$ -
0	Patch Panel to Hub Jumpers 2'	$ 3.00	$ -
0	Patch Panel to Hub Jumpers 3'	$ 3.00	$ -
0	Wall Connections with Faceplates	$ 7.00	$ -
0	Workstation Jumpers - 7'	$ 4.00	$ -
0	Workstation Jumpers -15'	$ 5.00	$ -
0	Workstation Jumpers - 25'	$ 6.00	$ -
0	Splice Boxes	$ 15.00	$ -
0	Wall Mount Race and Bends	$ 2.00	$ -
0	Conduit	$ 1.15	$ -
0	12 Port Patch Panels	$ 125.00	$ -
0	24 Port Patch Panels	$ 150.00	$ -
0	19" Modular Floor to Ceiling Racks	$ 150.00	$ -
0	UTP Connector Tool	$ 20.00	$ -
		Total Wiring	**$ -**

ROUTER AND HUB ELECTRONICS		Estimte	Total
Quantity	Description	Unit Price	Amount
0	CSU/DSU ONLY	$ 1,200.00	$ -
0	County Office Router (or central connection spot)	$ 30,600.00	$ -
0	Fiber Capable School Routers	$ 6,725.00	$ -
0	School Routers	$ 5,175.00	$ -
0	16 Port TP Switched Hub	$11,700.00	$ -
0	16 Port Fiber Switched Hubs	$17,700.00	$ -
0	16 Port TP/Fiber Switched Hub	$14,700.00	$ -
0	Hub Documentation	$100.00	$ -
0	12 Port Stackable Hub and SNMP Module	$1,400.00	$ -
0	4-12 Port Stackable Hub and SNMP Module	$3,700.00	$ -
0	Fiber Optic Transceivers (Multi-mode)	$335.00	$ -
0	UTP Transceivers	$125.00	$ -
0	Expansion Cables	$60.00	$ -
0	UPS/Line Conditioner - 4 plug	$ 600.00	$ -
0	UPS - 4 plug	$ 300.00	$ -
		Total Router And Hub Electronics	**$ -**

Sample Capital Improvement Budget (continued)

SERVERS AND WORKSTATIONS		Estimte	Total
Quantity	Description	Unit Price	Amount
0	County Office or District Office Server	$ 40,000.00	$ -
0	County Office or District Office Server	$ 16,000.00	$ -
0	School Administration Server	$ 10,000.00	$ -
0	School Educational Server	$ 14,000.00	$ -
0	Multimedia Workstations for Teachers and Students	$ 2,000.00	$ -
0	CAD Workstations	$ 4,000.00	$ -
0	Network Interface Cards as needed	$ 150.00	$ -
0	Workstation & Server Additional Memory as needed	$ 160.00	$ -
	Total Server and Workstation Equipment Budget		**$ -**
Upgrade & Peripheral Equipment Budget		**Estimte**	**Total**
Quantity	**Description**	**Unit Price**	**Amount**
0	Ethernet Cards and Transceivers	$ 150.00	$ -
0	Surge Protectors	$ 20.00	$ -
0	Workstation Additional Memory as needed	$ 160.00	
0	Active Matrix LCD Projection Panel	$ 2,500.00	$ -
0	Portable Overhead Projector	$ 450.00	$ -
0	Digital Camera	$ 650.00	$ -
0	Flatbed Color Scanner	$ -	$ -
0	Laserdisk Players	$ 700.00	$ -
0	VCR	$ 300.00	$ -
0	Large Screen TV Monitor	$ 700.00	$ -
0	Laser Printers (1 per classroom & lab)	$ -	$ -
0	Printer Transceivers	$ 285.00	$ -
	Total Upgrade & Peripheral Equipment		**$ -**
FURNITURE REQUIREMENTS		**Estimte**	**Total**
Quantity	**Description**	**Unit Price**	**Amount**
0	Workstation Desks	$ 150.00	$ -
0	Workstation Chairs	$ 75.00	$ -
	Total Furniture		**$ -**
SAFETY/SECURITY IMPROVEMENTS		**Estimte**	**Total**
Quantity	**Description**	**Unit Price**	**Amount**
0	Workstation Physical Securing Kit	$ 25.00	$ -
0	Deadbolt Locks (Installed)	$ 100.00	$ -
0	Rack Mount Securing Hardware	$ 25.00	$ -
	Total Security/Safety Improvements		**$ -**

Sample Capital Improvement Budget (continued)

WORKSTATION SOFTWARE		Estimte	Total
Quantity	Description	Unit Price	Amount
0	Antivirus/Disk Utilities	$ 50.00	$ -
0	Wordprocessing, Spreadsheet and Presentation	$ 45.00	$ -
0	Children's Multimedia Writing Tool	$ 30.00	$ -
0	Mail and Internet Software	$ 4.00	$ -
0	Other Instructional Software	$ 150.00	$ -
	Total Workstation Software		**$ -**
SERVER SOFTWARE		**Estimte**	**Total**
Quantity	**Description**	**Unit Price**	**Amount**
0	Network Management	$ -	$ -
0	Virus Protection	$ -	$ -
0	Security	$ -	$ -
0	Utilities (Disk, File, Backup)	$ -	$ -
0	Print and File Services	$ -	$ -
0	Web Server	$ -	$ -
0	Administation and Grading Software	$ -	$ -
0	Router Network Management Software	$ -	$ -
0	Other Software To Be Shared	$ -	$ -
	Total Server Software		**$ -**
INSTALLATION COSTS		**Estimte**	**Total**
Quantity	**Description**	**Unit Price**	**Amount**
0	Telco / WAN Installations	$ -	$ -
0	Wiring Installation and Testing	$ -	$ -
0	Network Electronics Installation	$ -	$ -
0	Fiber Optics Splicing	$ -	$ -
	Total Installation Costs		**$ -**
	TOTAL CAPITAL BUDGET		

Sample Technical Operating Budget

Quantity		Estimated Unit Cost
	Personnel (PT&B)	
	District Network Manager	
	School Network Technician	
	Maintenance Contracts	
	Network Hardware:	
	Router-Fiber capable	260
	Router-UTP	200
	Switched Hub-16 port fiber	160
	Switched Hub-8 port TP module	135
	Switched Hub-8 port Fiber module	270
	Switched Hub for County or central connection point	350
	Hub-12 port for each classroom	35
	Servers:	
	County or District hw/sw Contract	960
	County or District hw/sw Contract	1,440
	School Administration Server - $ for repair if no good contract available	600
	School Education Server - contract for 4 hr callback & within 3 day fix	575
	Workstations/Printers:	
	decide if needed	
	Software License and Upgrades	
	Routers, Network and Servers	
	School Router: Boundry Routing & All, Complete Protocols	400
	Network Management for County or District	9,000
	Network Management at School	700
	Network Operating System (NOS)	
	Utilities	
	Virus	
	Security	

Sample Technical Operating Budget (continued)

Quantity		Estimated Unit Cost	Total Amount
	Software License and Upgrades - Workstations		
	Workstation System OS - upgrade or school site license/yr		
	Antivirus - per seat/yr	7	
	Disk Utilities -per seat/yr	8	
	Word Processing, Spreadsheet and Presentation - upgrade or license	20	
	Children's Multimedia Writing Tool	20	
	Other Instructional Software - per seat per yr.	150	
	Internet, Mail and TCP/IP - per seat/account	4	
	Equipment Expense		
	General Repair/Replacement (per school)	10,000	
	Supplies (paper, disks, cartridges, etc. per school)	7,500	
	WAN Service		
	ISDN - 128KB per year (1 for K-5; 2 for 6-8)	770	
	Frame Relay - 384 per year	6,750	
	T1 (varies by distance)		
	Phone lines for Modems Remote Access to COE	9,600	
	Subsciptions		
	On-line Services, Mail Accounts		
	Educational Services		
	Phone Support for Applications (1 FTE/school)	2,000	
	Archiving		
	Tapes per school/yr.	350	
	Tapes for District and County	350	
	Training		
	Training Cost for each Teachers (5 days)		
	Subs forTeachers (5 days)	400	
	Training for Technical Staff - per person/yr	1,500	
	Facilities		
	Office Space for Personnel		
	Equipment Storage Space		
	Alarm Service		
	Temp. Control Costs		
	TOTAL OPERATING BUDGET		

Planning for existing systems

As a closing note to this planning chapter, even systems that have been in place for years require planning by the network manager. A well-planned network makes network use easy and allows all users to be productive. A system that was designed well can degenerate over time without planning, and can become difficult to use. This may cause its users to be frustrated and unable to perform tasks easily on the network. Students and teachers may lose interest if the network is difficult to use or subject to problems.

Network planners need to make on-going decisions about such things as network topology, types of cables, capabilities of computer equipment, network operating systems, and how best to allow for differing types of devices and applications on the same network. Investigation of these issues should be undertaken before decisions are made. It is important to establish a long-range plan which shows project goals, short range plans on how you are going to reach those goals, and annual re-evaluations of your plans given the quickly changing pace of technology.

Planning is equally important at the district and county office levels. Without planning, districts and counties can end up with a plethora of technologies, operating systems, network operating systems, and applications that will become increasingly more complicated to support and manage. It is extremely important to decide when it is time to divest of the old and convert to the new. In the long run that usually leads to a successful balance of system simplification and cost effectiveness, with technical support that meets the users' increasing complex requirements.

Glossary

See the *Building the Future K–12 Network Technology Planning Guide* by the California Department of Education.

Configuration
The software settings that allow different hardware components of a computer system to communicate with one another.

Ethernet
A local-area network standard defining a physical medium and its method of placing data, or packet signaling, on a cable. Based on CSMA/CD and 10 Mbps.

Ethernet address
The unique numeric identifier of a node on a LAN.

Graphical user interface (GUI)
A computer interface that incorporates easy-to-comprehend pictorial elements such as graphs and icons.

Icon
A graphical representation of various separate elements in DOS Windows.

IEEE 802.3
A subcommittee of the Institute for Electrical and Electronics Engineers (IEEE) 802 committee. Establishes standards for interface and protocol specifications for Ethernet, in accordance with the ISO model.

Input/Output (I/O)
The method, medium, or device (such as a keyboard, monitor, floppy disk, hard disk, network adapter, or printer) used to transfer data to a computing system or from the computing system back to a device, a network, and so on.

IPX
Internetwork Packet Exchange. This is a communication protocol that creates, maintains, and terminates connections between network devices, such as workstations and servers.

LAN
Local area network. A communications network within a limited physical area (up to about 6 miles or 10 kilometers) that provides high-speed (over 1 Mbps) data transmission. The basic components of a LAN are the boards that plug into each computer to connect it to the network, cabling, server hardware, and software for network control.

Mbps
Megabits per second.

Network
A series of nodes such as computers, terminals, or other peripherals interconnected by a communications channel.

Network adapter
A circuit board located inside each workstation and server on the network. It allows the device to listen and talk to other stations and nodes on the network.

NLM
NetWare Loadable Module. This is a program written to be run on a NetWare 3.x server. Such programs include disk drivers, LAN drivers, and other file server management and enhancement utilities.

Node
A point in a network where a communicating device is linked to the network and where information can be sent or received.

Protocol
A formalized set of rules that computers use to communicate. Because of the complexity of communications between systems and the need for different communication requirements, protocols have been divided into modular layers, in which each layer performs a specific function for the layer above.

Segment
All or a portion of a physical network or LAN.

SNMP
Simple Network Management Protocol. This is a network monitoring protocol for TCP/IP-based networks. It is a simple request/response protocol used to communicate management information between the network management station and the agent residing in the network elements. The protocol does not define the objects that can be managed. SNMP can be used with any network management variable that can be inspected and altered. SNMP management of 3Com's adapters is offered using 3Com's SoftHub.

Topology
The pattern of physical and logical links between nodes on a network.

WAN
Wide-area network. This is a network covering large distances (50 square miles or more) that may include packet-switched, public data, or value-added networks.

Appendix A — Acronyms

The acronyms listed here are used in this book. For detailed definitions and descriptions of the acronyms listed here, see the K–12 Network Technology Planning Guide.

Acronym	Meaning
ATM	Asynchronous Transfer Mode
bps	bits per second
BRI	Basic Rate Interface
CAPS	competitive access providers
CCITT	International Telegraph & Telephone Consultative Committee
CD	compact disk
CDE	California Department of Education
CDDI	Copper Distributed Data Interface
CERT	Computer Emergency Response Team
COE	county office of education
CPU	central processing unit
CSMA/CD	Carrier Sense Multiple Access/Collision Detection
CSU	Channel Service Unit
dpi	dots per inch (resolution)
DSU	Data Service Unit
DUA	disconnect unauthorized addresses
ESF	Extended Superframe Format
ETFS	Educational Television Fixed Service
FDDI	Fiber Distributed Data Interface
fps	frames per second (video)
FTP	File Transfer Protocol
GB	gigabyte
GIF	Graphics Interchange Format
Hz	hertz
IEEE	Institute of Electrical and Electronics Engineers
ISDN	Integrated Services Digital Network
ISP	Internet service provider
JPEG	Joint Photographic Experts Group
Kbps	kilobits per second
KBps	kilobytes per second
KHz	kilohertz
LAN	local-area network
MB	megabyte
Mb	megabit
MCU	Multipoint Control Unit
Mbps	megabits per second
MBps	megabytes per second
MHz	megahertz
MUX	multiplexer

NEXT	near-end cross talk
NLM	NetWare-Loadable Module
NT	network terminator
ppm	pages per minute
PRI	Primary Rate Interface
RAM	random access memory
RF	radio frequency
ROM	read-only memory
SNMP	Simple Network Management Protocol
SVGA	Super Video Graphics Array
TA	terminal adapter
TAXI	Transparent Asynchronous Transceiver Interface
TCP/IP	Transmission Control Protocol/Internet Protocol
UPS	uninterruptible power supply
UTP	unshielded twisted pair (wiring)
VGA	Video Graphics Array
WAN	wide-area network
WORM	write once/read many
WWW	World Wide Web

Appendix B — References

Building the Future K–12 Network Technology Planning Guide
by the California Department of Education.

Computer Networking for Educators by Ted D.E McCain and Mark Ekelund
©Published by the International Society for Technology in Education 1993

The Switched-on Classroom A Technology Planning Guide for Public Schools in Massachusetts, by the Massachusetts Software Council, Inc.

RFC 1244, the *Site Security Handbook* , a product of the Site Security Policy Handbook Working Group (SSPHWG), a combined effort of the Security Area and User Services Area of the Internet Engineering Task Force (IETF) by P. Holbrook CICNet, J. Reynolds – contributing authors; Dave Curry (Purdue University), Sean Kirkpatrick (Unisys), Tom Longstaff (LLNL), Greg Hollingsworth (Johns Hopkins University), Jeffrey Carpenter (University of Pittsburgh), Barbara Fraser (CERT), Fred Ostapik (SRI NISC), Allen Sturtevant (LLNL), Dan Long (BBN), Jim Duncan (Pennsylvania State University), and Frank Byrum (DEC)

Technical Guidebook ordering procedure

There are several ways to obtain copies of the Smart Valley Technical Guidebook for Schools. To expedite your receipt of the document and help us maintain an organized distribution you can do one of the following:

- If you have access to a copy of the Guidebook, you are free to photocopy the document as long as you abide by the reproduction rules in the copyright notice. We encourage you to photocopy the document whenever possible, before trying other means of obtaining copies.

- If you have World Wide Web access, you can download the entire document from Smart Valley's Web site. The document is available in multiple formats. The Guidebook can be found at:

  http://www.svi.org/PROJECTS/SCHOOLS/guidebook

- If you represent a school located in Santa Clara or San Mateo county, you can obtain printed versions of the Guidebook from your respective county office of education.

  Santa Clara County Office of Education 408-453-6727
  San Mateo County Office of Education 415-802-5444

- If you do not have Web access but have electronic mail, you can send a request for a printed version to document@svi.org. The body of the message should contain the phrase: Send Smart Schools Guidebook followed by your mailing address. Please allow two to three weeks for delivery.

- Only if none of the other options is feasible, call our offices at 408-562-7707. Leave a voice mail message with your mailing address. Please allow two to three weeks for delivery.

K–12 Guide ordering information

If you have Internet access, you can view or download the K–12 Network Technology Planning Guide from the following sites:

Gopher://goldmine.cde.ca.gov
ftp://goldmine.cde.ca.gov
http://goldmine.cde.ca.gov

The complete Gopher address for the K–12 Network Technology Planning Guide is

Gopher://goldmine.cde.ca.gov:70/11/C_D_E_Info/Technology/Guide

NOTE: Internet addresses change frequently, so the current address may differ from the addresses shown above.

A printed version of the K–12 Network Technology Planning Guide is available from the California Department of Education (CDE) as described in the CDE catalog:

Building the Future: K–12 Network Technology Planning Guide

Modern interactive, high-capacity communications networks can bring up-to-date information directly into the learning environment in a variety of electronic formats and educational contexts. This guide will help school administrators, teachers, and technology directors understand the technical issues related to network planning.

Items discussed include an introduction to the emerging role and benefits of networks; design parameters, planning guidelines, and training needs and resources. 1994, 188 pp.

Item No. 1166 $11.75

Instructions for ordering a printed version are as follows.

- By credit card:
  - Order toll-free by using your VISA card or MasterCard 1-800-995-4099 (continental U.S. only)
  - Order by fax (916) 323-0823 (worldwide but not toll-free) using your VISA card or MasterCard

If you use your VISA card or MasterCard, include your card number, expiration date, and signature. Please order by item number and title.

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Appendix C — Internet addresses

Devices such as personal computers connected to networks using the Internet and TCP/IP require a special address. This special Internet address is assigned by the Defense Data Network Information Center, or NIC as it is also called. Upon application from an organization, the NIC assigns a network address or range of addresses appropriate to the number of network-attached devices, or hosts, on the network. There are five classes of network addresses. The classes differ in the number of bits allocated to the network. The NIC defines a network as a collection of hosts.

The notation used for Internet addresses is called dotted decimal. It consists of four numbers between 1 and 255 separated by dots. The groups of numbers identify the network number followed by the local address or the specific host number. Here is an example of an Internet address represented in dotted decimal notation:

127.35.34.1

The following table shows the range of numbers for each Internet address class.

Class	**Address range**
A	1.0.0.0 through 126.0.0.0
B	128.1.0.0 through 191.254.0.0
C	192.0.1.0 through 223.255.254.0
D, E	224.0.0.0 through 255.255.255.254

The Internet addresses are used by many different types of organizations and for differing functions within the Internet. All Class D addresses have a special use in the Internet, and all Class E addresses are reserved for future use. Within the class A, B, and C addresses, a small number are also reserved; the remaining addresses are divided up for use among research, defense, non-defense, and commercial organizations.

Because the Internet addresses can be awkward to type and remember, system administrators equate them to a domain name. For example, the name VENERA.ISI.EDU is also IP address 10.1.0.52.

The DDN Network Information Center is located at Government Systems, Inc. in Virginia. You can reach them several ways.

By mail:

DDN Network Information Center

14200 Park Meadow Drive, Suite 200

Chantilly, Virginia 22021

By e-mail:

HOSTMASTER@NIC.DDN.MIL

Users requesting new Internet addresses can begin registration over the phone by calling:

1-703-742-4777

There is also a toll-free user assistance service available from 7 a.m. to 7 p.m. Eastern Standard Time at:

1-800-365-3642

There is no charge for an Internet address, but there are often backlogs in processing them, so it might take a few weeks to obtain an IP address.

Appendix D — Structured premises wiring

Structured premises wiring is an organized system of cables within a building. Structured wiring can be adapted to support the main network types. These components include the following:

- Wall outlets in the work areas
- Horizontal station drop cables
- Horizontal wiring patch panels
- Vertical wiring patch panels
- Vertical trunk cables
- Premises wiring system
- Wall outlets

In a structured premises wiring system, one type of connection interface is presented to the user in the work area. The RJ-45 wall outlet is one example of a common interface connector. Resembling a telephone wall-jack, the RJ-45 connector can be wired to provide interface to many different signaling schemes. Other types of outlets are also possible. The network station connects to the wall outlet using an interface cable and card appropriate for the network type in use.

Horizontal station drop cables

The horizontal station drop cables connect the individual work area wall outlets with a common connection point. This connection point is usually located in a wiring closet. The horizontal station drop cables are typically twisted-pair copper wire. Twisted-pair wire is usually used because of its physical flexibility and low cost. It is possible to use fiber-optic cable for station drops, but the cost is prohibitive for most uses.

Horizontal wiring patch panels

Station drop cables terminate in patch panels or wiring blocks providing a centralized location for connection management. This centralized location is usually in a wiring closet, which also typically houses the connection equipment for the telephone system.

The network type being implemented determines which type of patch cables are used to connect the patch panel connectors to the network concentrator also located in the wiring closet. The network concentrator could be a single segment workgroup concentrator or a multi-segment wiring hub. An additional patch panel to the vertical wiring system can also located in the wiring closet.

Vertical trunk cables

The vertical trunk cables distribute the network vertically between the floors of a building. Additionally, similar trunk cables can be used to distribute the network between buildings. Fiber-optic cables provide the high bandwidth typically required for network distribution.

Vertical cable patch panels

You can set up interfaces to the vertical cables through a patch panel. The type of cable used to interface to the patch panel is determined by the network type the connection is to support.

Termination connection

Workstation connection

The suggested minimum cabling at each network location is as follows:

- Three four-pair, Category 5 UTP cables terminated on RJ-45 jacks.

  Expected uses: Combinations of 10BASE-T connections, 100VG or 100BASE-X connections, telephone lines, existing LocalTalk connections, separate administrative and instructional LANs, or spare pairs in case of damage to one of the others.

TIP: For ease in identification and long-term support, consider using different jacket colors on the three cables; for example, assign gray to 10BASE-T, red to 100BASE-X or 100VG, and blue to telephones or LocalTalk.

- Two RG-6 75-ohm coaxial cables terminated on F connectors. One cable is for incoming video and two-way data, the other is for outgoing video.

  Expected uses: Distribution of analog video, either closed-circuit or cable TV, or broadband WANs.

- One six-strand, singlemode fiber-optic cable, unterminated until needed (terminated on SC or ST connectors).

  Expected uses: Longer-term, high-speed future WAN technologies, such as ATM, digital video, high-speed backbones. Optional and suggested when funding is available or uses listed are likely to develop in the near term.

- One six-strand, multimode fiber-optic cable (62.5/125 µm) unterminated until needed (terminated on SC or ST connectors).

  Expected uses: Near-term use of 10BASE-F Ethernet extensions to remote locations (10 Mbps), 100 Mbps high-performance multimedia workstations, Web servers or large file servers, 100 Mbps FDDI backbones, 100 or 140 Mbps Transparent Asynchronous Transceiver Interface (TAXI), or multimode OC-3 (ATM technologies).

Category 5 twisted pair is suggested for connecting all workstations to hubs, or hub-to-hub connections, as long as the network adheres to cable distance limits. For longer distances between equipment, 10BASE2 or 10BASE5 can be used — however fiber is suggested, because at present, there is no way to upgrade 10BASE2 or 10BASE5 to 100 Mbps technologies. This may change in time, so check with a network technology expert.

NOTE: Network design is a very complex and rapidly changing component of an overall networked computing strategy and implementation plan, with significant cost ramifications. It is strongly suggested that a network design consultant prepare or review proposed network topologies and technology choices.

Appendix E — Individual Contributors

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