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AUTHOR Piele, Philip K.
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ABSTRACT

Local area networks (LAN) are privately owned communication systems that connect multivendor devices at high speed. As microcomputers become more common in schools, user interest in sharing information, software, and peripherals will increase. A basic understanding of the operation of all LAN's can be gained by knowing four elements: media, topology, method of channel access, and bandwidth. LAN's used for instruction provide advantages not available from a single microcomputer. Cost savings result from students sharing public domain and network-licensed instructional software as well as peripherals. Teachers can unobstrusively monitor students' progress while programs make the assessment of student progress easier. Communications devices turn the microcomputer into a library. Administrative applications of LAN's include recordkeeping, word processing, budgeting, scheduling, and inventory control. The use of any micrcomputer LAN available today is limited by (1) the need for network management, (2) the shortage of technical support, (3) the lack of multi-user database management system (DBMS) software, and (4) the legal barriers to the use of single-user software on LAN's. School administrators should begin a process of hands-on LAN familiarity and training, site visitations, and data communications needs assessment before purchasing a LAN. Twenty-eight references are included. (MLF)

Local Area Networks in Education

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Philip K. Piele

ERIC Clearinghouse on Educational Management
College of Education, University of Oregon

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Foreword

This paper was prepared for the 1986 Yearbook of the National Society for the Study of Education (NSSE) on "Education and Micro-electronic Technologies," edited by Jack Culbertson and Vern Cunningham. The ERIC Clearinghouse on Educational Management is pleased to reproduce the paper in this format so that our clientele can gain maximum use from this information on a rapidly changing area of educational technology.

An earlier, shorter version of this paper appeared in the Proceedings of the Conference of The Computer: Extension of the Human Mind III, 1984, published by the Center for Advanced Technology in Education (CATE) at the University of Oregon.

Philip K. Piele is professor of education in the College of Education, University of Oregon, and is director of the ERIC Clearinghouse on Educational Management, as well as director of networks and communications for CATE. From January to June 1984 he studied local area networks while on sabbatical at Stanford University; since then he has taught courses and written articles on the subject.

Stuart C. Smith
Assistant Director
and Editor

Introduction

Considering the amount of talking and writing on the topic of local area networks (LANs) for microcomputers, it is not surprising that some vendor public relations personnel have declared 1985 to be "the year of the LAN." [1] Well over 150 LAN vendors have entered the market, according to some surveys, amidst promises of a microcomputer data communications Nirvana. What is surprising is that only a handful of these LAN vendors have installed their systems in any significant numbers, and fewer systems still have been installed in schools.

So why all this frenetic effort by so many companies to sell a product that so far has attracted so few customers? Two reasons serve to provide at least a partial explanation for this seeming madness.

First, the number of microcomputers installed in homes, businesses, and educational institutions is expected to exceed 15.5 million by the end of 1987, nearly quadrupling the 1983 installed base.[2] Second, as the microcomputer becomes more common in the office, classroom, and laboratory, user interest in sharing information, software, and peripherals will increase.

Microcomputers have allowed users to break the computing apron strings with the mainframe or minicomputer. Now many want to connect with other microcomputers and also to reconnect with mainframes and minis. One means for accomplishing this connection--physically at least--is supplied by the local area network.[3]

But what about schools? Is there a LAN in their future? According to a recent survey published by the Center for Social Organization of Schools, as of January 1983 approximately 7 percent of this country's elementary schools and 40 percent of its secondary schools had five or more microcomputers, nearly double the number of schools reporting at least five microcomputers six months earlier.[4] So as the base of microcomputers expands, the potential application for LANs will expand as well. Thus more and more school districts can be expected to begin exploring the possibility of acquiring a LAN to enhance both their administrative and instructional efforts.

But as a commercial offering, LANs are still in their infancy--more a concept than a product,[5] more questions than answers. This paper will attempt to provide some answers to several questions: What are LANs? What are the basic elements of their technology? What are their typical hardware and software components? What are some of their instructional and management applications in schools? What are the current limitations on their use? What should schools do about LANs now?

Finally, it should be clearly understood that what is here said about LANs is merely a "snapshot" of a highly complex, rapidly evolving technology. Within a year after the completion of this paper

(end of February 1985), leading computer companies such as Apple, Hewlett-Packard, and IBM will have new office LANs available for purchase from retail computer stores, established LAN vendors will have released new hardware enhancements such as gateways to other networks or faster and more versatile network servers, popular software companies such as Microsoft, Lotus, and Ashton-Tate will have announced or released LAN compatible products, and on and on and on.

Local Area Networks Defined

There are several definitions of a LAN--some quite technical, others oriented toward the strengths of a particular network design. The definition used in this paper, a composite of two previously written definitions [5,6] plus some original additions, emphasizes localized data communication links between microcomputers in an office, classroom, or building. A LAN, then, is a privately owned (not FCC regulated), user-managed, commercially available wire or cable-based communication system composed of both physical and logical parts, capable of connecting multivendor devices (computers, printers, graphic plotters) at high speed in an office, classroom, or building.

This definition is intended to deal with the multivendor nature of microcomputers in elementary and secondary schools, as well as limit the scope of this chapter. That is to say, this paper will not deal with LANs that only connect TRS 80s together or Acorns together, no matter how fast or how well supported or how reliable they are, because most schools in this country have acquired microcomputers from

several different vendors--Apple, Radio Shack, Commodore, Atari, Acorn, and IBM. So for LANs to have any practical value in schools they must be able to fully connect microcomputers from more than one vendor.

This definition and, therefore, this paper focus on office and classroom LANs and thus exclude broadband networks that provide data, voice, and video communication links between buildings over distances of up to thirty-five miles.

Although the technology of broadband LANs for intrabuilding use does not differ from that involved in linking buildings together, implementation of such a large system by most school districts generally involves a significant investment by the local CATV company or the availability of access to metropolitan optical fiber cable installed by AT&T or a regional telephone company.

This definition also excludes wide area (national and international) value-added networks like Tymnet and Telenet that provide, among other things, local data communication links to such national information utilities as The Source and CompuServe.

Overview of LAN Technology

A thorough knowledge of the architecture and design of LANs is not essential to understand their use or even to purchase and install some of the less complex ones. Nevertheless, knowledge of at least some of the basic elements of LAN technology is useful in comparing the performance, features, and applications of some of the more popular office and classroom LANs on the market today. A basic understanding of the operation of all LANs can be gained by knowing four elements: the media, the topology, the method of channel access, and the bandwidth. It should be noted, however, that while these four elements of LAN technology will be discussed separately, they are in practice closely interrelated. Technical jargon will be kept to a minimum. A selected list of recent books on local area networks is provided for those who want to learn more about such things as network architecture, multiplexing, and communications standards.[7]

Media

Medium refers to the physical connection between two or more devices over which information is transmitted. The three most common media used with LANs are twisted pair wire, coaxial cable, and optical fiber. **Twisted-pair** are two copper wires that are wrapped together and twisted to reduce external interference. It is the medium used by telephone companies for voice transmission and is therefore the most widely installed transmission medium in buildings today. Twisted-pair can also support data transmission either alone or in conjunction with voice transmission.

Local area networks using twisted-pair wire generally support no more than 64 devices. The medium is limited to transmission distances of up to 4,000 feet with repeaters and to transmission speeds of no more that two million bits per second. At present, this medium is less expensive than coaxial cable and optical fiber and, therefore, is frequently selected by cost-conscious schools and other local units of government regardless of other performance criteria.

The second most common transmission medium is **coaxial cable.** Coaxial cable is composed of two conductors, with one in the middle and the other one surrounding it to form a protective shield. This medium is commonly used by CATV companies to transmit video signals to televisions in homes throughout a community. While more expensive than twisted-pair wire, it can support as many as 1,000 devices over transmission distance of up to 10 kilometers at transmission speeds of up to 10 million bits per second.

Optical fiber is essentially spun glass that transmits

information on a beam of high-intensity light currently provided by a laser. Although several times more expensive than coaxial cable, it can support several thousand devices at transmission speeds of nearly 2 billion bits per second over distances of up to 20 kilometers. Furthermore, optical fiber cable is very difficult to tap without detection so it has extremely high transmission security. It also can withstand temperatures of up to 2,500 degrees centigrade, so it is virtually immune to lightning and to most building fires. Most LANs now using opical fiber are essentially designed to link to heavy-load, long-distance, large-computer interface networks where the higher cost of optical fiber can be justified. As demand for optical fiber cable escalates, supply will increase and price fall. But it is unlikely that optical fiber will replace twisted-pair or coaxial cable for LANs used to interconnect microcomputers for administrative or instructional applications in schools before the end of the decade.

Topology

The next basic element of network technology is the physical shape or configuration of the network. The technical term for this element is **topology**. The three most common topologies for LANs are star, bus, and ring. The oldest network topology is the **star**, which was the layout for all of the early timeshare computer systems. The terminals in these systems were linked point-to-point by twisted-pair wire (generally existing telephone lines) to a central computer that controlled, either through switching or a port selection process, the data transmission traffic for the

entire network. This is still the most common topology for school district computer services where terminals--placed in various locations throughout the district--are all linked to a central mainframe or mini-computer. The major problem with this topology is that if the central computer fails, the entire network fails. While the microcomputer has replaced the terminal in many school districts today, the problem of central computer failure with this network topology has not changed. For that reason, most intrabuilding LANs interconnecting microcomputers do not use this topology.

Far and away the most common topology for intrabuilding LANs is the bus. The bus topology is a single wire or cable linking all the microcomputers or other devices together in an office, laboratory, or building environment. Each device shares a single physical transmission medium through the use of taps or connectors, thus making it fairly easy to add or remove devices.

The bus topology is also less susceptible to system breakdowns: If each device on the network has its own intelligence (such as a microcomputer) and if the medium is broken in the middle, those intelligent devices above the break can continue to communicate with each other and those below the break can communicate, but of course the devices on either side of the break could no longer communicate. Furthermore, if each intelligent device is sharing network control functions, the failure of one such device does not cause the entire network to fail. How all the devices can share a single physical transmission medium without problems will be explained in the section on channel access.

The other common topology used with networks, though currently far less popular with intrabuilding LANs, is the **ring.** With the ring topology each device is physically connected with wire or cable to another device point-to-point to form an unbroken ring. The configuration is set up so that information units, called **packets**, transmitted from device A to device B anywhere on the network eventually return to device A. Since operation of a ring LAN depends on each device passing packets around the ring from sender to receiver and then back to sender, the failure of any device generally causes the entire network to fail. So, too, does a break in the network medium. Networks eliminating both problems, however, are now commercially available, but they are quite expensive.

Channel Access Methods

Since LANs usually connect several devices using a single medium with one or more communications channels, some method of channel access and control must be used to ensure reasonably equitable, uninterrupted, and error free transmission between those devices. Most LANs use one of two different methods, or **protocols** as they are frequently referred to in data communications jargon, to allow multiple devices on the network to access the same transmission channel. One method is called **contention.** The most common contention technique for intrabuilding LANs is Carrier Sense Multiple Access with Collision Detection (CSMA/CD). The other method is called **polling.** There are two type of polling techniques: **centralized polling** and **distributed polling.** [8] The most

common polling method for intrabuilding LANs is **token passing**, a distributed polling technique.

The contention technique known as **Carrier Sense Multiple Access with Collision Detection** (CSMA/CD) is a "listen before talking" method of channel access. Basically it works like this in the case of a microcomputer LAN: All the microcomputers (called devices) actively connected to the network "listen" to "sense" if there are any messages in the form of small information units, called packets, being transmitted. Hearing none, device A, for example, then sends a message to device B. If at the same instant device C sends a message to device D, A's and C's messages will collide, since both messages must use the same transmission channel, thus causing them to be garbled. But when the sending devices (A and C) detect the collision, they simultaneously stop their transmissions, pause briefly, and then retransmit their messages at staggered intervals to avoid another collision. Of course, these messages are being transmitted at very high speeds so the carrier sensing, message transmission, and collision detection sequence occurs almost instantaneously.

The contention method of channel access is claimed by its proponents to be particularly effective with LANs carrying "bursty" data transmission traffic, that is, sporadic, low volume data transmission of the kind associated with office or classroom microcomputer applications such as word processing, computer assisted instruction, and electronic messaging. With this kind of network application, contention theoretically gives every device on the

network a more or less equal chance to use the transmission channel.

The polling method of channel access includes "techniques [to] determine the order in which nodes [devices] can take turns accessing the network, specifically so that direct conflict (i.e., access collisions) between nodes [devices] is avoided." [8, p. 52] With centralized polling, access to the network is controlled by a central intelligence. Distributed polling, on the other hand, allocates control of access to the devices themselves. Several methods of channel access are associated with distributed polling, but the one most commonly used with intrabuilding LANs is token passing.

With **token passing**, access to the network is achieved when a device seizes an electronic token, signaling to the other devices on the network that the channel is busy. The device holding the token is allowed to control the channel for a specified period to transmit data. After the transmission is completed, the device releases the token signaling that the channel is free. Since the period any one device controls the network can be predetermined, this method of channel access is very effective for steady, high-volume traffic such as digitized voice or video, both of which have significant applications in education. Because IBM is expected to release a token ring LAN in about two years, interest will remain high in this method of channel access.

Bandwidth

Bandwidth is a term that generally refers to the messege-carrying capacity of a particular physical medium. In more

technical terms, bandwidth is "[t]he range of frequencies available in any particular channel." [9] There are two means of carrying electronic messages over physical media: one is called **baseband**, the other **broadband**. With baseband, the medium--either twisted pair wire, coaxial cable, or optical fiber--is dedicated to carrying data messages only. Furthermore, the messages are unmodulated, that is, they are not converted from digital to analog (voice) signals, so the signal occupies the entire bandwidth of the medium, thus allowing the messages to be transmitted at very high speeds.

With broadband, on the other hand, the bandwidth can be divided into several transmission channels with different frequencies to carry voice and video signals as well as data. The data messages are modulated on a broadband channel, that is, they are converted from digital to analog (voice) signals. Coaxial cable and optical fiber media have large bandwidths, thus making them especially suitable for broadband LAN applications, though high cost has thus far curtailed widespread adoption of opical fiber for use in intrabuilding LANs. Up to now, most broadband LANs have been used primarily as a means to provide wide-area communications backbones linking campus or office buildings over distances of up to thirty-five miles. However, with the release of IBM's intrabuilding broadband LAN, called PC Network, which can link up to 72 of its microcomputers (except the PC Jr.) over distances of up to 2,000 feet end-to-end, broadband LAN applications in the office and classroom are sure to increase dramatically.[10]

Basic Components of a Typical Instructional or Office LAN Installed in Schools

The size and capacity of an instructional LAN may vary depending on the number and size of the instructional programs or computer languages supported as well as the number of microcomputers attached. The basic components of a typical baseband LAN for, say, twenty Apple microcomputers installed in a high school computer lab are as follows: (1) one network interface card for each microcomputer to connect it to twisted-pair wire that physically links the various components of the network together; (2) one file server that manages access to a high-speed hard disk storage unit; (3) a hard disk storage unit with forty-five megabytes of storage capacity; (4) a print server to manage access to at least two printers--generally two high-speed dot matrix printers; (5) network software such as microcomputer operating systems support, print spooling, and network management; (6) assorted network hardware such as tap cables, network cables, and tap boxes; (7) miscellaneous network and device protection and life-extending equipment such as surge suppressors, desktop antistatic mats, and external fans for each Apple microcomputer to dissipate internal heat buildup; and (8) network installation and operation documentation. Although built-in or add-on disk backup and archival storage equipment is available for LANs, it is seldom acquired for instructional applications.

A typical baseband LAN installed in a school office will have many of the same components as that of an instructional LAN. The office LAN, however, is usually smaller, includes both letter-quality

and dot matrix printers, has built-in or add-on disk backup and archival storage, provides for the electronic transfer of messages between microcomputers, and frequently uses coaxial cable instead of twisted-pair wire. Some of the more expensive office LANs have a file transfer server that allows for the exchange of files between similar networks. Other LANs not only support the exchange of messages or files between microcomputers on the network but also between those located in, say, other offices or classrooms in or outside the building or even in the home. With office microcomputers more frequently downloading files directly from central computers, several office LANs are providing gateways to mainframe computers like IBM. Local area network gateways to value added networks like Tymnet and Telenet are also becoming available.

Instructional and Management Applications

The linking together of several microcomputers on a LAN provides for several advantages not available from a single microcomputer. With microcomputers linked together, students can share the use of public domain and network-licensed instructional software, thus eliminating the need for the teacher to manage the use of many individual copies of several different programs. And with appropriate software, the teacher also can unobstrusively monitor students' progress as they work at their own microcomputers. In addition, by means of network-compatible filing and database management programs, the network supports the central storage of student work and records, making the assessment of student progress and other aspects of classroom management easier and more effective. [11] Another advantage of the network is the opportunity for several microcomputers to share expensive peripherals such as letter-quality printers and graphic plotters. This sharing can often result in modest cost savings as well as more efficient use of such equipment.

The final major benefit of networks is obtained through the use

of communications devices such as modems, bridges, and gateways. With these devices, microcomputers on a network can send and receive files between similar systems, share information between microcomputers using similar software, send and receive messages (electronic mail), send and receive files from mainframes and minicomputers, and link with value-added networks such as Tymnet and Telenet for local access to bibliographic database services such as Dialog, BRS, and Orbit. These database services are particularly valuable to educators because, in effect, they turn the microcomputer into a library. From the classroom, office, or home, the teacher or administrator can search for and retrieve information from over 100 databases such as ERIC, Books in Print, National Newspaper Index, Microcomputer Index, Psychological Abstracts, and Dissertation Abstracts.

Instructional Applications

Several companies are marketing instructional software for LANs, especially those interconnecting Apple microcomputers. For example, Ideal Learning is marketing a series of full-year instructional packages for sixth-, seventh-, and eighth-grade mathematics, science, and foreign languages to operate on Corvus's Omninet LAN linking Apple II microcomputers. [12] According to the vice-president of the company, over 100 schools, primarily in Minnesota and Wisconsin, are using its instructional software on Omninet LANs linking Apple microcomputers. Public domain instructional software developed by the Minnesota Educational Computing Consortium (MECC) is reportedly running on several classroom LANs. A quarterly journal called The

Educational Networker, published by the Corvus National Educational End-Users Group, lists several pages of public school and college-level instructional software tested for compatibility with Corvus network operating systems. [13]

One of the largest recent installations of IBM PC microcomputer LANs for instructional applications is in the Indianapolis School District. During the 1983-84 school year, the district installed Orchid's PCnet LANs in its nine high school microcomputer labs. Two labs in each high school contain 30 IBM PCs with 128,000 bytes of random access memory and one disk drive, color monitors, three dot matrix printers, and an IBM PC XT that functions as the network server.

All the microcomputers and printers are interconnected using Orchid's LAN. [14] The system uses computer-assisted instruction (CAI) software for English and math instruction. [15] At the beginning of the 1984-85 school year, Corvus's Omninet LANs were installed in Apple microcomputer labs in each of the district's fourteen junior high schools. These LANs in the junior high schools use several CAI programs and a commercial word processing program (Magic Window) licensed for network use. [14]

Other school districts' use of LANs for instructional purposes has been documented. The Reynolds School District in Troutdale, Oregon, has networked fifteen microcomputers sharing a hard disk drive in each of its two high school computer labs. Oregon City High School in Oregon City, Oregon, has a computer lab of twenty microcomputers sharing a hard disk drive interconnected on a LAN. [16] The

Lexington, Massachusetts, school district uses a broadband LAN to manage instructional applications on its microcomputers as well as to report attendance, to send messages between administrators and teachers, and to transmit announcements and other information via a bulletin board.[17] The largest reported installation of LANs is in West Virginia where each of forty-five vocational high schools in the state has a computer lab containing twenty microcomputers networked together with four printers. Each LAN has communications software and a modem enabling it to transmit data over telephone lines to any other high school LAN in the state. In addition, users at each LAN "can call up data and programs stored in a state-operated central library." [17, p. 25]

Administrative Applications

Because the use of microcomputers for administrative applications is significantly behind that of instructional applications in most school districts, the use of LANs to interconnect office microcomputers is still in its infancy.

Once a sufficient number of microcomputers exist in the distict or building-level offices, the addition of a LAN to interconnect the microcomputers in these offices can be justified. Once installed, a LAN's administrative applications are many. Record keeping, word processing, budgeting, scheduling, and inventory control are but a few of the administrative applications that can be enhanced with the use of an office LAN. LAN vendor-specific vertical applications software--that is, software designed for a specific group of users--is

available for school attendance, student registration, school scheduling, and grade reporting.[18]

A growing number of general purpose administrative application programs such as word processing, electronic spreadsheet, database management, accounting, and electronic mail are currently available for several LANs.[19] A few popular business application programs such as VisiCalc (spreadsheet) and dBASEII (database management) will already run on certain LANs and are licensed to do so. Other widely used business software such as Lotus 1-2-3 (integrated applications) and Microsoft Word (word processing) are being developed specifically for certain LAN vendors, especially IBM, 3Com, and Corvus.

Electronic messaging and the rapid transfer of such information as budget projections, reports, and letters between microcomputers connected to a LAN represent the most exciting application of LANs in the school office. Consider the following near term scenario suggested by Lindelow:

> Ed Lanning, principal of Jefferson Middle School, arrived for work at 7:45 Monday morning. After logging onto his...micro-computer, he began to read his mail on the screen. His secretary wanted his approval on several letters before having them printed and mailed. Several teachers had sent messages, including a request for special materials purchase, two notes on disciplinary actions, and a suggestion from the English teacher for a new textbook. Dave Morgan, the assistant superintendent..., had left a message requesting transmission of Jefferson's tentative budget for the coming year. The last two messages were from other principals in the system, both responses to Ed's ideas on food service management, which had recently been posted on the district's electronic bulletin board.[20]

Local area network electronic mail and file transfer software necessary to make the above scenario a reality is available today. In a few school districts and community colleges parts of the scenario

are already operational. For example, in Banks, a small (1,000 students) school district west of Portland, Oregon, a LAN was installed in the central office in 1984. The LAN consists of an IBM PC XT network server, four Compaq microcomputer workstations, one dot matrix printer, and one laser printer. Letters, memos, and reports are regularly shared between the office secretary and various administrators including the high school principal and the superintendent. In addition, the district uses an electronic spreadsheet program to prepare the annual budget. The budget information is shared electronically between administrators on the network during the development stage. A database management program is used to format file transfers between the district and a statewide data processing agency located in Eugene, Oregon. Once formatted, the files are then transmitted over telephone lines to the data processing agency from one of the district's Compaq work stations using a data communications program and a modem. The district expects to implement an electronic mail program before the end of the year.

An electronic mail program has been used successfully for nearly a year on a LAN interconnecting Apple microcomputers installed in several administrative offices at Lane Community College in Eugene, Oregon. Written by a systems programmer at the college, the electronic mail program is used to exchange messages and electronic spreadsheet files between several central office administrators including the president. The electronic mail program will be used as the LAN communications backbone for the exchange of database management program files and the uploading and downloading of files

from the college's mainframe computer. Both of these applications are expected to be online in early 1986.

Current Limitations to Use of LANs

Users of any piece of technology as complex as a local area network are bound to encounter problems. In the case of LANs, limitations and difficulties fall into several categories: technical, personnel, financial, managerial, and legal. The bulk of this chapter pertains to four specific problems. Before discussing them, however, several other problem areas are worthy of mention.

Perhaps the most numerous problems facing LAN users are technical in nature. One such problem is the poor, if not impossible, communications between dissimilar microcomputers and networks. Lack of network standards and limited upward compatibility with newer, higher performance LAN systems is also a serious impediment to widespread LAN adoption. These and other such problems are regularly discussed in data communications trade journals and microcomputer magazines.

Also deserving mention are several personnel and financial problems that could deter the installation and use of microcomputer LANs by many school districts. These problems include (1) the general

lack of understanding by many administrators about the use of microcomputers in schools--compounded in many cases, by their own reluctance to use them; (2) the shortage of school district data processing personnel with training and experience in the use of current computer data communications and networking technology; and (3) the lack of funds (a) to purchase a LAN, assuming of course that the network is determined to be useful and cost effective, or (b) to hire or train a person to manage it.

The following discussion of four major limitations in the use of any microcomputer LAN available on the market today is based primarily on research involving interviews of LAN users and evaluations of LAN hardware and software [11, p. 8].

These four limitations are as follows: (1) The need for network management, (2) the shortage of technical support from retail stores and LAN vendors, (3) the lack of multi-user database management system (DBMS) software, and (4) the legal barriers to the use of single-user software on LANs. The relevance of these limitations to potential users of LANs in elementary and secondary schools will also be emphasized.

Need for Network Management

The management of a local area network for microcomputers is not a trivial process. For the stand-alone microcomputer, software applications in education are numerous and well documented for some machines such as the Apple. The opposite is true for most local area networks. More often than not, one must be able to write special

programs in the language of the LAN application software to ensure full utilization of the network. Furthermore, when resource sharing is one of the objectives of the LAN, someone has to set priorities for access to printers, graphic plotters, and other peripherals, as well as manage the output.

In the case of most local area networks the heavy workload is at the beginning. Installation--the process of setting up and debugging the network--can take anywhere from two weeks to two months or longer, depending upon the type of the network and the range of software applications. Implementation tasks include creating volumes for users, writing utility programs so that the application software users are accustomed to running on a single computer operates in the same manner on a network, writing a network users' handbook so everyone understands how to use the full capabilities of the network, and--where expertise is not available from the local retail store or network vendor (as is often the case with LANs)--physically connecting all the parts of the network together and making it work.

Most people using microcomputers in offices and classrooms have come to rely on them for various ongoing management and instructional applications. Therefore, when implementing a LAN, "one cannot afford such snags as software incompatibility, printer problems, or a serious disaster such as lost data." [21] Even with a network manager, such problems can and do occur. Without a network manager to help solve them, however, these and other problems can significantly disrupt the office or classroom environment and even jeopardize the use of the LAN altogether. As one purchaser of a popular local area network reports:

"We could not have made the decision to use ...the Omninet system without the assurance that generous amounts of experienced help for the technical business of setting up and maintaining the system would be at hand."[22]

Shortage of Technical Support from Retail Stores and LAN Vendors

Closely related to the problem of the need for network management is the shortage of technical support for LAN users from computer retail stores and LAN vendors. Persons responsible for installing most LANs on the market today must have considerable technical training and experience in data communications. "Networking is not a subject for the faint-hearted; there are problems with simply stringing cables--such as signal interference from other electrical products--it requires some degree of sophistication to solve."[23] Don't expect to find such persons at most of your local computer stores. All retail stores offering LANs for sale are glad to sell you the network, but

> [a]t present...it's tough to find consultants and dealers who have practical experience with networking installations for personal computers. Deciding which networking technology to use is a huge step beyond deciding which computer system to buy--and a matching level of technical sophistication to both sell and install the system is required.[24]

And don't expect very much help from the LAN vendors themselves, either. There is a surprising lack of technical expertise available to the purchaser of a local area network from the company that manufactured it. For example, an Oregon community college purchased a popular baseband LAN for use in its business offices. It took systems

programmers in the college data processing center approximately two months to install the LAN with no assistance from the vendor. Repeated calls to the vendor for help were not successful. When the hard disk unit failed, the vendor refused to replace it, instead offering to repair it at an estimated cost of $1,100. A local technician was finally able to repair the drive--at one-fourth the cost quoted by the vendor--by following instructions in a technical manual obtained from the vendor. The quality of technical support provided to LAN retailers by the major vendors will likely improve as more LANs are sold and installed, but such support will probably not be generally available to the end-user for several years.

Lack of Multi-User Database Management System (DBMS) Software

Multi-user access to database management system (DBMS) software written for single-user processing is difficult, if not impossible, to obtain on most local area networks. Very few DBMS programs currently include provisions for concurrent, multi-user access (read/write) to common files. LANs generally provide some form of primitive record locking to prevent more than one person from accessing a database at a time.

They do not, however, generally include more sophisticated means to guarantee database integrity common with mainframe and minicomputers such as synchronization and queuing.

Also, database security is not available for LANs at a level of sophistication that most database managers have come to expect with mainframes and minis.

Methods for restricting access to certain volumes, to certain records within a volume, or to fields within those records are either totally missing or only partially available on most LANs on the market today. Can LAN vendors guarantee that a student will not have access to his or her grades, but that a teacher, or counselor, or principal will have such access? Regrettably, the answer, in most cases, is no. Can a teacher have "read only" access, say, to his or her personnel file, but be prohibited from accessing a field containing letters of recommendations, where the right to see such recommendations had been waived? Again, the answer, with few exceptions, is no.

Legal Barriers to the Use of Single-User Software on LANs

Not only is most popular database management systems software not available for the local area network, but LAN versions of popular single-user word processing programs like BankStreet Writer and Wordstar or spreadsheet software like 1-2-3 or Multiplan are not available either (though they are likely to be for some LANs at least by the end of 1985). The reason a single copy of these programs cannot operate on LANs is largely due to legal barriers, rather than technical ones. To legally use any of these programs on a LAN, one must buy one package for each microcomputer on the network! To do otherwise is to violate either the software vendor's licensing agreement, which accompanies each box of program diskettes, or section 117 of the Federal Copyright Act of 1976, which makes it impermissible "to take a program that was not designed to copy itself in a network, and to distribute it to the various personal computers in the

network." [25]

Licensing represents a major legal barrier to the use of single-user software on LANs, but it is a highly complex and unsettled area of contract law. Most legal experts in this area appear to support the right of software vendors to license rather than sell their products, thus putting them outside the scope of certain sections of the 1976 Copyright Act. [26] One legal expert, however, writing in a recent issue of The Computer Lawyer, argues that when a user purchases a software package, the transfer constitutes a sale, not a licensing agreement. [27] Until the issue is settled, if at all, by the United States Supreme Court, suffice to say that persons using licensed single-user software on a LAN without permission from the vendor risk legal action.

The International Council for Computers in Education has issued guidelines for the use of copyrighted software on a local area network. These guidelines represent more hope than reality, however, with respect to the copyright issue. The hope is that software vendors will begin to acknowledge the growth of local area networks and supply software at a reasonable price for use in a multi-user environment--especially in schools. There is also the hope that schools in turn will honor the copyright limitations on single-user software while trying to reach accommodations with software companies--through some sort of licensing agreement--for network applications.[28]

What Educators Should Do about LANs Now

Even with their current limitations, however, LANs offer great promise to the microcomputer user in education. They allow users to retain their computing independence while also participating in the benefits of instructional and management applications enhanced by communications and the sharing of programs, data, and peripherials. [11]

But at this stage in the evolution of LAN technology, it would be unwise for most school districts to commit large sums of money for the purchase of LANs. No LAN on the market today is a "turnkey" product. You cannot just buy a LAN at your local computer store, take it to school, plug it in to two or more microcomputers, turn it on, and start transferring files, sharing printers, and accessing databases. If your district does have some money available, however, the purchase of a small, low-cost startup or prototype network initially interconnecting two or three microcomputers would be an excellent way to get some hands-on experience with LANs before attempting to install a larger system.

But before purchasing even a prototype LAN, you should learn as much as possible about what LANs are and what they can and cannot do now and what they might be able to do in a year or two. You can accomplish this in several ways, none of which are mutually exclusive. You could begin by reading some of the books and articles listed as references in this chapter. Next, attend a LAN training session. LAN workshops or seminars are often available in large cities, but they are generally very expensive and quite technical. Some universities such as the University of Oregon, University of Houston, North Texas State University, and New York University are offering classes and workshops on LAN and data communications technology and applications. Finally, try to visit two or three school districts in your state or region that have installed LANs for instructional and management applications. Be sure to talk to the people who use the network on a daily basis as well as to the network manager.

You should also begin to assess the present and future instructional and management data communication needs of your district.

The creation of a task force made up of students, teachers, administrators, and classified staff to begin this data communications needs assessment process is highly recommended. If sufficient expertise is not avaiable in the school district to conduct this assessment, consider calling in an outside consultant. But expect to spend some time finding a qualified consultant. People with the appropriate training and experience to conduct such an assessment and to assist the district in planning, selecting, and installing a local

data communications network are in short supply. When you do find a good consultant, expect to pay him or her several hundred dollars a day.

If you begin the process of hands-on LAN familiarity and training, site visitations, and data communications needs assessment now, in a year or two you will likely be ready to purchase a full-scale local area network. By then the average cost of a LAN is likely be $300 or less per student or work station instead of the current average cost of approximately $1,000. There will also be more and better network-based instructional and management application programs available--and they will cost less. Furthermore, LANs should be standardized around the technology and operating systems of two or three major vendors; they will be less complicated and easier to install and use; and their flexibility and compatibility will be significantly improved.

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