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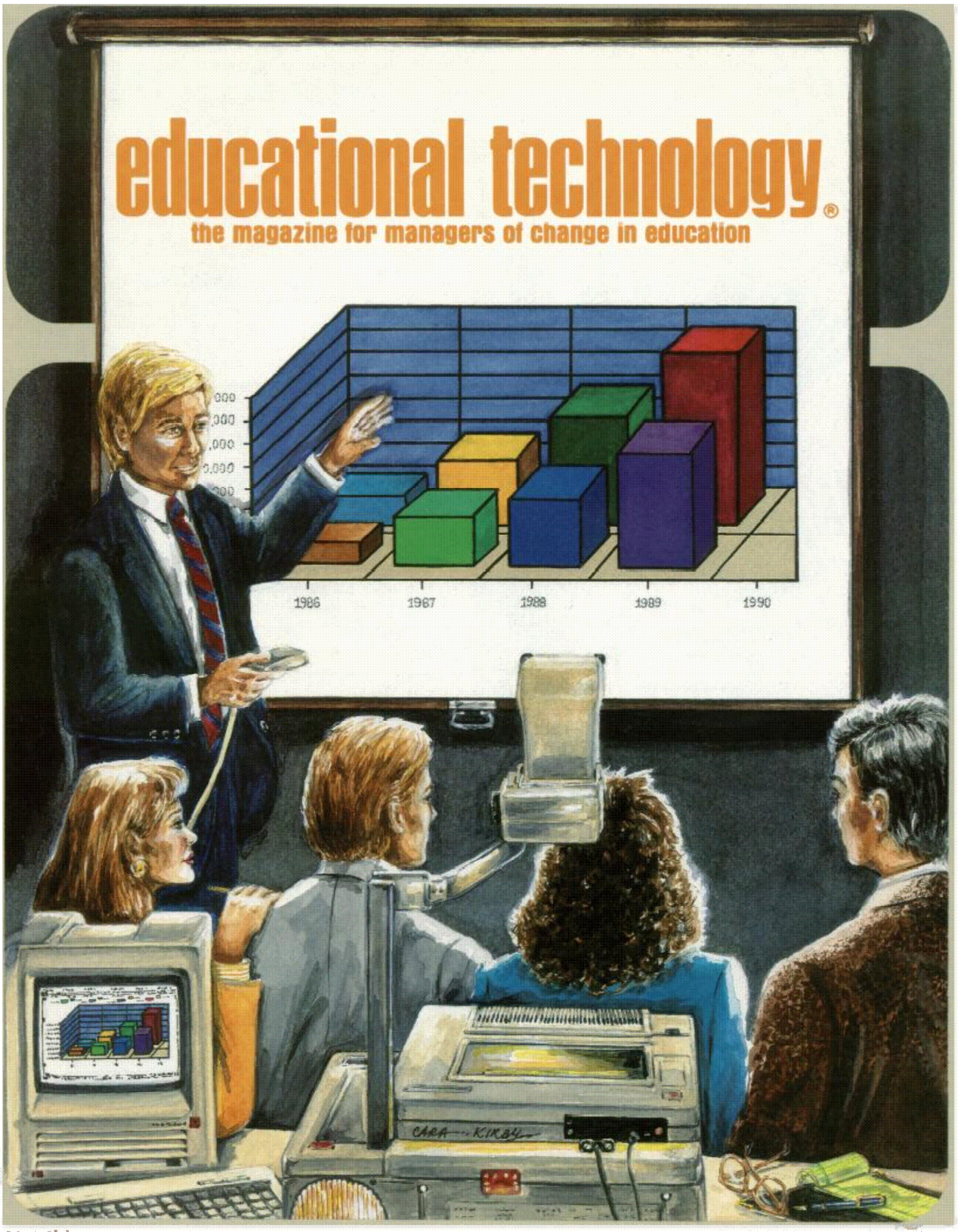

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Educational Computer Networks: An Overview

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Many professions, including education, seem excessively fashion-driven. In such a climate, productive debate and discussion is sometimes displaced by the establishment and uncritical use of buzzwords. (*Webster's New Collegiate Dictionary* defines "buzzword" as "An important-sounding, usually technical word or phrase, often of little meaning, used chiefly to impress laymen.") One of the newest educational buzzwords is *Networking*, and vendors and users alike are waxing eloquent about the educational benefits of this new trend.

As with most buzzwords, a precise definition of networking has never been agreed upon. Therefore, when the term is encountered, one is never sure exactly what the user is referring to (McCredie and Timlake, 1983). The following, for example, are all networks: (a) several microcomputers connected to a single printer or disk drive via a switch box; (b) a mainframe computer in one city connected with another mainframe computer in another city; (c) a mainframe computer connected to terminals located in field offices in different cities; (d) several minicomputers connected to a LAN (local area network); and (e) several microcomputers connected to a file server. These examples differ considerably, both in the technology and topology used, yet they merely scratch the surface of current network possibilities. (Sullivan, Lewis, and Cook, 1988, define *network topology* as the *interconnection pattern* of the devices included in the network.)

Despite the vagueness of the term, networking appears to be increasing in popularity. Apple Computer claims they have installed over 20,000 AppleTalk networks in schools (McCarthy, 1988). The market research company International Data Corporation (IDC), estimates that over 35,000 LANs have been installed in educational settings. Officials at IBM suggest that in the next few years, networking will be responsible for bringing down the student to computer ratio from the present one for 30 to one for five (McCarthy, 1988).

In order to provide a broad perspective of computer networking, this article will review both university and public school applications spanning the decade of 1978 to 1988. (It should be pointed out that published information on university networking is far more common than information on public school applications of networking.) In addition, we will also discuss some of the pros and cons of networking in educational environments. Recommendations of educators who have experience with networking will also be reviewed.

The following discussion reviews educational networking in three functional categories, although some overlap does occur. The three categories are: (a) networks for sharing peripheral equipment, (b) networks for exchanging information; and (c) networks for addressing instructional needs. These categories also follow a rough chronology, although again, some overlap occurs. Category A was typical of networking from about 1978 to 1985; category B from 1983 to 1987; and category C from 1985 to the present. Specific schools are often highlighted, not because they were the only institutions electing to implement networks, but because their motivations and implementations were representative of educational networking efforts of the day.

Networks for Sharing Peripheral Equipment

In the late seventies, The University of Missouri-Rolla departed from the mainframe tradition by teaching an assembly language computer science course on an IMSAI 808A microcomputer. Magel and Hamblen (1979) listed the following four reasons for using a microcomputer: "(a) it is physically small, (b) it does not require a special environment such as air conditioning, (c) it is relatively simple compared to most larger computers, and (d) it is relatively inexpensive" (p. 120).

Magel and Hamblen (1979) originally taught the course using a single microcomputer, but as enrollment increased they realized the need for additional machines. At the time, microcomputers were priced at about $1500.00 each and the printers needed to provide hard copy output cost between $1000.00 and $2000.00 each. The expense involved in purchasing separate printers would have doubled the cost of each workstation. Magel and Hamblen concluded that the solution to this financial dilemma would be networking. They decided to link ten IMSAI microcomputers via a standard RS-232 interface, to an eleventh machine

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that would provide buffers and control a single printer. This type of networking made the system economically feasible.

Charp (1982) reported the same microcomputing advantages as those listed above and added that microcomputers also provide access to increased capabilities such as graphics and color. She asserted that the popularity of networking was growing and was most often used to facilitate the sharing of storage devices, printers, and plotters.

Another peripheral sharing network in higher education was implemented at Lehman College of the City University of New York (CUNY). By late 1985, Lehman College had a hodgepodge of terminals and microcomputers including IBM PCs, PC Jrs, Apple IIs, and Apple Macintoshes. Each machine had a separate set of disks for the operating system, word processing, spreadsheet, database, and special software packages provided by faculty. The task of checking in and out and maintaining a collection of over a thousand diskettes was difficult and time-consuming. While studying the capabilities a network should include, Lehman officials concluded that existing business networks might not meet their needs. During the ensuing year, a list of specifications was developed. When funding became available, a system was installed including a network file server. This eliminated the need for a vast number of diskettes and also allowed the sharing of peripheral devices such as hard disks, letter quality printers, and hard-copy graphics devices.

One of the earliest attempts at establishing a large networking scheme in a public school district took place in 1984. The Indianapolis Public School District (IPSD) embarked on a three-year, three-phase, $10 million project aimed at bringing computer literacy to every student in K-12 (Adams, 1984). Clusters of 30 IBM PC microcomputers, one IBM XT microcomputer emulating a file server, and three printers were connected to a Local Area Network (LAN). Each cluster was located in a separate classroom lab. The network allowed the IPSD to share expensive peripheral devices such as hard disks and printers.

District officials estimated that this sharing resulted in a savings of approximately 20% over non-networked computers. The district also saved money by purchasing a site license for software such as Borland's Turbo Pascal, a computer language used in instruction. The $785.00 fee for a site license was far less than the $29,500 that would have been required to purchase a separate copy of the software for every microcomputer on the network (approximately 600 machines at $50.00 per copy). Roberts and Ruby (1983) also suggested that networks could be of special benefit to small schools by allowing them to purchase software they could not otherwise afford.

The IPSD networking scheme, in keeping with other instructional networking schemes of the day, resulted in substantial financial savings. There were other important considerations, however. IPSD officials stated that the primary motivation to network was the system's computer-assisted instruction (CAI) and computer-managed instruction (CMI) capabilities. For example, one application uploaded each student's daily math progress to the file server. The network software also provided for file and record locking, an important feature needed to ensure the integrity of shared files.

Networks for Exchanging Information

Networks in this category allow individuals to access information and services via a terminal, a telephone, and a modem. This category is dominated by the emergence of nationwide information networks, which continue to grow in number and popularity.

Several of the earliest and most popular of these information networks were *The DIALOG Information Retrieval Service of Lockheed Missiles and Space Company, Inc., The Source, CompuServe,* and *Delphi.* The DIALOG network consisted of databases covering such diverse areas as "business, education, current affairs, social sciences, law, medicine, the arts, and humanities" (Roberts and Ruby, 1983, p. 173). The Source and CompuServe were general purpose information networks that are still in existance today. They became popular because users were able to make airline, hotel, and automobile reservations, access a user bulletin board, apply for various jobs, and use an electronic mail service to communicate with other subscribers (Willis, 1987). Delphi was a less well-known and less expensive service aimed specifically at educators. Among other services, Delphi provided the ability to take part in teleconferences.

Another early information network intended for educators was *The Personal Computing Network* of Menlo Park, California. This network included a computerized bulletin board that allowed schools to post announcements of various types.

Higher education also became involved in networking and various networks, some discipline specific, were established. McCredie and Timlake (1983) listed the following networks used by higher education: (a) *ARPAnet* (Advanced Research Project Agency, of the US Department of Defense, now known as *DARPA*); (b) *CSNET* (Computer Science Network), (c) *EDUNET* (Education Network), (d) *BITNET* (Because It's Time Network); (e) *USENET* (for UNIX users), (f) *COGNET* (a network for cognitive scientists); and (g) *NSFNET* (National Science Foundation Network). Typical reasons for creating each of these networks includ-

ed facilitating communication with peers and providing access to resources.

As networking continued to grow in popularity, problems began to appear, McCredie and Timlake (1983) mention two major concerns: (a) the unplanned, uncontrolled, and chaotic growth of networks, and (b) the establishment of a number of incompatible "standards."

With regard to the first of these concerns, McCredie and Timlake (1983) lamented the fact that "Other academic networks are springing up with almost no formal planning and/or budget because a particular technology exists and individuals want to use it to communicate" (p. 5). These authors suggested that incompatible standards were a problem because they prohibited users of one network from communicating directly with users of another network.

Networks for Addressing Instructional Needs

As networks became more powerful and sophisticated, instructors of specific disciplines began to experiment with networking for the teaching of individual courses. Morrison (1985) discussed the flexibility of using a computer network as a resource in developing programs for economics education. He described a modified database at the University of Delaware that contained over 75 lessons in business, economics, and consumer education. The network allowed individuals at home, senior centers, public libraries, and other locations to access accurate and timely information.

Herrmann and Herrmann (1986) presented a paper on the use of computer networks for teaching writing courses in college. They mentioned that memory limitations of early microcomputers prevented applications such as word processing with integrated spelling and style checkers. These authors stated that networks provide new options in the writing environment. They predicted that students should soon be able to gather data for a paper, collaborate with classmates and the instructor on ideas, compose a rough draft, send it out for review, accept comments, check grammar and spelling, revise the final copy, and send the final draft to the teacher, all via networked computers (Herrmann and Herrmann, 1987).

These authors went on to assert that although the above scenario is technically feasible with current hardware, specialized software needs to be developed before this can take place. They also pointed out that for networks to serve the educational community, both *local area networks* (LANs) and *wide area networks* (WANs) would be needed. LANs provide the ability to share data and ideas within a classroom or school system. WANs provide the ability to gather needed data from remote databases and online libraries.

Thompson (1987) described a network using specialized software to accomplish an instructional end. She discussed her use of a LAN to create a classroom community where writing is learned primarily by writing. Thompson's article is noteworthy since it emphasizes pedagogical concerns and deemphasizes technical details. In fact, the type of microcomputers used, the availability of printers and hard disks, and the LAN configuration itself (except for a brief note about *Fox's 10-NET*) are never mentioned.

Thompson uses a software package called *CT Classrooms in Writing Centers* developed by CompuTeach, a Washington DC-based consulting firm. This software, originally designed to teach hearing impaired students, uses the ENFI (English Natural Form Instruction) method for teaching composition. The software divides each student's screen into two windows. One window, which is private, is used for composing. The other, which is public, is used for displaying transmitted messages. The master station, controlled by the teacher, can display a student's text on any or all other screens on the network. Thompson (1987) suggested that "One of the big advantages of the CT System III is that I can keep the students on task, insisting that they revise the text while I key in changes" (p. 96).

Summary and Discussion

Early networks were systems designed primarily to share expensive peripheral equipment (hard disks, printers, and plotters) and software. One exception may have been the network implemented in the Indianapolis Public School District. IPSD officials may have been a bit ahead of their time in recognizing the instructional benefits of networking. However, the system might not have been implemented had it *not* resulted in substantial financial savings on hardware and software.

Hardware and software sharing is still one of the big motivations for networking. However, compatibility remains a major problem. Today, there are a multitude of vendors whose hardware is often incompatible. Sholtys (1988) refers to this problem:

> Unfortunately, this ideal computer network simply doesn't exist. In stark contrast to voice communications, where equipment made by one manufacturer can communicate with equipment from any other, different computers made by the same company often have trouble communicating with each other. Multi-vendor equipment compounds the problem. (p. 4)

Archer (1986) endorses this view in a discussion of the *Open Systems Interconnect (OSI)* model for LANs:

> The lack of a complete set of official standards for all the layers is the reason that network components from one vendor may not work with components

> from another vendor, even though both are, for example, "Ethernet compatible." Since both are designed for Ethernet, it is very unlikely that either "will go up in smoke" when connected to the same Ethernet cable, but there is no guarantee that one vendor's workstation will work with another vendor's print server. (p. 10)

As networks became more sophisticated, they evolved into tools for disseminating information. Information networks, with their online databases and libraries, allowed individuals to access information with their microcomputers. The networks used in higher education allowed researchers to share their findings.

It has been said that there is no such thing as a free lunch. As networking proliferated, it became more accessible but more complex. Various problems surfaced. McCredie and Timlake (1983) list a number of difficulties, including data security, libel, software copyright and licensing, control, and continued funding of networks. Mandell and Mandell (1989) emphasized a variety of privacy problems:

> Some people have misused bulletin boards by placing notices about access codes to corporate computers, describing instructions for building weapons, posting information about crimes or illicit sex, and inserting programs that destroy the user's software. (p. 251)

A recent example was widely covered in the news media, and dealt with a "computer virus" placed on a national network. This virus (a special, destructive program which itself contained an inadvertent flaw) caused the disruption of several thousand computers that were connected to the network.

Eltoft (1989) addressed problems associated with installation and management:

> There are serious problems that can crop up with the introduction of a network layered on top of a single user PC such as network congestion, accessibility, reliability, security, and the most often unforeseen giant - manageability. (p. 22)

These problems can be especially acute in educational settings. One of the current authors manages three PC labs at a university, one of which is networked. In this lab, efficient management procedures have been difficult to establish and time-consuming to maintain. Examples of problems that have been dealt with include excessive time required to create and delete individual student accounts; preventing student theft of copyrighted software, coping with down time required for maintenance and operating system upgrades; and controlling, protecting, maintaining, and explaining various levels of access to the file server.

As networking continued to become more and more common, and despite increasing problems such as those discussed above, individual instructors began to see how networks could be used to help teach specific courses.

This trend has continued, even though a host of new problems are gaining increasing attention. In recognition of these problems, a number of articles have been published dealing with deciding whether a network is appropriate, how to choose a network, protecting network security, providing for maintenance, and the need for prudent and continuous network management.

Henderson and Maddux (1988) provide recommendations for public school officials who, despite potential problems, decide to implement networking. Their recommendations are particularly applicable in situations in which schools contract with one of the companies that specialize in providing everything needed for an educational network: (a) since networking firms offer a limited choice of software, preview the software to ensure that it will meet the needs of the district; (b) review the network management software with an eye to underlying theoretical and philosophical principles; (c) equip each computer with at least one floppy disk drive so that new software can be used and so that hard drive failure will not put the entire system out of business, (d) be sure the contract establishes the responsibility of the networking firm for maintenance of both software and hardware; (e) include a provision of "loaners" when district hardware breaks down and establish a maximum time period for repair or replacement; (f) protect the hard disk from accidental erasure by requiring the installation of a security system, and do not allow students to save files on the hard disk; (g) include inservice training in the contract, and be sure that several people receive this training.

What can we conclude about networking? Networks often provide substantial benefits, including important savings in hardware and software costs. They can make otherwise inaccessible information available to anyone with a computer and a modem. They can streamline instructional design and data management in specific courses. However, potential advantages must be weighed against inevitable related problems. Then, too, unless there is considerable planning and foresight, the associated problems may be overwhelming.

It can be difficult to obtain good advice concerning networking, since vendors and other advocates are prone to engage in considerable hype. For example, Roberts and Ruby (1983) listed some rosy future possibilities for networks:

1. A business teacher may dial a university database somewhere in this country and in a few minutes get a list of colleges that fill a particular high school graduate's needs.
2. A teacher will be able to attend seminars by traveling no further than the nearest computer.

3. Students will be able to compete in events, such as those FBLA/OEA sponsor with other students throughout the country and never leave their building.
4. Microcomputers will become an excellent means to help students to maintain standards. Databases in almost every area will be at the end of their telephone.
5. The computer terminal will also become an important tool for all students.
6. Teachers will be able to connect one classroom with another classroom across the nation.
7. Networks will provide an outlet for any group that may have ideas to share with another group across the country.
8. Networks will put libraries at the fingertips of students all over the country.
9. With the price increases in books today, the day may come when such material will be too costly to print. The network could fill this void.
10. Networks will bring the outside world to the handicapped student who is unable to leave his/her home. (p. 174)

These predictions were made over six years ago - a relatively long time in the fast-changing field of computing. Unfortunately, however, only a few of these possibilities have been even partially implemented.

Network hardware is becoming increasingly powerful and the software more robust. The result is a tool with almost unlimited capabilities. Inevitably, however, increased power leads to increased complexity, and increased possibility for abuse. Because of the problems discussed in this article, networking is far from living up to its considerable potential.

Networking can be useful, but it is not for everyone. Eltoft (1989) sums up the state of the art in networking when he warns that "The unfortunate truth is that having a network is not always better than not having one" (p. 22). For those considering networking, the phrase "caveat emptor" may be the most appropriate and useful advice. □

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