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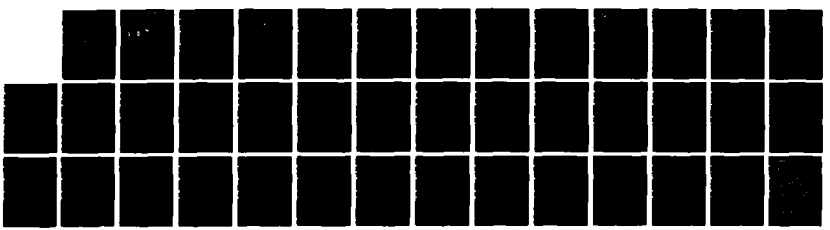

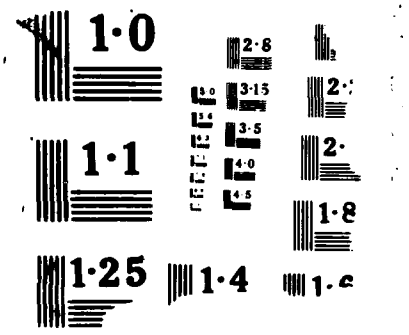
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AIR COMMAND AND STAFF COLLEGE

STUDENT REPORT

NETWORKING OF ACSC MICROCOMPUTERS

MAJ SIMEON D. BREAULT 88-0370

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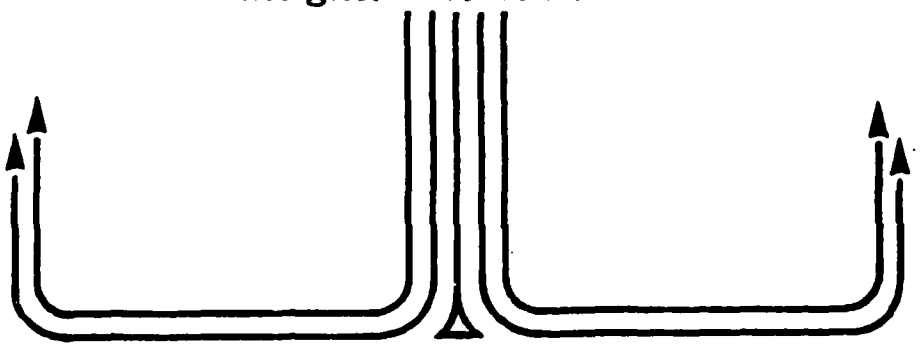

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REPORT NUMBER 88-0370

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This paper explores the feasibility and utility of implementing a local area network (LAN) at ACSC. Basic LAN technology and applications are discussed. Three methods of implementing a LAN are explored: Token Rings, Ethernet, and a generalized broadband LAN. The utility of implementing a LAN is explored by speculating on possible staff and student applications at ACSC. A thumbnail implementation plan is also presented.

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PREFACE

In about the last four years or so, personal computers (PCs) have proliferated throughout the Air Force at an increasing rate. This phenomenon is partly due to significant price reductions as the market for PCs has increased. The day may soon come when every desk in the Air Force has a PC on it.

ACSC has itself witnessed this proliferation. Just about every office, including the student seminar rooms, is now equipped with one or more PCs. As personnel become more familiar with PCs, they have become more productive at manipulating large amounts of data and producing written products. However, another quantum increase in productivity could possibly be realized if electrical communications were added to the PCs, creating a local area network. Thus this paper explores the feasibility of implementing a local area network at ACSC.

The technology of local area networks is outlined in broad terms. Then specific methods of networking PCs are discussed in more detail. The paper also presents some ideas of the applicability of a local area network to ACSC and sketches a simplified implementation plan.

The author wishes to acknowledge the assistance of the project's advisor and sponsor, Maj Jim Gatewood, for his help in preparing this report. Also, the up-to-date information provided by Capt Ron Ford, ACSC/XP was greatly appreciated.

ABOUT THE AUTHOR

Major Breault was commissioned through the ROTC program at the University of Lowell, Massachusetts, in 1974. His BS degree was in electrical engineering and he has worked as a developmental engineer throughout his Air Force career. His first assignment was as an electronic intelligence analyst at System Command's Foreign Technology Division, Wright-Patterson AFB, OH. In 1977 he went to AFIT and earned a MS degree in electronic engineering, specializing in microelectronic device fabrication and in digital systems. Following AFIT, he was assigned to Rome Air Development Center, Griffiss AFB, NY, where he worked as a microelectronic reliability test engineer. In 1980 he went to Germany as an R&D exchange engineer. He worked at the Institute of Telecommunications of the German Aerospace Research Establishment (Germany's version of NASA), researching the application of spread-spectrum techniques to satellite communications. In 1982 he was assigned to System Command's headquarters at Andrews AFB, MD. There he managed advanced space technology programs run by the AF Space Technology Center. His last assignment before attending ACSC began in 1984. He worked for the Joint Special Studies Group of the JCS, at Ft. Meade MD. He formulated requirements and performed systems engineering for a JCS information processing and display system being installed in the Pentagon and at the headquarters of selected Unified and Specified commands.

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REPORT NUMBER 88-0370

AUTHOR(S) MAJOR SIMEON D. BREAULT, USAF

TITLE NETWORKING OF ACSC MICROCOMPUTERS

I. Purpose: To survey methods of interconnecting ACSC microcomputers via a local area network (LAN) and explore the utility of a LAN at ACSC.

II. Problem: Personal computers (PCs) are proliferating throughout the Air Force at an increasing rate. ACSC has also experienced this proliferation since it now has one or more PCs in nearly every office and seminar room. Adding electrical communication to the PCs, in the form of a local area network, could possibly result in a quantum increase in productivity through very rapid data dissemination and sharing.

III. Data: Chapter one discusses the basics of local area network technology and some typical uses of such networks as they are currently used. A local area network (LAN) is a communications system linking personal computers and peripheral devices in a geographically small area, typically in a single building. Resource and data sharing is realized by hardware/software packages called servers. Examples of services provided include shared printers, shared data, and shared access to external networks. Chapter two surveys methods of networking PCs. In particular, Token Rings, Ethernet, and a generalized broadband LAN are discussed. A broadband LAN may be attractive since it could use the existing cable TV cabling. Chapter three describes the current PC resources of ACSC and speculates on

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some applications that would be enabled via a LAN. ACSC currently has 65 Z-100 microcomputers and 65 newer Z-158 PCs distributed throughout the staff offices and student seminar rooms. All of these PCs currently use Version 3.1 of SMART, an integrated software package providing word processing, spreadsheet with business graphics, database, communications, and time management (calendar) application modules. AU/XP is currently planning to have installed a campus wide LAN covering the entire Maxwell AFB complex of PME facilities. Both ACSC staff and students could benefit from the rapid data dissemination and data sharing features that a LAN could provide. Finally, chapter four, presents a thumbnail implementation plan for acquiring a LAN for ACSC.

IV. Conclusions: Local area networks are a viable way of interconnecting personal computers. There are several methods available for implementing LANs. Tangible benefits to both the ACSC staff and student body could be realized if a LAN were implemented here.

V. Recommendations: The author recommends that ACSC should implement a local area network. A project manager should be appointed to lead the implementation as sketched in chapter four of this paper.

Chapter One

LOCAL NETWORK TECHNOLOGY

INTRODUCTION

Personal computers (PC) are proliferating throughout the Air Force at a tremendous rate. This phenomenon is partly due to significant price reductions in recent years as the technology for making these PCs improves. Hardware has become very cheap. For example, in a previous assignment the author was in an eight person program office. Each had an individual Wang PC to use; the office also had an IBM PC to help in travel voucher calculations, and a pair of Macintosh microcomputers with a laser printer for graphics applications. The Wang PCs were networked through a Wang system called Alliance, allowing the sharing of a letter quality, daisy-wheel printer and a laser printer.

Personal computers have also proliferated at Air Command and Staff College (ACSC). Through an Air University (AU) Wargaming Center contract ACSC was blessed in March 1987 with 65 new Zenith Z-158 Personal Computers (PCs), including dot matrix printers, color monitors, and large capacity cartridge disk drives. (16) With an integrated software package called SMART marketed by Innovative Software, these PCs are well equipped to handle the major PC applications of word processing, spreadsheet calculations, data base management, and communications. They also have some impressive presentation-aid software, allowing the generation and sequenced presentation of graphics during briefings. ACSC also has 65 Zenith Z-100 microcomputers installed in offices throughout the school. The Z-100s were upgraded this year with the installation of GEMINI boards, making them IBM PC compatible and allowing them to also use the SMART software package. (16)

This large collection of PCs could probably be more effectively used if they could communicate with each other. A local area network (LAN) would enable such communication and allow users to share and rapidly disseminate information. Retired Rear Admiral Grace Hopper, a pioneer in computer technology, gives the following analogy on LANs: "When our forefathers worked the land they used an ox to pull their plows. When the plows got bigger and heavier, they didn't get a bigger ox, they got two oxen. That's why LANs make sense." (7)

And so this research project, sponsored by the Educational Technology Division of ACSC, explores the applicability of local area networks to the ACSC environment.

This chapter discusses the basics of local area network technology and the typical uses of such networks as they are currently used. Chapter two surveys some methods of networking personal computers. Chapter three then outlines how a local area network could be used at ACSC. Chapter four presents a plan to implement an ACSC LAN.

What is a local area network (LAN)?

"A local area network is a communication facility that covers a limited topology [physical configuration], and interconnects in an effective manner different types of servers [host or mainframe computers] and workstations [distributed terminals], more particularly personal and professional computers." (1:ix) Thus, a LAN is a communications network, interconnecting computers (usually small) and peripherals, and is confined to a small area, usually to a single building. One of the chief advantages of LANs is that they provide shared access to information and permit the rapid movement of data. (4:1) Users can also communicate with each other on a LAN. "In all local networks, the concept is that of an invisible messenger carrying information from place to place either on request or as part of a regular routine. The local network strives. . . to make current information available -- within the limits of security and privacy -- throughout the organization." (2:4) Another key advantage is the ability to share relatively expensive peripheral devices, such as laser printers and large mass storage devices. Access can also be shared via external data links to other networks.

Local Network Architecture

Network architecture describes how the computer resources, peripherals, and communication facilities are interconnected. LANs use multi-point connectivity. That is, they are designed so that any one device can broadcast information to all other devices on the network. By examining address data included in the broadcast, the listening devices "decide" whether the broadcast information is intended for them. (13:2)

LANs are typically connected in one of three topologies: star, ring, or bus .

Star. In a star network, there is a single central node. All other devices on the network are directly connected to the central node, like the radiating arms of a star (Fig. 1). The central node acts as a switch board to control the communications on the network. (13:3) However, the central node must be exceptionally reliable and have the capacity to handle all of the network traffic. (4:7)

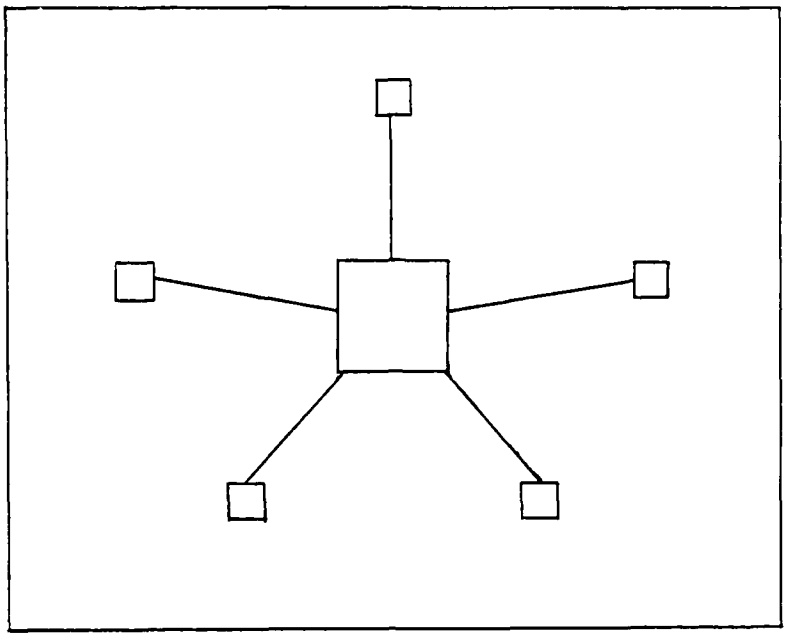

Figure 1 - Star Topology

Ring. In a ring network, each device is connected to two other devices through a communications medium. The connections form a closed pattern, hence the name ring (Fig 2). "Communications between nodes is generally unidirectional and must pass from node to node until it reaches its destination." (13:3) Inactive or failed nodes can be easily bypassed via relays at the nodes. Expansion of a ring network can be a problem since the ring must be broken to add new nodes.

Bus. In a bus network, all the devices on the network are connected to a communications medium, much like the leaves on a tree (Fig 3). Messages broadcast are received nearly simultaneously by all users. The bus topology "is probably the most commonly used LAN topology and best serves a large number of nodes over a relatively short distance." (13:4)

LANs can be connected using various electrical media. One of three media is usually used: twisted pair wiring, coaxial cable, or optical fibers. As its name implies, twisted pair wiring consists of two insulated copper conductors twisted together. It is relatively inexpensive and is good for low speed (less than 1 million bits per second (M bps)) applications. (15:27) Coaxial cable is a familiar medium used with cable TV (CATV) systems. A central copper conductor is surrounded by insulation; the insulation is enclosed in a tube shaped solid or braided conductor with a protective outer covering. The central conductor and the outer layers share the same axis, hence the term "coaxial." Coaxial cable has a large

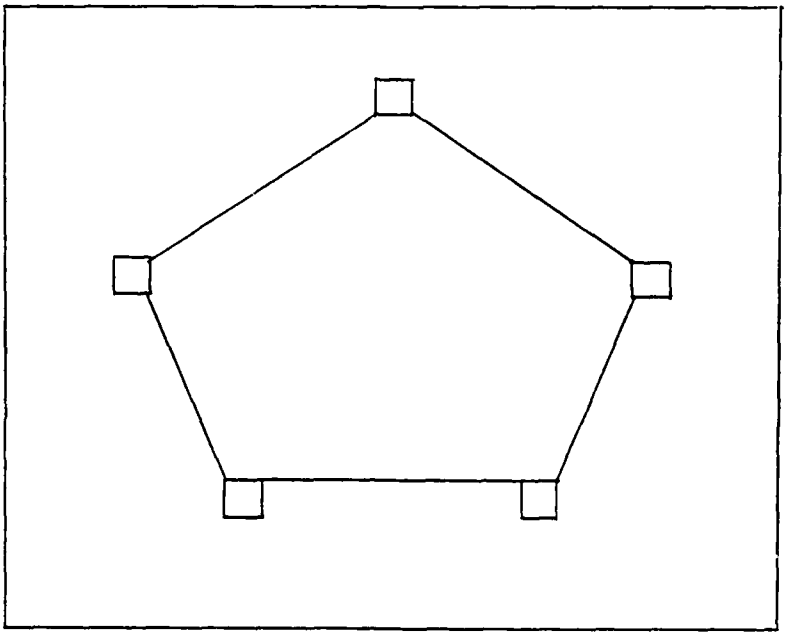

Figure 2 - Ring Topology

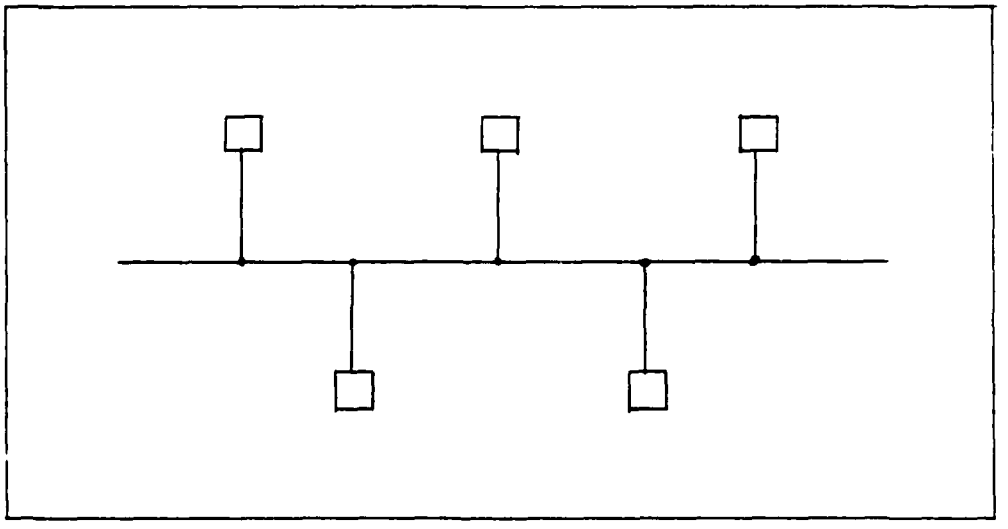

Figure 3 - Bus Topology

bandwidth and can carry several signals on different frequencies without interference. (15:28) Optical fibers are fine strands of glass through which light beams, carrying information signals, are propagated. They have very large bandwidths and are immune to electrical interference. However, since they represent relatively new technology, optical fiber systems are quite expensive. (15:29)

In any network, the computers and shared peripheral devices are connected to the network media through network interface controllers and signal conversion devices. A signal conversion device converts digital data into a form suitable for transmission over the medium being used, and converts signals received over the medium back to digital data (e.g., modems and line drivers). (4:60) A network interface controller is the electronic hardware needed to connect the computers and shared peripheral devices to the network. This hardware, which typically comes on a circuit board which is inserted into the computer or device to be networked, determines when the station may transmit, detects arriving messages, checks for transmission errors, and may include buffers for temporarily storing transmitted and received messages. (4:148)

Various access methods are used to determine which of several network stations wanting to send a message will be next to use the shared medium. They fall into two broad categories: deterministic and random access. Token passing, used on ring or bus networks, is a deterministic method. The token, a unique bit pattern, is passed from node to node. Possession of the token permits a node to transmit a message. After a node transmits a message, it releases the token to the next node. IBM markets a popular token ring network for its PCs. (13:37) Carrier sense multiple access with collision detection (CSMA/CD) is a random access method. Stations wanting to transmit check for a carrier signal to determine whether the network is busy before sending. If a station senses traffic, it waits until the network is quiet and then sends its own message. Collisions occur when two or more stations attempt to send messages at the same time. When that happens, the stations wait a random time interval before trying again. (13:36)

Resource and data sharing is realized by hardware/software packages called servers. Servers should be thought of as programs that provide services, rather than specific pieces of hardware. Examples of services provided include shared printers, shared files, and shared access to external networks. A print server allows anyone on the network to have access to a printing service, such as a laser printer. A file server is a program allowing users to have controlled access to common data bases and programs residing on a designated mass storage device (such as a cartridge disk drive). (4:93)

APPLICATIONS OF LOCAL NETWORKS

LANs can provide many of the applications typically provided by standard computer systems, such as interactive transactions between a user and a host computer. Users on a LAN can transfer bulk data, such as graphics or text files, across the network to other users or to peripheral devices for hardcopy output. Shared data base update and retrieval is enabled. Also, with gateways, users can communicate with other networks. The list of uses could go on. (15:19)

A very popular use of LANs is office automation. The most important application in office automation is word processing. On a LAN, all users would usually use the same word processing software, enabling the rapid coordination of draft documents through distribution on the LAN. Other commonly used office automation applications include electronic mail and scheduling software. Users can use electronic mail to exchange messages and complete files. With scheduling software, administrative assistants can maintain schedules for office chiefs and other important personnel; with access to other users' calendars, data can easily be gathered to schedule meetings.

This chapter provided the reader a very brief introduction to LAN technology and mentioned some typical LAN uses. The next chapter surveys in more detail a few of the methods available for networking personal computers.

Chapter Two

METHODS OF NETWORKING PCs

This chapter surveys methods of networking IBM compatible PCs, such as the Z-158 PCs and upgraded Z-100 microcomputers used at ACSC. Given all the current vendors of LAN hardware and software products, and using various combinations of their products, there are probably hundreds of ways a given set of PCs could be interconnected in a LAN. The Appendix shows a recent compilation of 69 LAN product manufacturers and their products. It is clearly beyond the scope of this paper to examine all the possibilities, so just likely options are outlined. The three methods discussed are Token Rings, Ethernet, and a generalized broadband LAN. These LAN options have become quite popular with industry and they could easily accomodate the large number of users at ACSC. Additionally, a generalized broadbased LAN is discussed since it could use existing cable TV wiring, impacting its overall cost.

Token Rings

The token ring, first marketed by IBM for its PCs, has become a defacto standard in the LAN industry due to its popularity. In fact, this IBM originated technology is described by the IEEE 802.5 standard, and many vendors offer products which are completely compatible with this standard. Since these products comply with a recognized standard, they are theoretically interchangeable and offer the LAN designer considerable flexibility.

As the name implies, token ring LANs are connected in a ring topology. To facilitate expansion, nodes in the ring can be connected through a wire center, which may contain bypass relays and test points to troubleshoot failed nodes (Fig 4). Expansion is achieved by simply adding more wire centers where a node might be located. Such an arrangement looks schematically like a set of interconnected star networks. (4:9) Token rings usually use twisted pair wiring (similar to common telephone wire), so the cabling is relatively inexpensive and easily installed with little disruption. Access control on the network is achieved by token passing, mentioned in chapter one.

Some of the vendors and their products are mentioned here. The 3Com company produces two token ring interface controller cards compatible with the IEEE 802.5 standard: TokenLink and TokenLink Plus. TokenLink Plus is a higher performance

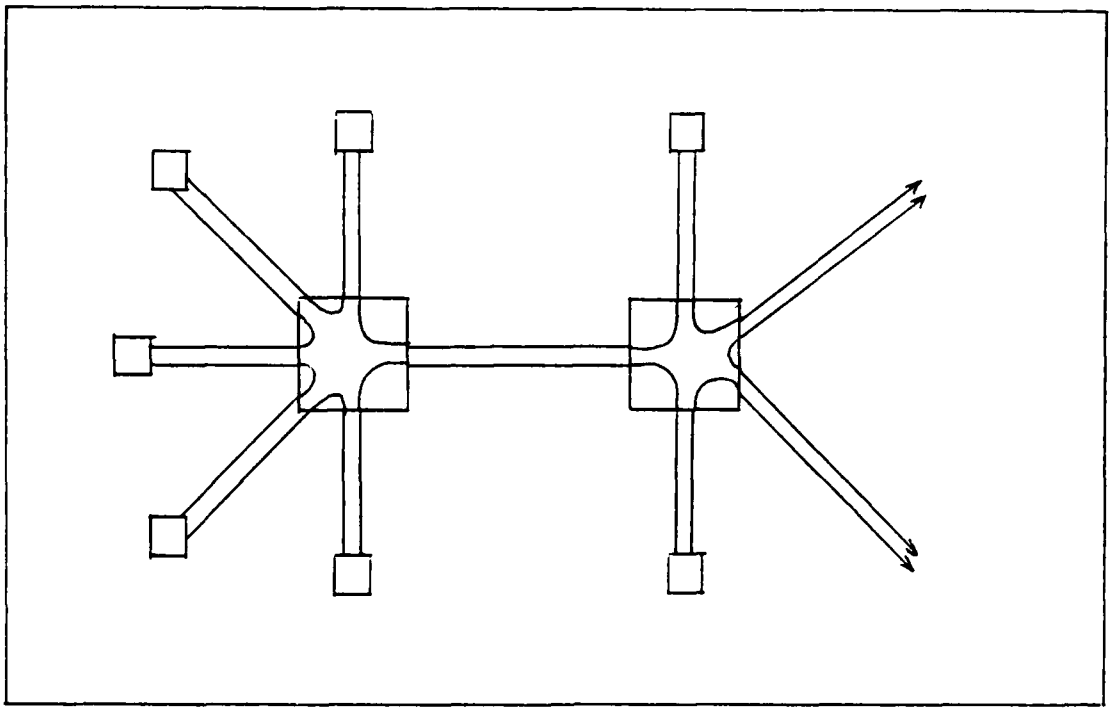

Figure 4 - Ring Topology With Wire Centers

controller suitable for nodes designated as servers (i.e., where shared files are stored) (9:54). IBM, of course, also offers interface cards and wire centers. IBM calls its wire centers Multistation Access Units or MAU. (9:55). Proteon offers ProNet-4, a turnkey token ring network, including interface cards and wire center. It supports several cabling options. (9:56) Racore's product is called LANpac, a PC interface controller card, and is the least expensive card available, about $100 less than their competitors. (9:56) Other vendors include Sytek and Ungermann-Bass. Generally, the token ring interface cards offered by these manufacturers cost about $700 each, and the wire centers or MAUs cost about $1000 each.

ETHERNET

Ethernet is another very popular LAN architecture that has become an industry standard. Ethernet commonly uses coaxial cable and interconnects the stations on the network in a bus topology. Ethernet uses baseband signalling at a data rate of 10M bits per second. Baseband signalling means that the digital signal is applied to the medium without first translating it in frequency so that it occupies the "base" end of the frequency spectrum (0-10MHz in this case). Access control is done using Carrier Sense Multiple Access with Collision Detection (CSMA/CD). (8:55) CSMA/CD is described in chapter one.

Ethernet LANs are easy to install and to expand. A station connects to the Ethernet cable using a "T" connector through a transceiver. A transceiver is a device which supports the transfer of transmit and receive data, and collision detection. Transceivers are usually part of the interface controller card inserted into a PC. A terminator is put on the ends of a cable segment to prevent reflected signals from propagating on the cable. Depending on the specific components used, segments are limited in length and the number of stations that can be supported. For example, 3Com Corporation's version of Ethernet uses 1000 ft. segments supporting up to 100 stations each. (8:54) Ethernet segments can be linked together in a single chain using Ethernet repeaters between the segments. Multiple cable segments, feeding different floors and wings in a building, could also be wired to a central point using a device called a multiport transceiver. This would provide a single point for troubleshooting the several cable segments. (8:58)

Some of the better known manufacturers of Ethernet hardware and software include Digital Equipment Corporation, Hewlett Packard, Xerox Corporation, Ungermann-Bass Inc., and 3Com Corporation. In a recent survey, it was determined that there are now about 300 companies making Ethernet related products. (8:54)

GENERALIZED BROADBAND LAN

In a broadband LAN, the digital signals are converted to analog signals and translated in frequency before being put on the medium, coaxial cable as used for cable TV (CATV). Broadband systems are usually expensive, but offer several advantages. Basic broadband technology is proven; it uses many of the same components as a CATV system which are rugged and long-lived. The coaxial cable used has huge bandwidth, carrying up to 60 6MHz wide TV channels; one TV channel could be subdivided into several data channels. (Ethernet also uses coaxial cables; but, since it operates at baseband and uses incompatible signalling, it cannot share the bandwidth on a CATV cable.) The coaxial cable is shielded, protecting against electrical interference. A broadband network can span up to 55 miles using ordinary CATV amplifiers. Expansion of the network is relatively easy, using simple signal splitters and taps to connect new stations to the network. A broadband network is connected as a tree; individual branches can fail without affecting the rest of the network. (10:46)

Broadband LANs have two main components: a "headend" and a cable system. The headend is a large multiplexer. The headend receives signals from a transmitting station on one frequency (return channel) and translates them to a different frequency (forward channel) to which the stations listen. (10:50) Stations are connected to the network using network interface units (NIU) and radio frequency (RF) modems. Up to eight

stations can be connected to one NIU which in turn connects to an RF modem connected to the cabling system. (14:13).

Such a broadband system should at least be considered for use at ACSC since the necessary cabling system is already installed with taps to every room in the building. The other LAN options discussed above would require new cable installations.

Chapter Three

APPLICABILITY OF LOCAL AREA NETWORK TECHNOLOGY TO ACSC

This chapter briefly describes the current personal computer resources of ACSC and speculates on some applications that would become possible if these PCs were interconnected in a LAN, or possibly a network of LANs (since a LAN cannot accommodate an unlimited number of PC workstations).

THE ENVIRONMENT

There are primarily two types of PCs distributed throughout ACSC: the recently acquired Zenith Z-158s, each with a 20 Megabyte cartridge disk drive, color monitor, and dot matrix printer; and older Z-100 microcomputers. Of the 65 Z-158s, one each is located in the 44 student seminar rooms. Six are located in the ACSC Computer Center, five are located with the Associate Program personnel in a different building, and the remaining ten are used by the curriculum development staff. Of the 65 Z-100s, 30 are used by the Associate Program personnel, and the remaining 35 are distributed among the Faculty Instructors and other ACSC resident staff. (16)

In January 1987, Version 3.1 of the SMART software package was installed on all of the above mentioned PCs. SMART is an integrated software package which includes word processing, spreadsheet with business graphics, database, communications, and time management (calendar) modules. Using almost the same commands in all modules, SMART allows files or selected portions of files to be quickly and easily moved from one module to another. (6:36) This version of SMART is completely network compatible, supporting many popular PC LANs and providing file-locking and multiuser protection. (5:1) In the multiuser mode, several workstations may have access to the same data files. To prevent conflicts, only the first user to access a spreadsheet or word processing document can save it under its current name. Subsequent users would be warned that the file is in use and would have to rename the file before saving it, creating a new version of the file. (5:55)

AU/XP is currently planning to have installed a campus wide local area network covering the entire Maxwell AFB complex, including ACSC and the other PME facilities here. This will provide an external network to interconnect the facilities, but each facility will still have to provide its own internal network. (14:5) Funds for installing a LAN at ACSC are currently programmed in the FY90-94 AU POM. (16)

POSSIBLE APPLICATIONS

As mentioned in the introduction, two of the chief advantages of LANs are shared access to information and the possibility of electronic communication among users. These advantages can be useful to both ACSC staff and student operations.

Staff Applications.

Having their PCs interconnected via a LAN provides the ACSC staff with the advantages of office automation. Word processing files, generated with standardized software, could be distributed electronically for review and coordination, a process that can take days using paper versions of documents. Standardized spreadsheet software allows users to record, manipulate, and display statistical data, such as student evaluation results. With a LAN, all offices could access and review such spreadsheet data. With a LAN, staff officers could send mail and memorandums to a particular individual or to groups of personnel. The communications capability of the LAN could be used to forward completed documents to the staff for review and comment. (14:6-7) The faculty presently maintains a database to handle scheduling of speakers and seminars. Having a LAN would facilitate wide access to the data and allow for timely updates.

The staff could realize several benefits with such a system. Standardization provides a built in back up effect. Since all the equipment on the system is compatible, a user could use any terminal on the system if his/her terminal failed. Training is facilitated; little or no retraining would be required when personnel move within the staff. Electronic communication would improve the ability to keep information moving. Consolidation of comments and inputs from several staff members on a single document could be made in much less time than normally required. Since documents would not have to be physically moved from office to office, coordination time should improve. Personal calendars could be maintained on the system which could aid planning and scheduling of meetings. (14:7-8)

Student Applications.

There are several ways the ACSC students could use the data sharing capabilities of a LAN. Seminars could use the spreadsheet application to compile statistical data for the Long Haul aerobics program. Then the LAN's communication ability could be used to compile squadron level and school level statistics for recognizing especially high achievers. Softball scores could be easily compiled to determine "champion" seminars. Billing information for use of the student copier machine could be rapidly disseminated for efficient payment collection.

Rapid information dissemination and electronic mail could offer advantages. Students could get the latest schedule updates without waiting for printing. COMSTAFF meeting announcements could be similarly handled. Electronic mail could speed up coordination of luncheon arrangements; after each seminar entered their data, lists of attendees could be compiled with just a few keystrokes.

Shared databases and communication facilities would help when students are selecting a research project. The "Hire a Brain" could be indexed in a shared database to help students rapidly find project topics in a particular area of interest. Also the Faculty Experience compilation could be similarly indexed to help students choose an appropriate advisor for their research projects. Assuming the ACSC LAN is connected to the AU wide network, students could access the AU library's electronic card catalog. Such a communications capability could allow the seminar PCs to be used as terminals for the Fast Stick theater warfare exercise.

Tutorial programs, or computer aided instruction, developed by the staff or students as research projects could also be easily shared over a LAN. The LAN would allow simple gathering of evaluation results and rapid compilation of student feedback.

Chapter Four

AN IMPLEMENTATION PLAN

Chapter two shows that there are many technical solutions for interconnecting the personal computers at ACSC into a LAN. Chapter three suggests that a LAN could be used effetively at ACSC for both staff and student operations. How would one go about getting a LAN installed? This chapter suggests an approach for implementing a LAN at ACSC. Specific guidance for carrying out the below mentioned steps can be found in AFR 700-3 (12) and in The Air Force Manager's Guide to LAN Planning (11)

The first step should be to appoint a project manager. This person would be responsible for coordinating and accomplishing the tasks which follow. This person could also later become the overall network manager, a job that should only require a few hours a week to accomplish.

DEFINE REQUIREMENTS

What are ACSC's needs for a LAN? Chapter two suggests several applications to facilitate staff and student operations. These applications could be satisfied by a LAN. The project manager should formally survey the potential user community, which includes staff and students, to determine the degree of desirability of the suggested applications, and to possibly find other desired applications. To the maximum extent possible, these desires should be expressed in quantitative form to enable the network manager to establish ballpark figures for required network throughput and response time. Lefkon (3:106-118) suggests a methodology for doing this based on a formal survey.

ESTABLISH A COORDINATING COMMITTEE AND DELAGATE TASKINGS

This continues the process of defining requirements. Expertise should be sought out and tapped to determine requirements for floor space, environmental controls, power, cable installation needs, physical security, training, acceptance testing, and maintenance. (15:49-50)

PERFORM NEEDED SURVEYS

As mentioned above, a desires survey will help establish the requirements for the LAN. A site survey also needs to be

performed to determine installation feasibility of various types of LANs. The site survey determines the locations of workstations to be connected to the LAN, and identifies building construction characteristics that may influence the network layout and installation. (4:46)

PROJECT FUNDING NEEDS

This has already been done and funds have been programmed for networking at ACSC in the FY90-94 AU POM. (16).

SUBMIT REQUIRED FORMS AND PLANS

The appropriate contracting office for AU will define what forms and plans are needed to prepare a request for proposals (RFP). The RFP would then be published for evaluation by potential vendors.

COORDINATE WITH HIGHER HEADQUARTERS

This is necessary throughout the planning and implementation process. AU is planning to install a network that will link the various Maxwell PME facilities together. ACSC needs to ensure its LAN can be linked to the AU network.

GLOSSARY

The following definitions are from A Handbook for Local Area Networks (15:51-56) and from Local Area Networks (4:133-158).

access methods -- Techniques for determining which of several stations that desire to transmit will be the next to use a shared transmission medium.

architecture -- A structured, hierarchical framework for designing computer systems.

bandwidth -- The measure of a device's or medium's ability to transmit signals that span a range of frequencies without degrading the amount of power in the signal more than some percentage (usually 50%).

baseband -- A transmission system in which signals are applied to the transmission medium without being translated in frequency (modulated onto a carrier signal).

bps -- Bits per second, a measure of transmission speed.

broadband -- A transmission system in which signals are applied to the transmission medium after being translated in frequency. Typically, many different sets of signals (e.g., voice, data, TV) are on the transmission medium at one time, each having been translated to noninterfering frequencies.

broadcast -- Transmission of a signal that passes all nodes on a network. Nodes have the capability to recognize and receive signals addressed to them.

bus -- A local area network topology in which all stations attach to a single transmission medium so that all stations are equal and all stations hear all transmissions on the medium.

bus interface unit -- A network component attaching peripheral devices onto a cable.

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bypass relays -- Relays in a ring network that permit message traffic to travel between two nodes that are not normally adjacent. Usually such relays are arranged so that any node can be removed from the ring for servicing and the two nodes on either side of the removed node are now connected via the bypass relay.

capacity -- Amount of data that a medium can handle at anyone time, related to the bandwidth of the cable.

carrier detect circuitry -- Electronic components arranged to detect the presence of a carrier signal and thus detect that a transmission medium is in use.

carrier sense multiple access (collision detection) (CSMA/CD) -- Access method which allows multiple nodes to gain access to a single channel by listening to the cable and transmitting if not in use. Collisions between nodes are detected and nodes retransmit after a random time length.

channel -- A path for the transmission of data, either one physical circuit or one frequency band on a broadband network.

circuit -- A communications path between two points.

coaxial cable -- A type of electrical cable in which a piece of wire is surrounded by insulation and then surrounded by a tubular piece of metal whose axis of curvature coincides with the center of the piece of the wire.

collision -- When two or more nodes transmit at the same time, producing garbled data on the medium.

community antenna TV (CATV) -- Use of coaxial cable to transmit a number of television channels from a single location to many receivers on one physical medium.

common file system -- A combination of hardware and software that provides all users of a network with access to the same information. The ability to update the information may be given to all users or may be limited to a privileged few.

configuration -- Logical and physical arrangement of softwwre and hardware to allow operation as a complete system.

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CSMA/CD -- Carrier Sense Multiple Access with Collision Detection, a method of having multiple stations access a transmission medium (multiple access) by listening until no signals are detected (carrier sense), then transmitting and checking to see if more than one signal is prsent (collision detection).

data base -- A collection of data, generally on the same subject, stored in computer-readable form, and usually indexed or arranged in some other logical order. Computer or network users can use the index or logical arrangement to find a particular item of data.

disk server -- A computer system equipped with disks and a program that permits network users to create and store files on the disks. The persons creating the files can read and write data in their own portion of the disk. Controlled sharing of access to files is usually limited or nonexistent.

error detection -- Code within a data signal with specific rules that can detect errors within the signal. Any data unit in error can then be delivered to the destination or back to the receiver with or without notification that an error exists.

Ethernet -- Baseband LAN developed jointly by Xerox, DEC, and Intel corporations. Uses bus topology with coaxial cable.

expandability -- Feature of a network allowing the network to be expanded with more medium, peripherals and network components.

fiber optics -- A technology that uses light waves to carry the information. Can replace twisted pair wire or coaxial cable. Very small physically and can carry great amounts of information. Immune to interference. Emits no radio signals. Excellent security characteristics.

file -- An ordered collection of data, usually stored on a disk or tape and associated with or created by a particular person.

file server -- A computer system equipped with disks or tapes and a program that permits network users to create and store files on the disks or tapes. The persons creating the files can allow other network users to read the files, to read and write in the files, or to have no access at all.

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flexibility -- Feature fo a network allowing easy modification to its configuration or applications.

frequency -- Number of cycles of a wave signal per second. Usually expressed in Hertz (Hz) or cycles per second.

gateways -- Network components that allow communication between two different networks through protocol translation or data conversion.

hardware -- Physical peripherals and components.

headend -- In a broadband local area network utilizing a single cable, apparatus that translates the frequencies used for reception of data from the cable.

IEEE -- Institute of Exectrical and Electronic Engineers.

local area network -- A geographically limited communications network designed to provide a communications backbone for the interconnection of heterogeneous (multivendor) data and communications equipment.

log-in -- The process of identifying and authenticating (via password) oneself to a computer system.

mail server -- A computer system and associated software that offer an electronic service analogous to that provided by a national postal service. Users may send or forward electronic mail messages to anyone else served by the system and accumulate messages in a "mailbox."

medium -- The instrument to carry signals between two components. Usually twisted pair phone wire, coaxial cable, or fiber optics cable.

message -- Data unit transferred over the network.

modem -- Modulator/demodulator. Component to convert computer digital signals to analog (waves) for transmission and then converting back to original form at the destination.

multiplexer -- Component to transmit two or more data streams on one single channel or circuit.

multipoint -- A single line with more than two nodes or devices.

network interface controllers -- Electronic circuitry that connects a station to a network. The circuitry determines when the station may transmit, detects arriving messages, indicates error conditions, and may include buffers for storing transmitted and received messages.

network management -- Administrative services and system to properly manage a network.

nodes -- Points in a network where service is provided, service is used, or communicatins channels are interconnected.

peripherals -- Computer components such as terminals, printers, copiers, disk units or tape drives.

personal computer -- A computer (including such elements as a keyboard, display, memory, and computational elements) provided for the use of one person and remaining idle when that person is not using it.

point-to-point -- Transmission of data between two distinct components with no intermediate nodes between them.

printer server -- In a local area network, a program, residing in a computer associated with a printing device, that provides network users with shared access to the printer.

protocol -- A set of formal rules or conventions to govern the format and exchange of information between two communicating devices.

random retry -- In Ethernet, a station desiring to transmit and encountering a collision will wait a random period of time before attempting to transmit again using CSMA/CD rules.

ring -- a local area network topology in which each station is connected to two other stations, this process being repeated until a loop is formed. Data are transmitted from station to station around the loop, always in the same direction.

server -- A program, and possibly a dedicated computer sytem, that provides a service to local area network users, such as shared access to a file systm, control of a printer, or the storage of messages in mail system.

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software -- Programs, routines, and procedures that control the operation of computers.

standards -- Documents that describe an agreed-upon way of doing things such that independent groups or companies can design and build hardware, firmware, software, or combinations thereof and have them interwork with similar products designed and built by others.

star -- A local area network topology in which all stations are wired to a central station that establishes, maintains, and breaks connections between the stations.

tap -- Connection between a network component or peripheral and the communications medium.

throughput -- Total information processed within a time unit. Usually specified as bits per second.

token -- Bit patterns that contain the right to transmit data. Used in token passing networks (ring or bus).

token passing -- A procedure where each node systematically passes the token from node to node. This gives each node the right to transmit data and avoid conflict with other nodes.

topology -- Configuration of network components in a geometric arrangement such as a bus, star, or ring.

transmission method -- Signalling technique for transmitting data through the communications medium. Within a local area network, these methods are usually associated with broadband ore baseband methods.

twisted pair -- Common double pair phone wire. One pair recieves and one pair transmits.

wire centers -- Token ring networks may use radial wiring plans rather than running wires in an actual circle. When such systems use radial wiring, two pairs of wires (transmit and receive) run from a central point to each station like spokes of wheels radiating from central hubs. The central points or hubs are the wire centers, points at which the transmit pair from one station is connected to the receive pair from the next station in a consecutive fashion until an electrical ring has been formed.

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APPENDIX

LAN PRODUCT MANUFACTURERS

The following list comes from an October 1987 article in LAN Magazine (21)

Manufacturer	Product(s)
ACS Telecom	10CAD Plus
AST Research	Star Adapter, Resource Sharing Network, Star Hub
AT&T	Starlan
Alcoa Fujikura	RS-232C Optical Extender, RS-232C Optical Adapter
Algo	MC-610 RS-232 Multiplexer
Allen Bradley	VistaLAN/PC, VistaLAN/1, VistaMAP LAN
Alloy Computer Products	PC-Slave/16 card, PC-Slave/286 card, NTNX operating software, PC-XBUS expansion bus, Plus4, ClusterPlus
Apple Computer	AppleTalk Personal Network, AppleTalk IBM PC Card
Applitek	IEE 802.3 RS-232 Terminal Servers, UniLAN RS-232 Terminal Servers
Applied Knowledge Groups	The Knowledge Network
Artel Communications	Fiber 100M-bit LAN Backbone, Fiber 100M-bit LAN Bridge, LAN 100M-bit Software Control
Augat Communications Group	Fiber-Optic Data Link
Avatar Technologies	Alliance
BICC Data Networks	4112 PC Controller, 4113 PC Controller plus Driver, 4610 RS-232C Terminal Server
Banyan	VINES, VINES/286, VINES/386, BNS and DTS network servers

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LAN PRODUCT MANUFACTURERS

Manufacturer	Product(s)
Bridge Communications	PCS/1 Personal Communications Server, IVECS, EtherLink Card, TokenTerm
Centram	TOPS for the Mac, PC and UNIX, TOPS Repeater, TOPS Print
Codenoll Technology	Codenet Ethernet LAN, Codenet ARCNET LAN
Codex	Codex Asynch LAN, 4000 Series LAN
Communications Machinery Corp.	ENP Ethernet node processors for VMEbus, Multibus, Unibus, Qbus and IBM PC/AT/XT
Connect Computers	Wonunder Arcnet Toshiba T3100 card, Wonunder Ethernet Toshiba T3100 card, Lanscope network control system software
Contemporary Control Systems	STD Arcnet Interface, Multibus Network Interface Module, PC Arnet Intrface, Modular active hub
Corvus Systems	Omninet IBM, MAC, Apple, DU2 Unibus and DQ2 Qbus interface cards, PC/NOS, Constellation III network service program for MAC and Apple II
DNA Networks	DNA Networks Master/Product II, Station/Product II, Master, Station, E-Mail
DCS Nestar Systems	PLANStar file server, PLAN 5000 file server, PLAN 1000 device server, network interface cards
Datapoint	Arcnet cards, ARC network, Starbuilder
Data/Voice Solutions	Centaur RS-232 LANs

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LAN PRODUCT MANUFACTURERS

Manufacturer	Product(s)
Digital Products	Net Commander Sub-LAN, Print Dircetor Sub-LAN
EasyNet Systems	EasyNet
Eicon Technology	Eiconet Adapter, Eiconet Gateway
Excelan	TCP/IP-Ethernet Networking Package Series for PC, VAX, MicroVAX
FiberLAN	NET 10
Fibronics	IBM 327X Multiplexers, IBM Channel-to-Ethernet, RS-232 Fiber Optic Multiplexer, FDDI Network, Fiber-Optic Ethernet LAN
Fox Research	10-Net LAN, 10-Net Fiber Optic, 10-Net Starlan
Gandalf Technologies	STARPORT Computing LAN
Gateway Communications	G/Net, NetBIOS emulator
IBM	PC-Net and Token Ring cards, bridges, multiple access unit, PC LAN Support Program
IDEAssociates	IDEAshare, IDEAnet
Interoptics	Optical RS-232C Port Expansion Master, Slave, DTE/DCE
JC Information Systems	Arcnet intrface card, four- and eight-port active hub cards, eight-port active hub subsystem, four-port passive hub
Kimtron	K-Net, XL-11-1 Interface Card, I/O Workstation Interface Card
Localnet Communications	D-Link+ Ethernet Adapter, D-Link Network (twisted pair) Adapter, D-Link Network Program, NetBIOS/Netware Adapter

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LAN PRODUCT MANUFACTURERS

Manufacturer	Product(s)
MICOM-Interlan	NI5210 Ethernet Controller, NP600 Protocol Processor, NTS100 Server, NT1000 Transceiver, 8-4-1 Multiport Transceiver
Network Research	Fusion network software
Newbridge Networks	EasyStreet, MainStreet
Novell	S-Net, NetWare
Orchid Technology	PCnet cards, Orchid NetBIOS emulator
PC Office	Net-Board, Clerk, NetBIOS interface
Performance Technology	Powerim II high performance Arcnet card
Proteon	ProNET-4, 10, 80
Pure Data	PDI series Arcnet cards
Quadram	Quadnet VI, IX, Quadstar
Racore	LANpac I, LANpac II, LANpac Token Ring
Rose Electronics	Master Switch data PBX, Master Net RS-232 LAN software, Master Link switch control software, Caretaker Plus automatic switch, Porter code activated switch
Santa Clara Systems	8-User Netware Operating System, Ethernet Network Interface Card
Server Technology	EasyLAN 2 and Expansion Kit, EasyCOM Expansion Boards
Standard Microsystems	Arcnet-PC110/PC210 controller boards, active hub, active link

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LAN PRODUCT MANUFACTURERS

Manufacturer	Product(s)
Sunol Systems	Sun Disk, Sun Net networking multiplexer, Mac interface card, IBM interface card, 105i internal disk
Synoptics Communications	Ethernet transceivers, concentrator boards and boxex for shielding twisted pair (IBM Cabling), unshielded twisted pair (AT&T PDS Cabling) and fiber optics
Sytek	LocalNet
The Software Link	PC-MOS/386, LANLink, MultiLink Advanced
Thomas-Conrad	ARC-CARD, ARC-CARD CE enhanced, ARC-CARD HZ high impedance, ARC-CARD FO fiver optic Arcnet cards, 8 port active hub, 4 port passive hub with terminators
3Com	3+ Software, EtherSeries Software, EtherLink, EtherLink Plus
Tiara Computer Systems	TiaraLink
Torus Systems	Tapestry Network Manager, Tapestry Workstation Package
Ungermann-Bass	Net/One
Univation	LifeLink, LifeNet, LifeServer
Waterloo Microsystems	PORT PC LAN Program, Port Network Interface Card
Western Digital	StarCard, StarLink, StarCard Plus, StarHub, EtherCard Plus, ViaNet

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