NEW DIRECTIONS IN LOCAL NETWORKING

INPUT

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INPUT Planning Services for Management

NEW DIRECTIONS IN LOCAL NETWORKING

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NEW DIRECTIONS IN LOCAL NETWORKING

CONTENTS

NEW DIRECTIONS IN LOCAL NETWORKING

EXHIBITS

I INTRODUCTION

I INTRODUCTION

- This report is part of the Management Planning Program in Information Systems, and discusses the major local area network systems that have emerged, as well as the IBM alternative to local networking.

- The report also discusses the technological issues that are involved in integrating local area networks with corporate EDP systems, and the role of information systems management with respect to local area networks.

- There is no intention to suggest that full integration of local area networks and EDP systems is inevitable.

  - Since local area networks are just beginning to be installed, networking concepts have not yet stabilized. INPUT suggests prudence in approaching the subject of integration because of the fluidity of these concepts.

  - Information systems management must, however, strive to remain intelligently informed about local area network issues to avoid unpleasant surprises.

- Comments and questions from clients are invited.

II EXECUTIVE SUMMARY

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A. OVERVIEW

- Local area networks are emerging as substitutes for, or logical extensions of, the process of placing computing power at the disposal of office workers.

- Generally, local area networks are not intended to displace a corporation's data processing resources, although some alternatives can deliver as much, or more, functionally useful throughput as full-fledged EDP systems.

- The emphasis of local area networks varies with the vendor, but by and large they seek to integrate one or more office functions.

- The productivity of local area networks can, in some cases, be enhanced by permitting them to interact with major corporate information systems.

    - However, direct integration with the company's EDP system is not always necessary or desirable.

    - Identifying the tradeoffs involved is a task that belongs to the management of the information systems department.

    - This task cannot be executed properly without an understanding of the role and current status of local area network alternatives.

B. THE EMERGENCE OF LOCAL NETWORKS

- Local area networks are one of the newest ways to address the longstanding need to share information processing and data storage resources at the end-user level. Vendors who have devised hardware solutions to meet this need offer end users an apparently simple, low cost way to avoid some of the perceived shortcomings of information systems departments which may be unable to satisfy each specific end user's demands as quickly as desired.

- Timesharing, an early attempt to solve this problem, included the technique of communication with a more or less remotely located computer over links provided by the common carriers (or private equivalents), the only technology for data transmission readily available during the 1960s and 1970s.

- The phenomenal growth of the microprocessor industry provides real alternatives to the use of timesharing, by incorporating intelligence directly in a variety of sophisticated office systems equipment, including:

  - Word processors.

  - Copiers.

  - Computerized telephone systems.

  - Facsimile transmitters.

  - Personal/small computers.

- The growth of this equipment promises to be explosive, as shown in Exhibit II-1.

EXHIBIT II-1

RELATIVE GROWTH IN SELECTED OFFICE SYSTEMS EQUIPMENT

OFFICE SYSTEM	1980-1985 GROWTH (percent)
Word Processing	400%
Copiers	100
Computerized Telphone Services	400
Image Processing	
Facsimile	200
Microfilm	100
Personal Computers (In Large Corporations)	600

- Much of this equipment has been obtained and installed directly by individual departmental units to meet particular problems. Often there is little coordination or forward planning involved; for example:

  - Different units of a department may order incompatible word processors from different manufacturers.

  - Quantitative output from a department's small computers may be manually reinputted to word processors, or vice versa.

  - Word processing output may be sent by facsimile device to another organizational unit where it is re-entered into office systems equipment.

- As advanced office systems become more widespread and critical to an organization's business, the operational interdependence of the different pieces of equipment becomes increasingly important.

  - Users of office systems want their devices to be able to "talk" to one another, at least within the same organizational unit.

  - Vendors are beginning to respond to this need. But it should also be recognized that vendors have their own, somewhat different, agenda:

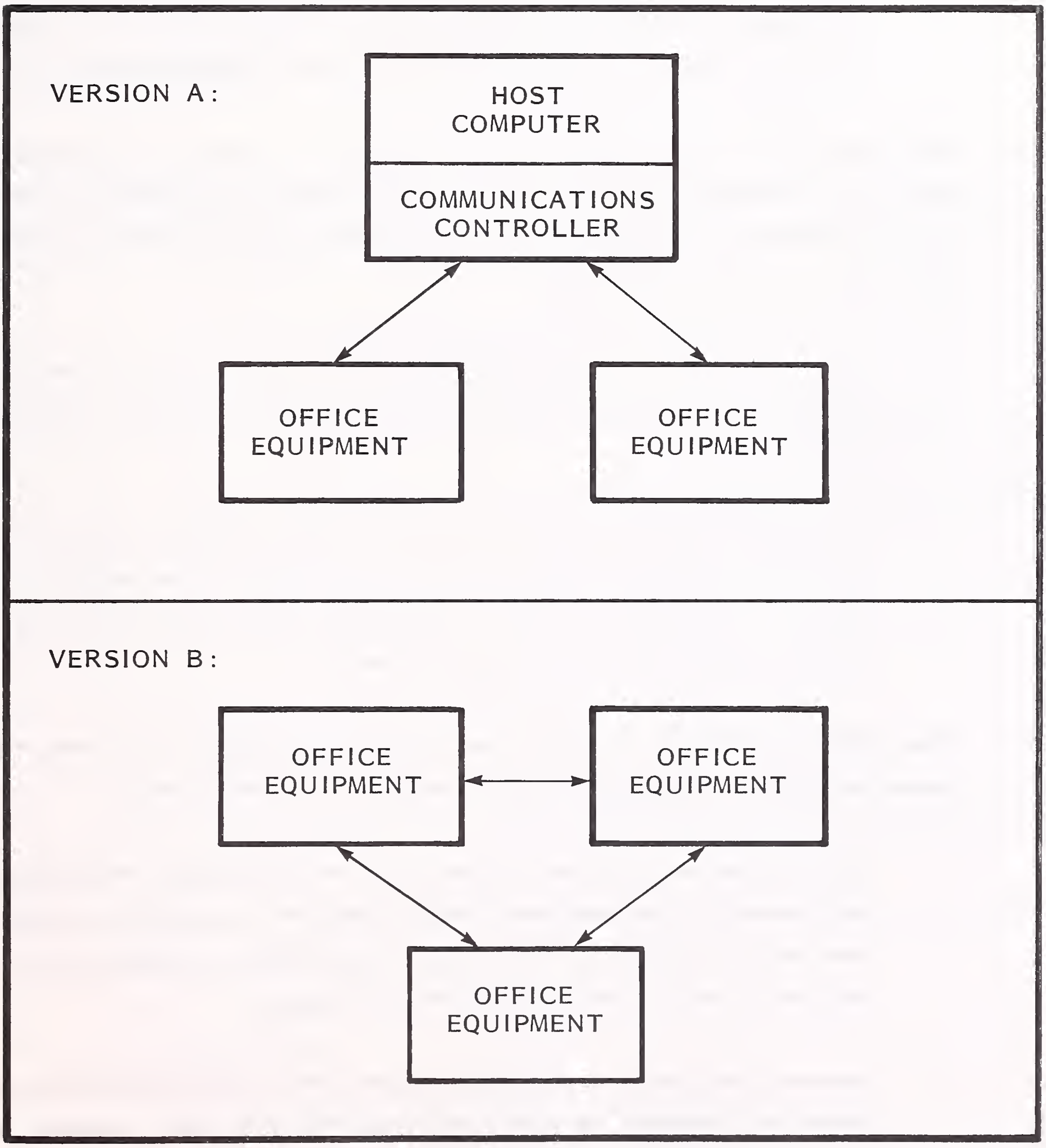
    - They want to make it attractive to buy more office systems equipment.

    - If possible, each vendor would like to arrange things so that his equipment is the most attractive (or, better still, the only feasible alternative).

- In the last several years, contrasting techniques have been proposed for linking office systems together. In essence there are two conceptual approaches, as illustrated in Exhibit II-2:

EXHIBIT II-2

ALTERNATIVE INTERCONNECTION APPROACHES



- Version A is the "host computer" approach wherein a central controller, usually a traditional mainframe or minicomputer, serves as the link between different pieces of office equipment. IBM has the chief example of this approach, using a variety of computing equipment, communication protocols, and software.

- The "peer level" approach in Version B has different pieces of office equipment communicating directly with each other, as in the Datapoint Attached Resource Computer (ARC), WangNet, Ethernet, systems.

• IBM's alternative to the local area network concept is based on economies of scale in large timesharing or corporate computing resources, whether centralized or distributed. Recent offerings in timesharing software have expanded the original concept significantly.

  - In a System/370, VM host operating system environment, a user can change the hardware configuration as well as the guest operating system at will.

  - Using ACF (Advanced Communication Function), multiple networks can be interconnected in such a way that a terminal on one network can invoke a processing function (information retrieval, data update, program execution, etc.) in another network.

• Thus, IBM's alternative to local area network processing is to make the resources of a full System/370 or 30XX available to a remote user.

  - This alternative is obviously appealing to the organization that already has terminals, lines, and spare capacity in place or planned at many or most office locations. In this case, it may be the overriding factor in deciding to limit or avoid local networks altogether.

  - However, the luxury of choosing between IBM or local networks may no longer be available, as local area networks are being installed or implicitly committed without the knowledge, recommendation, or cooperation of information systems management.

- One approach or one particular implementation is not better than another. The different approaches reflect different management philosophies, costs, technical strengths, and functional capabilities.

C. THE ISSUES

- Although local networks are just beginning to come into vogue, management ought to be considering:

  - What is the likely business impact of local networks?

  - Should the company install a local network now, later, or never?

  - What effects will technology and vendor changes have on the company's plans?

- Each issue is discussed below.

1. THE IMPACT OF LOCAL NETWORKS

- Local networks have as much potential for affecting the way office units conduct their business as the telephone and convenience copier have had.

- However, all the impacts are not necessarily positive ones. Seven major areas of potential impact are:

  - Work quality.

  - Productivity.

- Employee changes.

- Decision making effectiveness.

- Organizational structure.

- Costs.

- Overall synergy.

- Exhibit II-3 provides a summary of these points. This exhibit is not meant to be exhaustive. However, it shows that there is at least some downside risk to installing local networks, as well as possible large benefits.

2. DECIDING TO INSTALL A LOCAL NETWORK

- Many criteria for installing local networks depend on office systems already in existence or under consideration, and the question of how extensively they are or ought to be integrated.

- The extent of integration can include one or more of the following types of communication:

  - Data (e.g., word processing or computer output).

  - Voice (e.g., telephone).

  - Messages (e.g., telex or TWX).

  - Image processing (e.g., facsimile, videodisk).

  - Freeze frame or full motion TV.

EXHIBIT II-3

POTENTIAL LOCAL NETWORK IMPACTS

IMPACTED AREA	POSITIVE IMPACTS	NEGATIVE IMPACTS
Work Quality	• Wider data accessibility, fewer "lost" items • Wider participation in creating and reviewing work	• Indeterminate or mediocre data quality • Reduced independence and initiative
Productivity	• Increased workload handled by more powerful office systems equipment	• Increased resources used to perform inconsequential work
Employee Changes	• Improved skill levels in current staff • More challenging work • Reduced status distinctions	• Fewer jobs for marginal performers • Less personal interaction • Insufficient status distinctions
Decision Making Effectiveness	• Quicker availability of relevant facts • Greater analytic capability • More people involved in hypothesis building and testing	• Fact component of decision making becomes too high • Trees and forest problem • Could encourage "group think"
Organizational Structure	• More effective decentralization	• Decentralization may get out of control
Costs	• Overall cost reduction	• Overall cost increase, soft benefits used as justification
Synergy	• Enables the planning of new business approaches	• Creates increased complexity and dysfunctional dependence relationships

- A complicating factor in the decision is the question of timing. An imminent move to a new building, for example, creates an urgency to decide upon a particular local network implementation before all the facts are in.

    - Several companies have deferred this decision by simply installing extra empty conduits to every office location, a fairly conservative solution under the circumstances.

- The relative importance of particular criteria for installing local networks will vary between companies.

    - In many cases, the importance to local units is more apparent than overall corporate interests, especially where pilot or early implementation is involved.

    - Also important is the record of an individual department's prior performance in absorbing new technology.

    - Last, and certainly not least, is the performance record of prospective vendors. This factor entails much more than just the technical characteristics of the local network, and includes such things as:

        - Actual installation experiences.

        - Understanding of basic office system issues.

        - Experience and competence of support people assigned to your account.

        - Experience in firms similar to yours.

- Exhibit II-4 shows a logical matrix that could be used as an analytic tool by companies considering a local network.

EXHIBIT II-4

LOCAL NETWORK DECISION FACTORS

DECISION CRITERIA	WEIGHTING FACTORS				
	IMPORTANCE TO		RECORD AND READINESS OF		RECORD OF PROSPECTIVE VENDORS
	ENTIRE COMPANY	LOCAL UNIT(S)	ENTIRE COMPANY	LOCAL UNIT(S)	
• Amount of localized data available/required					
• Use of combined central/local data					
• Previous office systems productivity					
• Unused employee skills/potential					
• Importance of personal status					
• Use of facts in decision making					
• Use of analytic tools in decision making					
• Extensive personnel involvement in decision making					
• Decentralization characteristics, present and future					
• Ability to monitor decentralization					
• Office cost reduction					
• Cost of office system installation					
• Current office system compatibility					
• Level of technical support (internal, external)					
• Vendor staying power					
• Need/desirability for integration of:					
– Data only					
– Voice and data					
– Voice, data, and message					
– Above plus image processing (e.g., facsimile)					
– All above plus freeze frame TV					
– All above plus full motion TV					

- The critical part of the analysis is to identify weights for the factors which are most important to the company's situation, and the extent to which both the company and the prospective vendor are positioned to meet the requirement.

3. THE IMPLICATION OF CURRENT LOCAL NETWORK OFFERINGS

- The first local network offering, although not called that, was Datapoint's ARC system in 1977. Since then many other vendors have proposed or offered local networks.

  - Key characteristics of current well known local networks are shown in Exhibit II-5.

- As can be seen, the characteristics of representative vendors' offerings differ markedly even on these largely tangible measures.

  - There are likely to be even greater differences when potential clients evaluate a vendor's experience and record in a particular area.

4. THE IMPACT OF FUTURE DEVELOPMENTS

- One sure prediction about future developments in local networks is that some vendors will be forced to drop out.

  - Some systems will prove to be technically unworkable.

  - Some vendors will find that the cost benefit of their particular offering will not be judged attractive by the market.

  - However, even perfectly good products may drop by the wayside because of lack of client support or a loss of commitment on the vendor's part.

EXHIBIT II-5

KEY CHARACTERISTICS OF MAJOR LOCAL NETWORK OFFERINGS

CHARACTERISTIC	LOCAL NETWORK		
	XEROX ETHERNET	WANGNET	DATAPOINT ARC
Number of Installations	About 50*	About 10*	About 2,000
Year First Installed	1979	1981	1977
Size of Networks	Theoretically 1,024 stations. Maximum length 1,500 feet per segment, 1.5 miles per network	Theoretically 65,534+ stations. Maximum length 2,000 feet per segment, at least 2 cable miles total per network	255 stations. Maximum length 2,000 feet per segment, 4 miles per network
Data Capacity (Bandwidth)	10 Mbps	340 Mbps	2.5 Mbps
Transmission Medium	Single Coaxial Cable (Special Type)	Dual CATV Cable	Single Coaxial Cable or three pairs of telephone wires
Total Vendor Sales (1982 est.)	$9.0 billion	$1.0 billion	$0.6 billion

* INCLUDING INTERNAL AND BETA TEST SITES

- INPUT believes there is ultimately room for no more than three or four unique approaches, possibly fewer. Surviving vendors will have to be highly compatible with each other in order to remain viable.

- It is technically, though not yet economically, feasible for a new category of vendors to come into existence whose business will be to furnish "black box" devices or services to make the various local network alternatives compatible with each other.

  - This is known as the "gateway" concept. Some products and services have already been announced and a few delivered.

  - Most user organizations have been slow to patronize this "black box" approach, fearing the additional cost, complexity, and increased exposure to breakdowns.

    . Standards are few to non-existent.

    . Participating vendors are small and unproven.

    . Interconnection requirements change almost daily.

  - However, it is highly likely that no single local network alternative will meet all of any organization's needs, and that there will be many different implementations that will eventually have to be linked together.

    . INPUT believes that sociological and managerial considerations will turn out to be the pacing factor, and that the technology will be ready long before people will.

D. RECOMMENDATIONS

- Identify and quantify the impact of local area networks on long-range information systems plans to the fullest extent possible. Become proficient in the use of network performance and cost models, since too many variables are involved to allow consistently accurate "seat of the pants" network analysis.

- Prepare for multiple rather than only one large local network. Determine objectives to be achieved by possible integration, but do not be locked into a single, "do everything," approach which is too complex for most current or near-term office environments.

- Calculate payout benefits on no more than a two-year basis, because new products are entering the market almost daily.

- Build on your installed base of word processing equipment, especially if it has been purchased.

  - If starting fresh, look for menu-driven, user friendly equipment that requires minimal training to use.

- Be aware that the more powerful benefits achieved from local networks require extensive changes in work habits.

  - Involve the ultimate users in the evaluation and decision processes to ease the transition. Get started early.

III LOCAL AREA NETWORKS

III LOCAL AREA NETWORKS

A. PLANNING CONSIDERATIONS

- Regardless of whether the processing of information uses computing or microprocessor-based equipment such as intelligent copiers and word processors, the need to share information remains essential to the conduct of business operations.

  - End-user acceptance of computer-based products for handling information has led to the use of digital communications to facilitate information sharing among users of these products.

- Enforceable conceptual and architectural standards do not exist outside of the mainframe/common carrier environment. Therefore, in the process of developing local area networks, vendors and users alike have devised communications conventions and protocols optimized for the particular products or applications involved.

- Uncoordinated local area networks can have a serious adverse effect on plans for orderly development of corporate computer-based networks. If local area networks come into being without the knowledge of, or improperly coordinated with, the information systems department, forecasts of data processing equipment and software requirements to support integration of corporate systems will be inaccurate at best.

- Conversely, the planned and coordinated use of local area networks can considerably enhance the availability of information and reduce the overall information resource costs to the organization. The key words are "planning" and "coordination."

- This chapter examines the characteristics of local area networks and the rationale behind their development, discusses considerations attending their integration into a computer-based telecommunications network, and evaluates the role of information systems management in dealing with such networks.

- The terminology employed in local area networking can be troublesome because a great deal of it has been borrowed from other disciplines; unless terms are clearly defined, a discussion can be extremely confusing.

  - For example, the suffix "-net" is used in the names of proprietary local area network systems such as Ethernet and WangNet. But Digital Equipment Corporation's DECnet refers to the set of program products that support common carrier interconnection between DEC processors, and are definitely not local area network candidates.

  - As another example, to the telephone companies the expression "local loop" refers to the wired connection between a telephone and a central office switch. Local area network vendors, however, may use the term "local loop" to describe a ring topology network configuration (see Section B below).

B. KEY CONCEPTS

- Local area networks have evolved in response to a need to share information and resources among a variety of devices used in the office, including small desk-top computers, data storage devices, plain paper copiers, and printers.

- A realistic example of a local area network would be a brokerage office where each stockbroker is supplied with a personal computer. Attachment of high-capacity disk drives and letter-quality printers to each computer may not be cost justifiable, but sharing of such resources makes sense. A local area network could be configured to allow all the brokers' computers to share one or two disk drives and a printer. Client portfolio data could be stored on disk, together with pricing information so that all brokers on the network could access their clients' portfolios to execute portfolio valuations on their own computers. Exhibit III-1 is a schematic diagram of such a network.

- Another example is a number of interconnected word processors equipped with dot matrix printers for the preparation of document drafts. When final copies are desired, the finished drafts are spooled to a microprocessor or minicomputer on the network that drives a heavy duty letter-quality printer. This station may be devoted exclusively to production of print-quality documents from data transmitted to it by all other stations, as illustrated in Exhibit III-2.

• A major distinguishing characteristic of local area networks is that the data path connecting the devices on the network is not provided by a common carrier.

  - The data paths used in these networks are cables (usually twisted wire pair or coaxial, but flat cables and fiber optics appear to offer substantial promise), radio, or infrared light links.

  - Currently, data paths employed in local area networks can support transmission speeds of up to 50 million bits per second (50 Mbps), but their range is limited to a maximum of 15 kilometers (9.4 miles). Typical usage is a more modest 1 to 10 Mbps, at ranges less than 4,000 feet; i.e., within a single building or plant site.

EXHIBIT III-1

SCHEMATIC DIAGRAM OF ONE TYPE OF LOCAL AREA NETWORK
(COMPUTERS SHARING DISK DRIVE AND PRINTER RESOURCES)

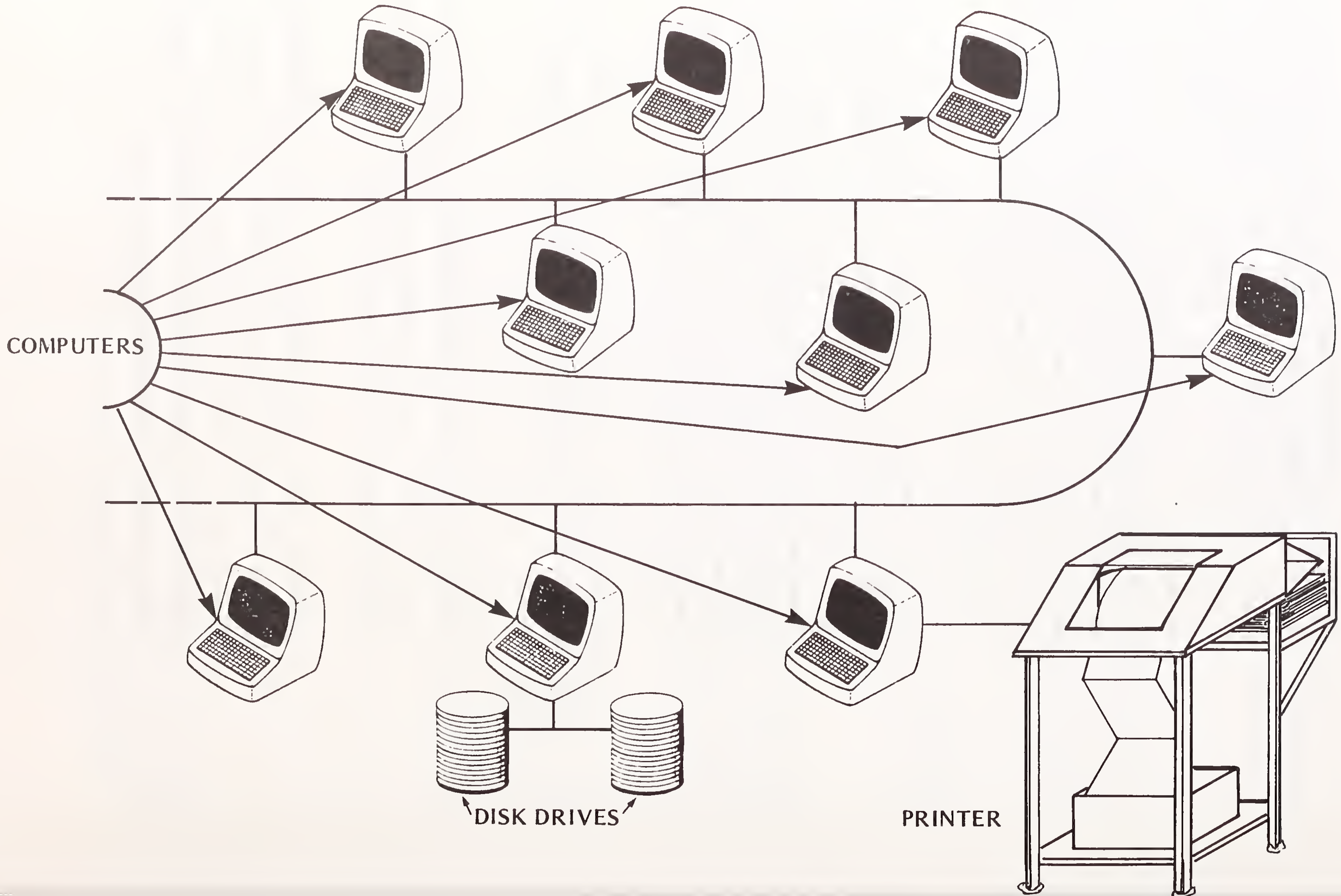
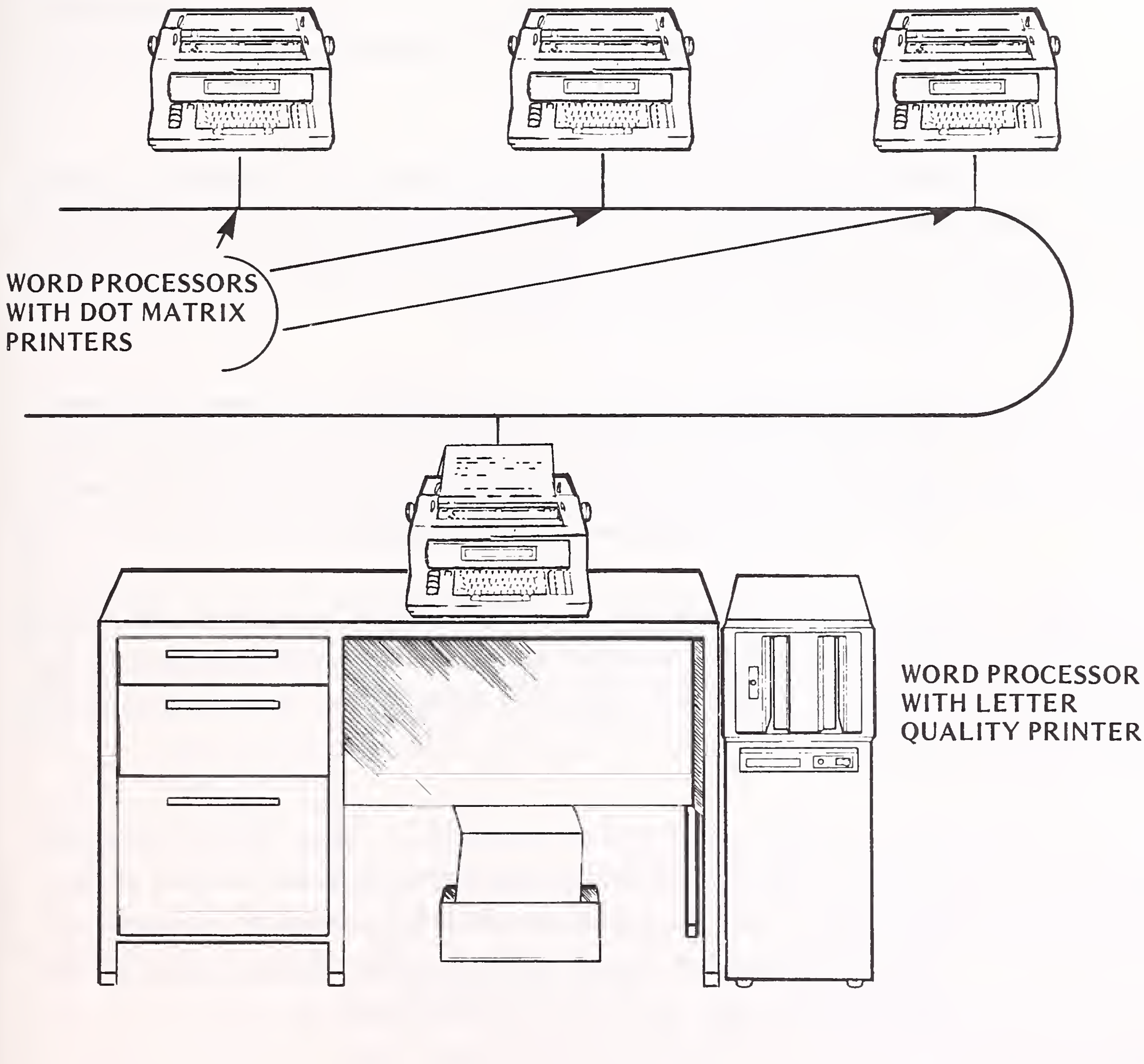


EXHIBIT III-2

LOCAL AREA NETWORK OF WORD PROCESSORS



- Another characteristic of local area network systems is that all stations on the network have equal access to the data path at any time. This contrasts with traditional data communications, where a connection between two stations (e.g., a terminal and a host computer) is rendered exclusive for the duration of the transmission by some mechanism such as software control on a leased line, or the common carrier's switching system in a point-to-point connection.

  - This characteristic has produced novel approaches to the development of local network protocols that are incompatible with traditional forms, and with each other.

- It is beyond the scope of this report to even attempt to present a comprehensive survey of local area network systems, as new variants are announced almost daily. Examination of a number of systems, however, is warranted by their unusual market and technical attributes.

  - Ethernet, developed by Xerox, deserves attention because it represents the baseband technology, and because the Institute of Electrical and Electronics Engineers (IEEE) has adopted a specification almost identical to Ethernet as a local area network standard.

  - Datapoint's Attached Resource Computer (ARC) system, introduced in 1977, has the largest installed base, with about 2,000 users to date, and integrates directly with Datapoint's digital PABX. It also uses baseband technology.

  - Wang Laboratories' WangNet, announced in June 1981, is important because of Wang's spectacular rise to a preeminent position in computer-based word processing systems, and because it represents the broadband technology. It, too, can interface directly to a digital PABX, although Wang does not yet offer such equipment.

I. LOCAL AREA NETWORK COMPONENTS

- Logically, a local area network system has three components:

  - A transmission medium.

  - Network interfaces.

  - Network stations.

- In the following discussion, the term "transmission medium" (or "medium") refers to the physical connection over which data and related control signals are physically conveyed from one device to another by some form of energy; usually direct electric current, but sometimes lightwaves or microwaves may be used.

- Topology is the delineation of a surface. With reference to networks, the topology of a network refers to the abstraction which describes how network components are connected to each other. Common topologies are star, ring, and bus, all illustrated in the next section.

- A major criterion employed in the selection of a transmission medium is bandwidth, because the greater the bandwidth the more traffic can be supported. Additionally, the greater the bandwidth, the lower the bit error rate, and consequently less frequent retransmissions are required for error recovery.

  - Coaxial cable is a popular medium because it can sustain a very high data transfer rate over several miles without signal regeneration, and is readily available from electronic distributors.

    . Some vendors have standardized on RG-59/U 75-ohm coaxial cable, which is the type of cable commonly used to link TV sets with a master antenna, while others use the larger half-inch diameter CATV cable. CATV cable has a seamless aluminum shield that meets fire codes without being run through conduits. Both types of cable, as well as related hardware such as connectors, are in common use and have proven high reliability. Either a single or double cable configuration may be required.

. Ethernet requires a special type of double shielded coaxial cable.

- Fiber optics can be used in some topologies but not in others because the connections for fiber optics network interfaces are not as simple as for coaxial cable. As explained later, this makes a difference in structuring the network. Fiber optic cables are not much more expensive than coaxial cable, but can carry a bandwidth of 400 Mbps to 1 Gbps and are not susceptible to random electrical noise.

- Noncoherent infrared light links and microwave radio can be used when there is a requirement for high bandwidth line-of-sight transmission in a network segment between locations separated by short distances, such as two buildings within a mile of each other.

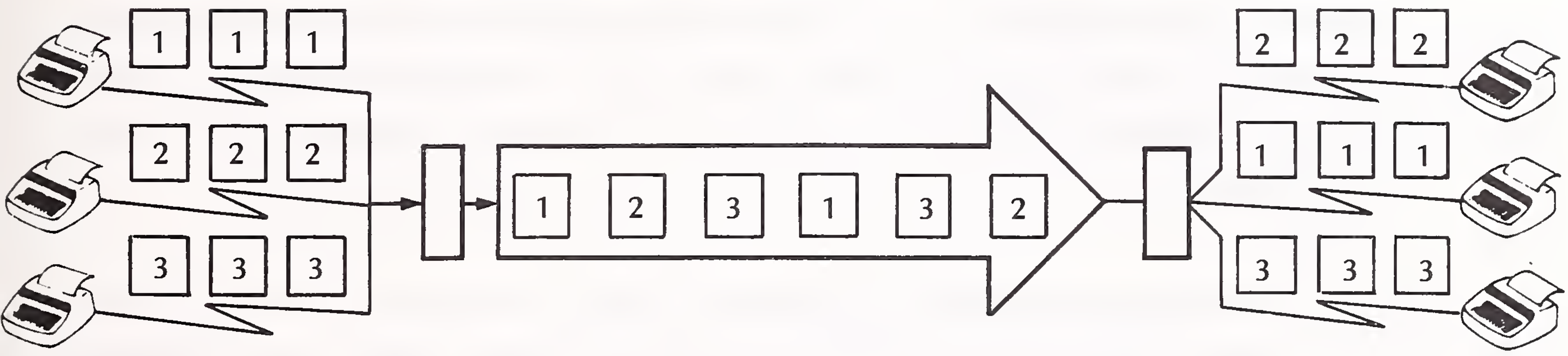
- High bandwidth transmission over twisted pair (i.e., telephone) wire has been achieved over distances of several hundred feet in a nonhostile environment, but is more commonly restricted to rates that do not exceed 9,600 bps per pair.

- Two methods of transmission used in local area networks are time division multiplexing (TDM) and frequency division multiplexing (FDM), as diagrammed in Exhibit III-3.

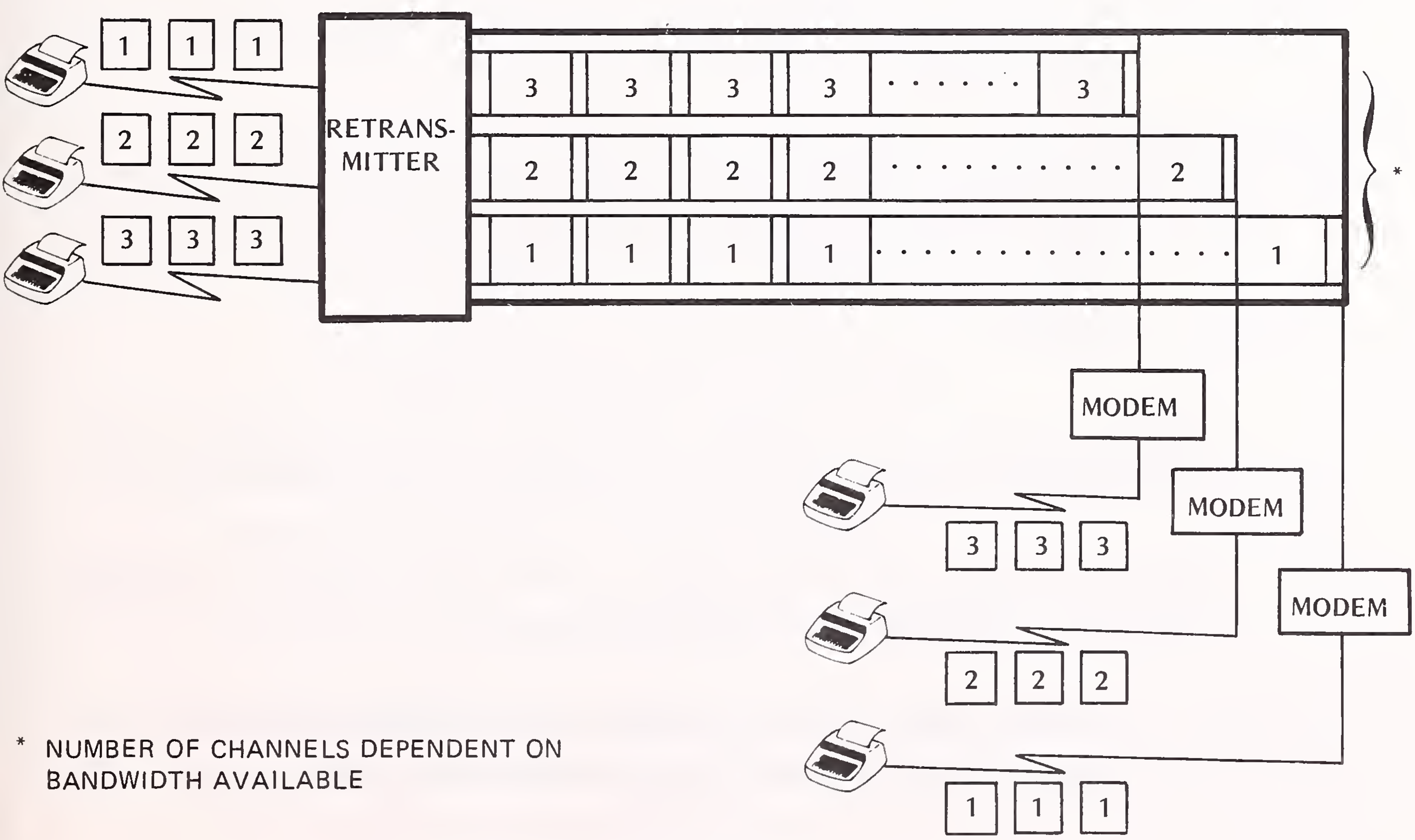
- TDM is, essentially, timesharing of the line. Within the context of local area networks it is usually associated with baseband transmission, where the frequency spectrum generated starts at zero hertz (0 Hz). To transmit information, the line can be either left at zero voltage or raised to a nonzero voltage; thus only one signal can be carried at a time.

EXHIBIT III-3

TIME DIVISION AND FREQUENCY DIVISION MULTIPLEXING



TIME DIVISION MULTIPLEXING



* NUMBER OF CHANNELS DEPENDENT ON BANDWIDTH AVAILABLE

FREQUENCY DIVISION MULTIPLEXING

- While this transmission method offers the advantage of simplicity, a disadvantage is rapid signal attenuation, which limits the range of transmission to short distances (two miles or less).

- FDM utilizes a central carrier frequency which is modulated to transmit data (broadband transmission). Each network station utilizes a different carrier frequency for signaling in exactly the same way that many radio and television systems can convey signals simultaneously without interfering with each other. In fact, network stations are miniature broadcasters operating at radio frequencies (RF).

  - Broadband transmission occurs at very high frequencies, in the 100 MHz range, where there is far less signal attenuation than in the baseband spectrum, permitting signal transmission over several miles. CATV cable can easily carry a bandwidth of 350 MHz. Devices for attaching network stations are inexpensive and readily available due to the growth of the CATV industry.

  - This bandwidth provides ample transmission capacity for voice and video transmission as well as for data channels.

  - A drawback of FDM is that it requires more expensive RF modems to attach to the cable. In some configurations retransmitters may also be required, and a failure in the retransmitter may disable the entire network.

- Network interfaces have two logical functions. One is to interface with the transmission medium, and the other is to interface with the network station.

- Physical interfaces with coaxial cable are easily accomplished with devices called "taps," developed by the CATV industry.

  - Coaxial cable consists of a solid metal conductor surrounded by a metallic shield, separated by an insulating layer of polyurethane. The taps used to attach devices to coaxial cable pierce through the cable from the outside to make separate contacts with the conductor and the shield.

- Taps can be attached to coaxial cable without disrupting transmissions.

- While taps easily achieve an electrical connection, fiber optic cable requires special connectors which require severing the cable segment. Transmission of signals over fiber optic cable employs visible light frequencies, rather than electrical current.

  - Before a fiber optic cable segment can be inserted, all transmission on the network must be halted to avoid loss of data.

- Attachment of a device to a broadband network requires the use of a modem to tune the device to its assigned frequency. The modem might be either a fixed frequency modem, or when circuits are switched, a "frequency agile" modem which tunes a device to the frequency of the circuit that is assigned for the duration of a switched connection.

- Interfaces with the network stations are electronic circuit boards, chips, or separate devices that vary according to the device being connected to the network. A single station interface may attach to one or more stations.

  - Station interfaces are the equivalent of a communications controller or an integrated communications adapter (ICA).

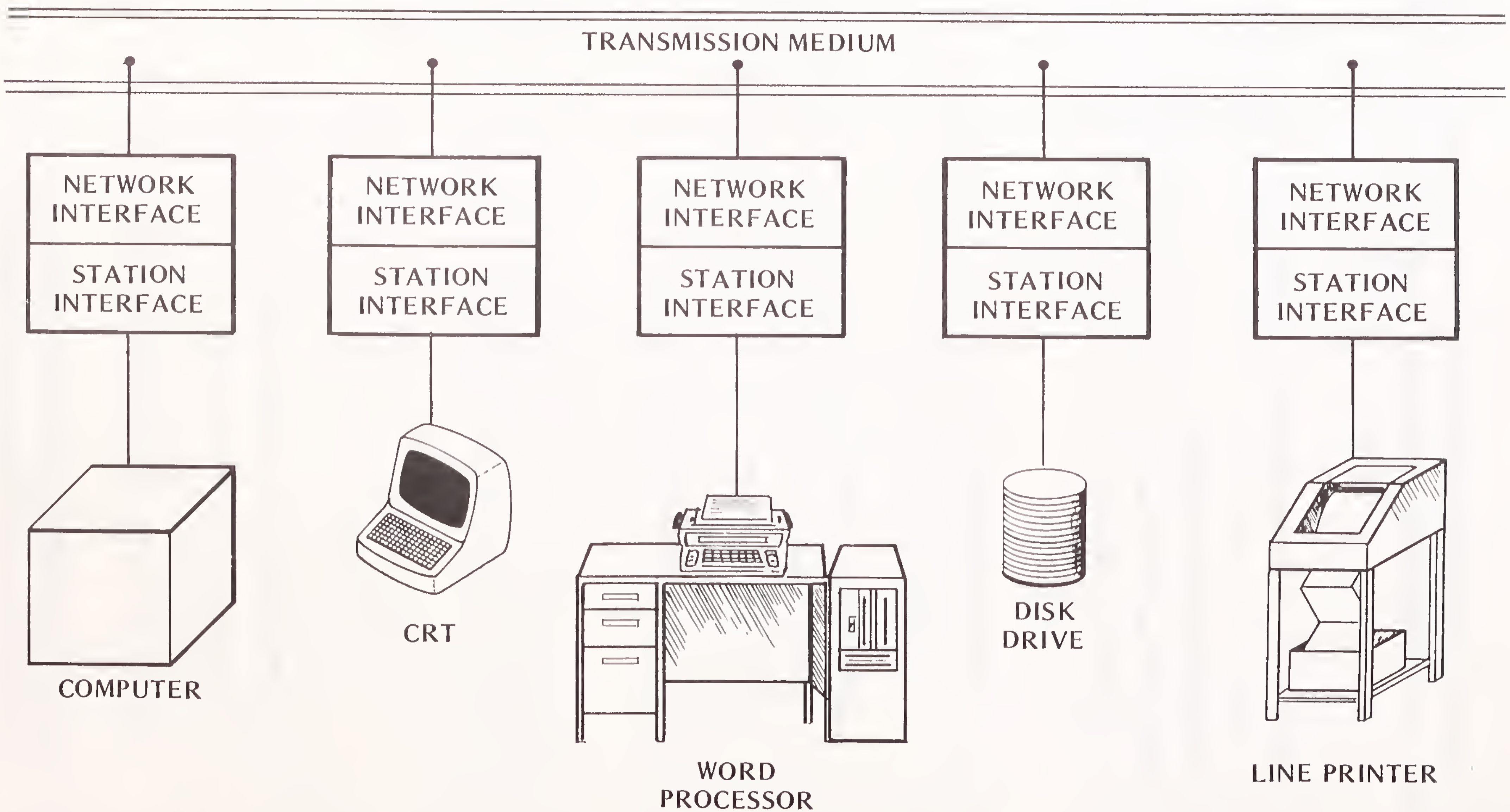
- Network stations can include computers, terminals, copiers, disk drives, word processors, and printers, as shown in Exhibit III-4.

2. LOCAL AREA NETWORK OPERATION AND CONTROL

- Unlike traditional data communications, which evolved from the combination of computers and common carrier transmission facilities, local area networks tend to be designed without central control.

EXHIBIT III-4

LOCAL AREA NETWORK INTERFACES



- Star network configurations, schematically depicted in Exhibit III-5, are typical of many traditional telecommunications systems. This topology undoubtedly evolved from the concept of telephone central office networks. Connection between any two terminals in such a network requires routing transmissions through the central control node.

- Local area networks, on the other hand, tend to employ ring or bus topologies, which permit station-to-station connection without requiring a central node. These topologies are shown in Exhibits III-6 and III-7.

  . Ring networks, sometimes known as Cambridge Rings because of initial development efforts at Cambridge University in England, employ a closed loop around which traffic flows in one direction.

  . Bus topologies allow traffic to flow in either direction, sometimes resulting in collisions.

- In both ring and bus networks, since there is no central control mechanism to route traffic, all stations must monitor all traffic to identify messages directed at them.

  . Thus, network control in ring and bus networks is distributed among the attached stations.

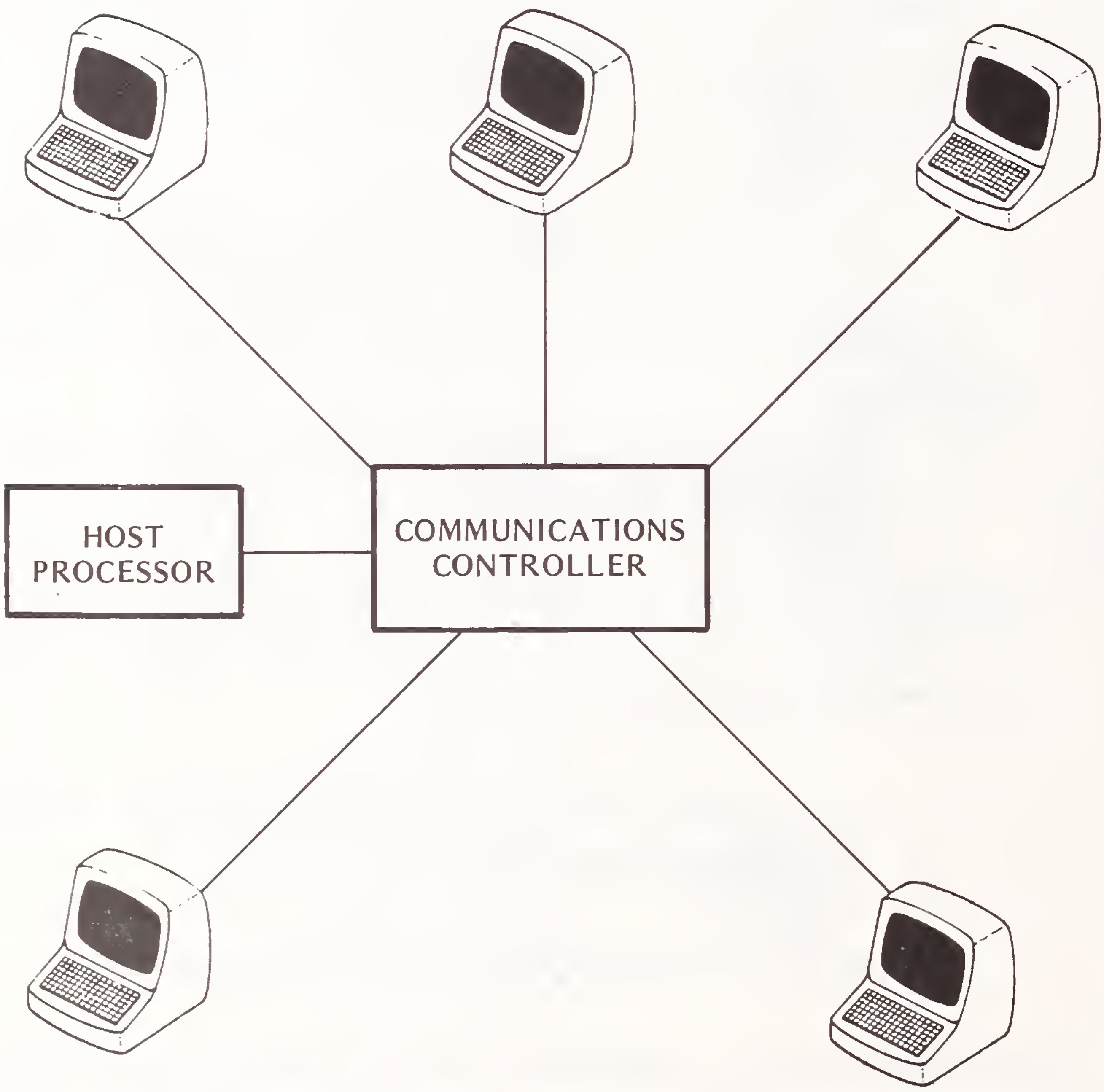
  . Data security can, therefore, be a potential problem.

• Protocols developed for ring and bus networks involve the use of packets, or frames, of data generally formatted, as shown in Exhibit III-8.

  - The packet header portion contains information such as source and destination identification, message type, and other control information. Header length varies with the system.

EXHIBIT III-5

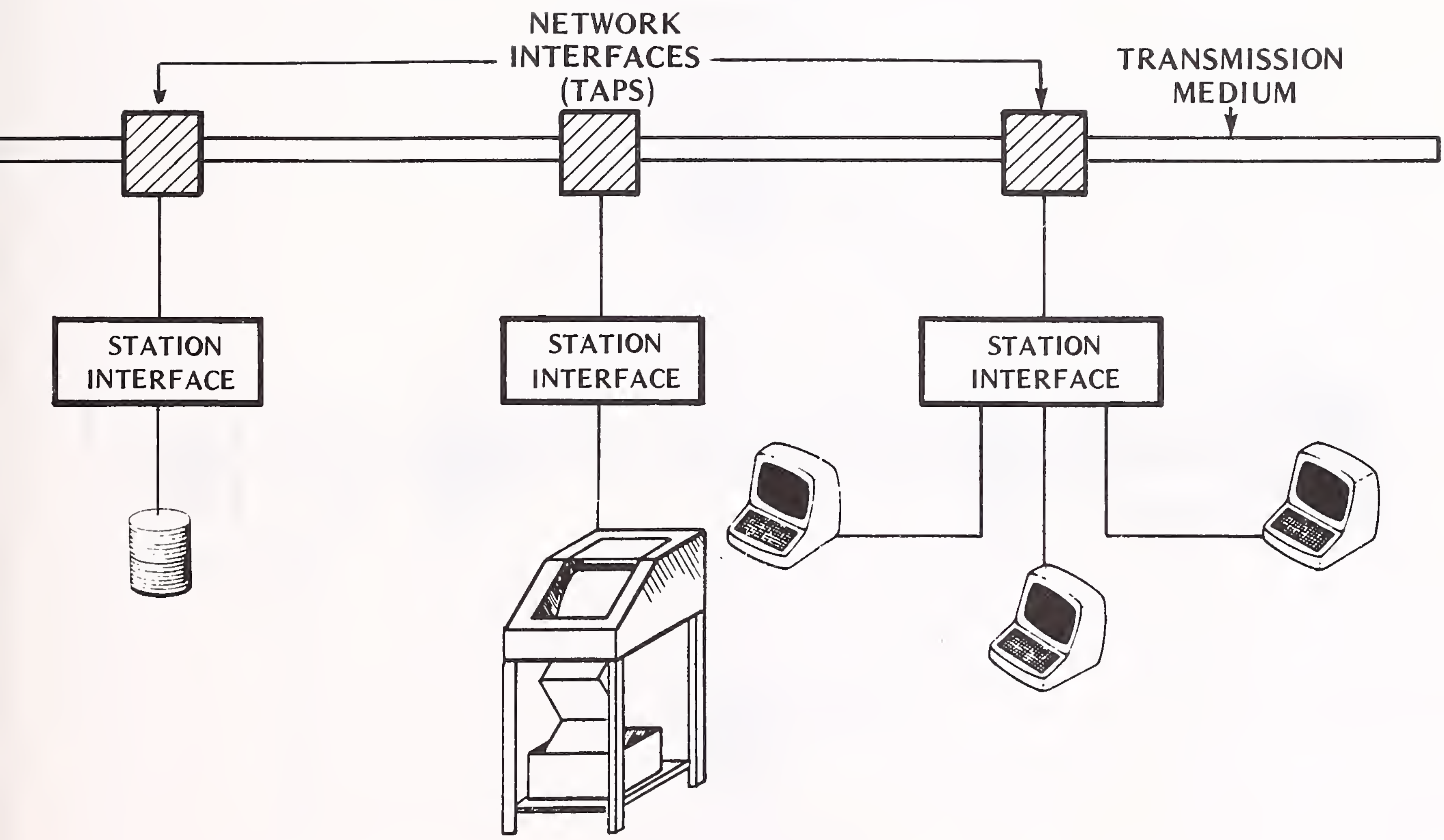
STAR NETWORK TOPOLOGY



 = TERMINAL STATIONS

EXHIBIT III-6

BUS NETWORK




= TERMINAL STATIONS (e.g., CRTs OR WORD PROCESSORS)

EXHIBIT III-7

RING NETWORK

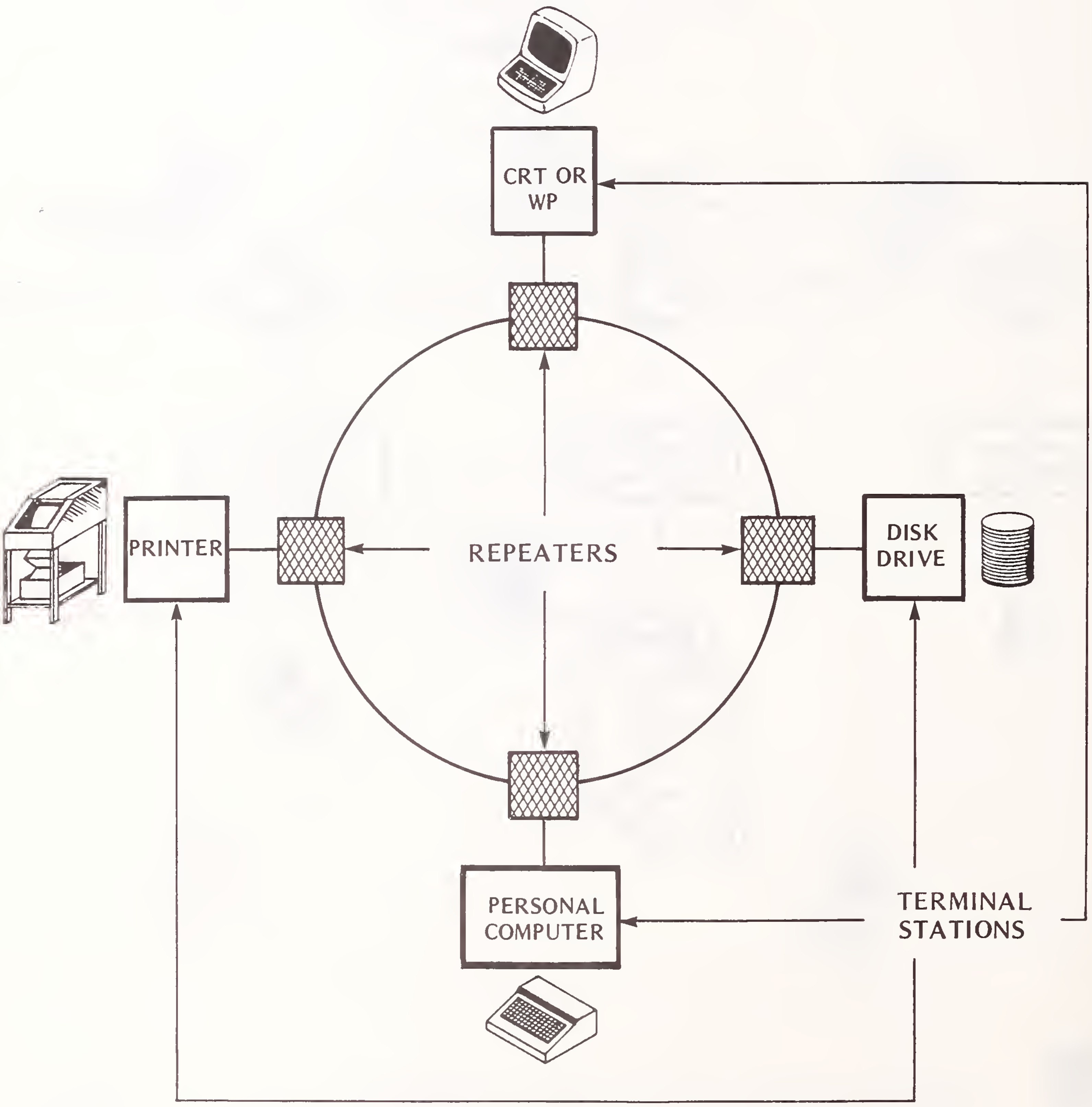
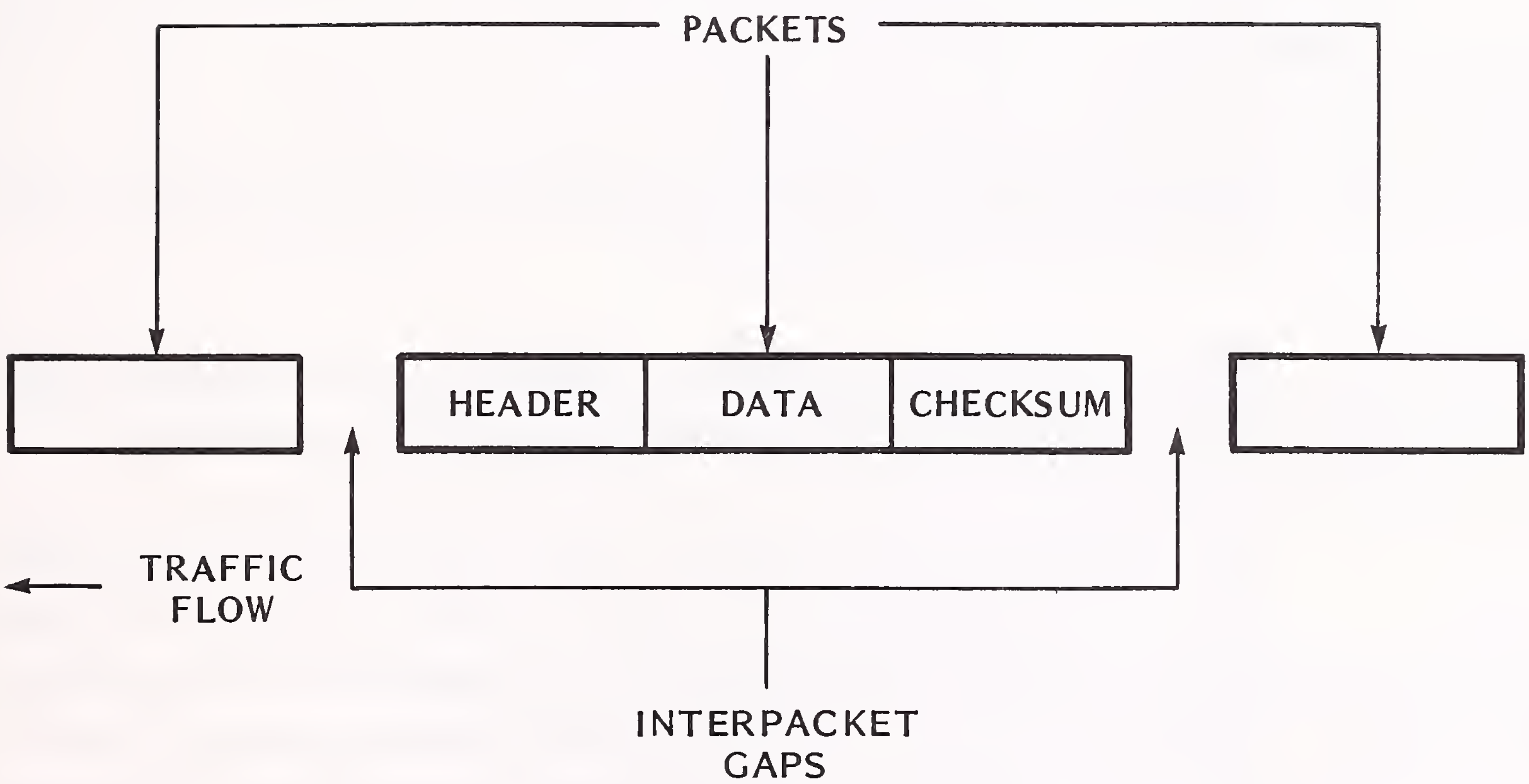


EXHIBIT III-8

GENERALIZED PACKET LAYOUT



- The checksum portion, generally 16 or 32 bits, provides a mechanism for prima facie detection of transmission errors, comparable to cyclical redundancy check bits in data records stored on magnetic media.

- For a variety of reasons, including line utilization efficiency, total frame or packet size (header, data, and checksum) is limited to a certain maximum number of bits that varies with the implementation, from approximately 1,100 bits to around 12,000 bits.

• As depicted earlier in Exhibit III-7, network interfaces in a ring network are repeaters, or signal regenerators, that retransmit frames to the next station on the loop.

  - This permits the use of a control mechanism involving empty frames that are circulated around the loop.

  - When a station has something to transmit, the first available empty frame is filled with data and the header is modified appropriately.

  - The destination station copies the data frame and marks the header with an acknowledgment bit. When the frame returns to the sending station, it can be examined to determine whether the acknowledgment bit has been set. If it has, the sending station recognizes that the destination station has received the transmission, and consequently marks the frame to indicate that it is now ready for reuse.

    . This technique prevents immediate reuse of a frame, thus avoiding the likelihood that one station will monopolize the line.

  - Another form of control employed in ring networks involves the use of a short message called a "token." When a station wishes to transmit, it waits until it detects the token, alters the token, then transmits a message frame, after which it recreates and transmits the token.

- The distinction between a token and an empty frame is that an empty frame can be converted to a data frame, whereas a token is merely a signal indicating when data frames may be inserted into the transmission stream. Thus, where empty frames are used there is a fixed number of packets circulating around the ring, while in a token-passing scheme the number of packets is variable.

- In a bus network, on the other hand, traffic can flow in either direction. It is, therefore, possible for packets to collide, and in fact they sometimes do.

  - However, the extremely high transmission speeds and short distances involved mean that the individual packets are on the line for extremely short periods of time, thereby considerably reducing the likelihood of collisions.

- When collisions do occur, the transmitting stations try again. To prevent a recurrence of a collision, various techniques are used to delay retransmission by randomizing the delay time, in an effort to avoid simultaneous re-initiation of transmissions.

  - The effectiveness of this technique is suggested by statistics gathered during a test of a prototype bus system. This system supported 120 stations, transmitting 2.2 million packets per 24-hour period over a 3-Mbps bus.

    - Collisions during the test period occurred only 0.03% of the time.

    - Over the period, 99.18% of transmissions succeeded on the first try, and in only 0.79% of the time was it necessary for a station to defer transmission because the line was in use.

- This technique relies on Xerox's patented control method known as carrier sense multiple access with collision detection (CSMA/CD). This method requires each station to sense for carrier signals to determine if a transmission is in progress, through a "listen-while-talk" capability - the ability of a station to listen to its own transmissions while they are being sent.

  - A message that is colliding with another will sound garbled, and when this is detected the transmitting station ceases transmitting at once. The station times out for a randomly generated number of time intervals and then attempts to retransmit.

- Some network vendors omit the collision detection feature entirely, citing the very low incidence of collisions that occur under normal load conditions, since collision detection hardware and the patent license add considerably to total network equipment costs.

  - The risk involved in omission of this feature is that network efficiency can drop markedly under heavy load conditions.

3. OTHER LOCAL AREA NETWORK CONSIDERATIONS

- Bus networks employing coaxial cables are the easiest networks to reconfigure, as stations can be attached or detached using cable taps, even when transmission is in progress.

- Adding or removing a station in a ring network requires stopping transmission in order that the related repeater can be inserted or removed by disconnecting and reconnecting two repeaters.

- Fiber optics probably will find readier application in ring networks because of the segmented nature of the ring connections. The physics of fiber optics suggests that the optical equivalent of cable taps is unlikely to become commercially available in the near future.

- The use of repeaters in ring networks creates a potential problem in that the failure of one repeater can disable the whole network unless station bypass procedures are properly designed into the system.

- Bus network architecture tends to predominate in office systems due to the ease of reconfiguration and the variety of devices that can be supported, while ring architecture seems to be more popular in scientific or deterministic systems where high performance is the overriding design objective. ("Deterministic" is the term applied to systems that control and guarantee access and response time, as through the "token" access method.)

IV PRODUCT OFFERINGS

IV PRODUCT OFFERINGS

A. ETHERNET

- Ethernet is Xerox Corporation's proprietary local area network concept. Introduced in December 1979, it incorporates the CSMA/CD protocol, developed and patented by Xerox, described previously.

- A set of standard specifications dealing with data rates, reliability, and access techniques was developed jointly with Intel Corporation and Digital Equipment Corporation, based on years of actual experience with an experimental version. The specifications, containing detailed electrical and low-level communications protocol definitions, were published in September 1980.

- Desirous of encouraging the adoption of Ethernet as a transmission standard, Xerox offered Ethernet licensing to other manufacturers for a nominal ($4,000) one-time license fee. By the end of 1980, 10 licenses had been granted.

- Beginning in November 1980, Xerox introduced a number of products specifically designed for integration into Ethernet.

  - The Xerox 8000 network system includes a File Server that stores up to 10,000 pages of documents and data; a laser-equipped Print Server that can produce 3,000 words or 12 pages per minute in a variety of fonts; and a Communications Server that links remote machines with Ethernet or links two separate Ethernet systems over telephone lines.

- The Xerox 5700 electronic printing system functions both as a stand-alone plain paper copier and as an electronic printer on an Ethernet network, printing text, forms, and graphics from digitally encoded data or stored information (or a combination of both). The 5700 can send or receive a page of text in three seconds, and can accept text directly from one or several word processors, as well as from tape cassettes, magnetic cards, and diskettes. It prints an unlimited number of type styles (although the maximum number of fonts that may be used at any given time is 50) in sizes from six points to 24, and provides automatic distribution and storage of individually addressed electronic mail.

- The Xerox 8010 Star professional/executive workstation combines the functions of a computer, a word processing system, a communications system, and a graphics terminal.

- The Xerox 800 series of word and data processors.

• Ethernet is a bus network architecture based on a single coaxial cable link, as shown in Exhibit IV-1.

  - Ethernet transmissions occur at rates of 10 Mbps over distances of up to 2.5 kilometers (1.5 miles).

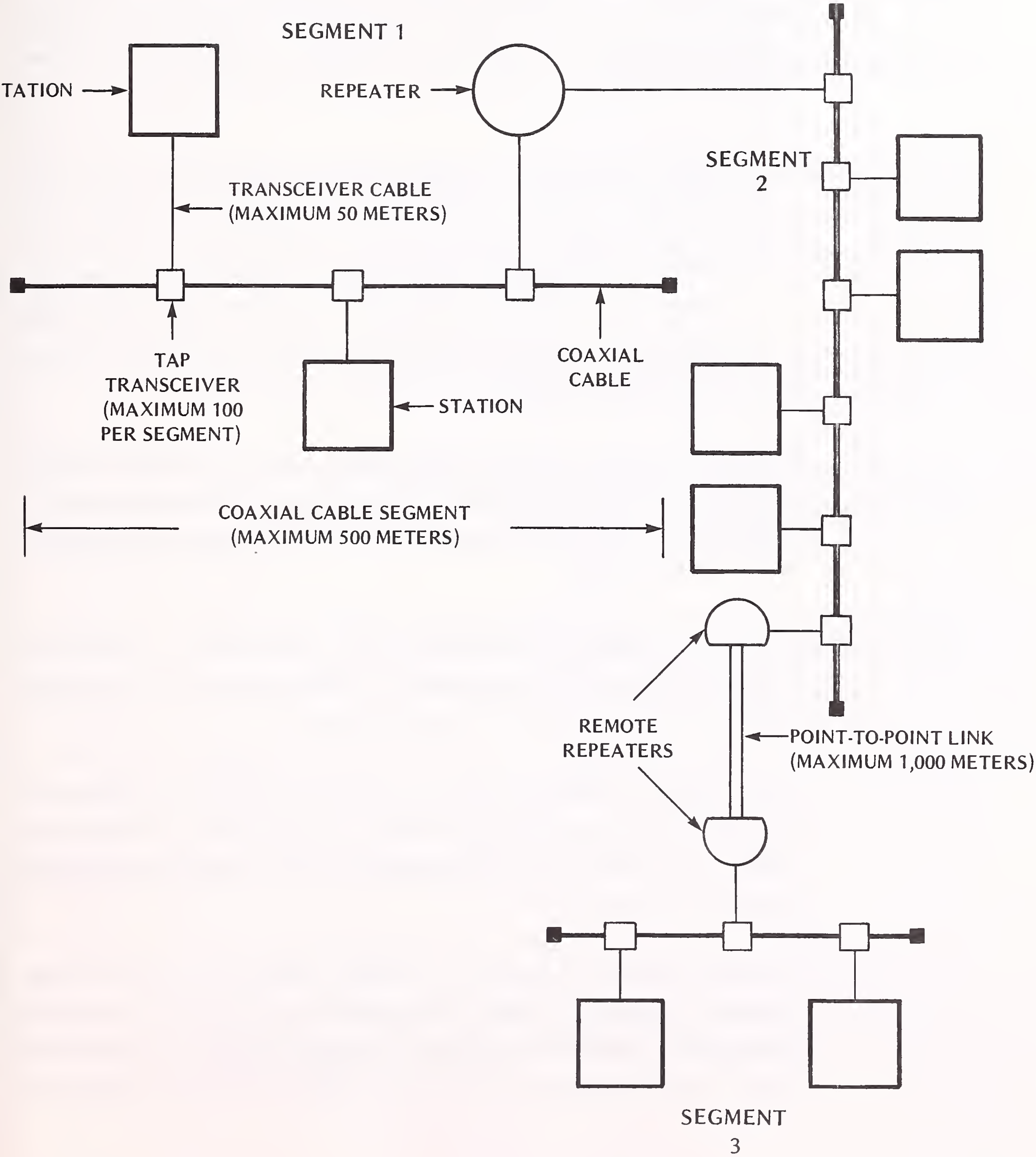
  - The maximum number of devices that can be attached to one Ethernet system is 1,024.

  - All transceivers on an Ethernet cable are always monitoring the line to recognize messages destined for them; thus, terminal stations are aware of whether or not the line is in use ("carrier sense"). Under Ethernet conventions, no station begins transmitting until it senses that the line is not in use.

  - When a transmitting station detects a collision, it abruptly terminates the transmission in progress and sends a short burst of noise. Each

EXHIBIT IV-1

SAMPLE ETHERNET CONFIGURATION



transmitting station times out for a period related to the distance between the sending and receiving stations and the number of transmission retries attempted for the packet that collided. Each transceiver will, therefore, usually have a time-out period different from that of any other. As the frequency of collision increases, the time-out periods get progressively longer, and eventually all packets are successfully transmitted.

. While this description sounds awkward and unwieldy, this is the technique employed in the prototype system described in the preceding section where collisions occurred only 0.03% of the time and delays were experienced in 0.79% of transmissions. Thus, in over 99% of the attempts to transmit under normal load conditions (2.2 million packets a day), transmission was successful on the first try.

- Prototype versions of Ethernet have been in operation for several years: at the Xerox Palo Alto Research Center and Stanford University in California, at the Library of Congress and the White House in Washington, and at other locations.

• Clearly, Xerox is aiming at enlarging its role considerably in the office marketplace, but unlike IBM, its philosophy of office automation is not based on centralized control by a master computer complex.

- Xerox apparently believes that its customers are better equipped to tailor their office automation systems to meet specific requirements rather than adapting their requirements to fit a relatively inflexible hardware configuration.

- This philosophy is reflected in Xerox's willingness to allow other equipment vendors to design equipment that conforms to Ethernet conventions. While the company's licensing practice and generous terms will undoubtedly result in lost sales of terminal stations to competitors, Xerox obviously has ample confidence in its technological ability to meet competition for office automation products.

- Intel's participation in Ethernet suggests that the price of hardware interfaces for Ethernet will decline dramatically over the next several years as this semiconductor industry leader begins to mass-produce VLSI (very large scale integration) chips to interface with Ethernet.

  - Intel has already announced the iSBC-550 Multibus Ethernet interface currently priced at $4,000. INPUT expects this price to drop significantly as volume production of components gets underway. The device supports from one to four stations.

  - Thus, office equipment vendors can restrain the prices they will be charging for Ethernet-compatible devices, to the benefit of the user.

- Digital Equipment Corporation has had a long-term relationship with Xerox, including the collaboration that resulted in the Xerox 9700 printing system (the control element of the 9700 is a DEC PDP-11/34 computer).

  - In the joint press release announcing the tri-company effort, Digital's expertise in all aspects of networking was cited as a significant contribution to the development of the specifications.

  - Digital remains committed to supporting Ethernet as a local network alternative, and although the company has not yet announced specific Ethernet products, it appears fairly obvious that their introduction is merely a matter of time.

  - From the standpoint of an information systems manager who may be faced with the prospect of integrating an Ethernet system with a computer-based telecommunications system, Digital's involvement in the development of Ethernet points the way to one solution.

- User installations of Ethernet are just beginning. In view of the attractiveness of the underlying concept, its current availability, and the powerful and relatively broad-based support that the concept has received in its early stages, as well as Xerox's rapid development of Ethernet products, INPUT believes that Ethernet will be an important local area network system over the next several years.

B. THE DATAPOINT ARC SYSTEM

- Introduced in 1977, Datapoint's ARC (Attached Resource Computer) system boasts an installed base of over 2,000 users. The ARC system interconnects up to 255 Datapoint (and other) processors on a coaxial cable bus system that transmits at a rate of up to 2.5 Mbps. Maximum effective distance is up to four miles.

- ARC is Datapoint's proprietary implementation of the concept of distributed processing. The three elements of an ARC system, as shown in Exhibit IV-2, are:

  - Applications processors are usually located in an office environment.

  - File processors are dedicated data management system control nodes that manage disk space on shared disk drives and access files for a number of applications processors.

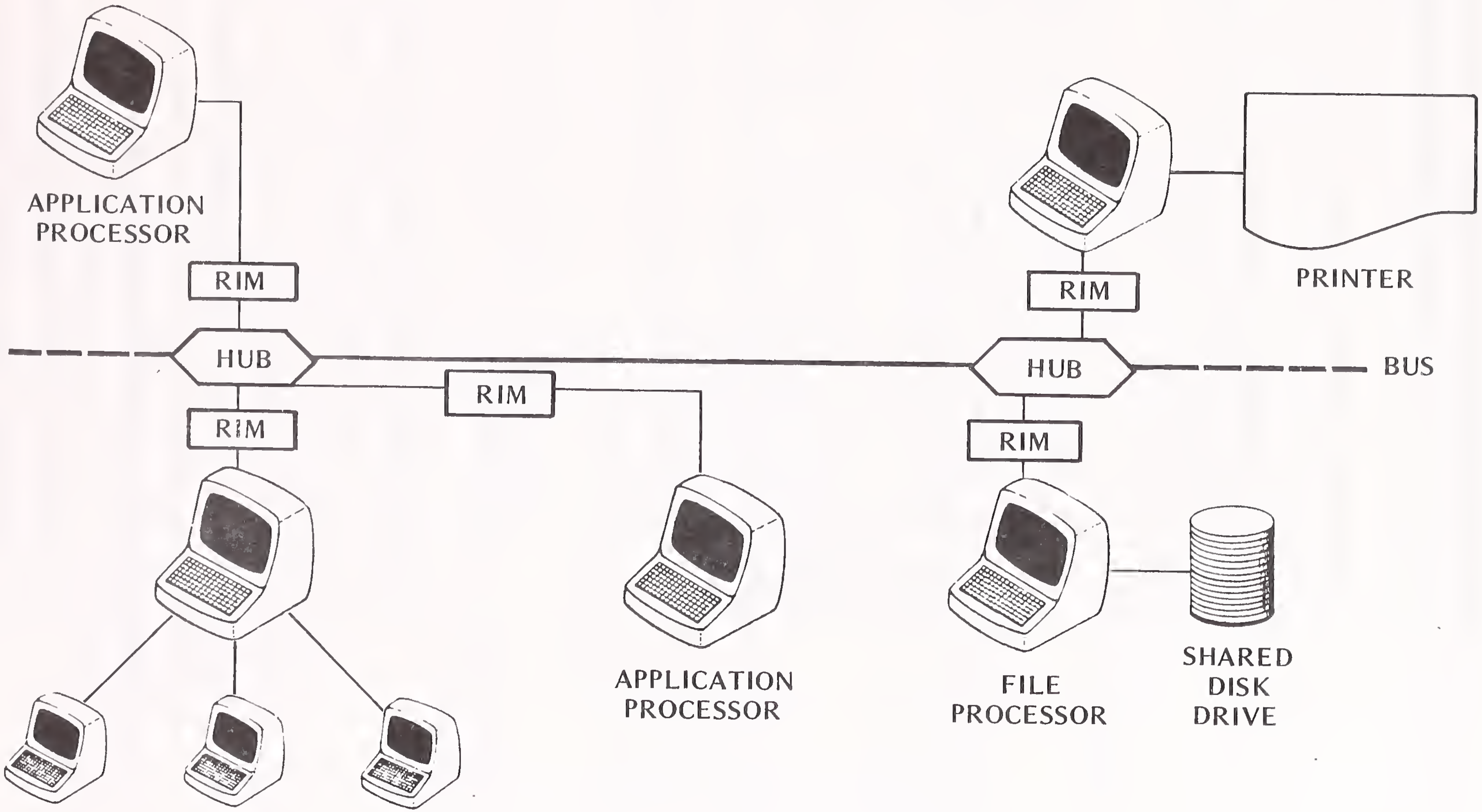
  - An interprocessor bus carries the transmission among processors.

- The interprocessor bus consists of coaxial cable, hubs, and resource interface modules (RIMs).

  - Hubs are network interfaces to which station interfaces are attached. Passive hubs are used to attach four or fewer stations, while active

EXHIBIT IV-2

TYPICAL DATAPOINT ARC CONFIGURATION



hubs are amplifiers and are required on any system that has more than four stations and/or more than 2,000 feet of cable.

- Passive hubs cannot be intermixed with active hubs in an ARC system.

- A maximum of 16 stations can be attached to an active hub. Extension of the interprocessor bus cable requires an active hub for every 2,000 feet of cable, to act as an amplifier.

  . A maximum of ten active hubs can be used to extend the bus to its effective maximum length. Expansion of the system to its maximum of 255 stations requires attachment of active hubs directly to other active hubs.

- RIMS are station interfaces, and are microprocessors that monitor and control data transmission, perform data buffering functions, and execute error recovery and system reconfiguration tasks.

  . A RIM is used to attach a Datapoint processor's input/output bus to a hub.

  . A RIM can also be used to attach a non-Datapoint processor to the system.

- Hubs and RIMS in an ARC system contain the network control element, which is a token passing scheme that is completely transparent to the workstation.

• With an ARC system, a user can share a file processor among several applications processors and establish the same or another processor as a common output sink for volume printed output.

  - For example, in a brokerage firm applications processors may be sitting on stockbrokers' desks executing applications such as retrieving a client's investment portfolio, performing portfolio valuations and portfolio analysis, executing bond yield spread analyses, and entering trades for a client's account.

- In the firm's investment research department, analysts may be using another group of applications processors for financial analysis, security performance evaluation, and financial statement modeling.

- Elsewhere, the firm's economics staff may be using applications processors for econometric modeling.

- In the order room, a processor equipped with a printer may be installed to receive trading instructions from the brokers' stations and on which confirmation of trades can be entered for transmittal to the broker concerned.

- All of these processors can be linked by an interprocessor bus to one or more file processors located elsewhere in the building, and the file processors may have high-speed line printers attached. Volume reports can be spooled to the printers from any of the applications processors, including commission reports, model output, and spread sheets.

- With an ARC system, each application processor located in an office environment has immediate access to large data files and can direct the production of reports without making the office look like a computer room.

- Extensive software products have been developed for ARC since its 1977 introduction that enable ARC systems to communicate with computer-based non-Datapoint network systems.

- Datapoint also offers its own digital PABX that can interface directly with the ARC nework, and also serve as a gateway (for certain applications) to other Datapoint or non-Datapoint systems.

- In November 1981, Datapoint announced three new products designed for attachment to an ARC network.

  - The 9660 laser printer is a non-impact printer capable of producing 20 pages per minute from digitally encoded graphics forms and computer data.

  - The 9680 Color Business Graphics (CBG) system requires no user programming to create and display color graphics images, and has options that permit the production of 35mm slides, color prints from 35mm film, 8" X 10" Polaroid prints and 8" X 10" color transparencies.

  - The 9498 Facsimile Communications Interface (FCI) allows network stations to interface with both manual and automatic facsimile machines. Used in conjunction with the 9660 laser printer, the FCI can provide store-and-forward capability for facsimile transmission.

  - Deliveries have already begun for the color graphics system, while the laser printer and the FCI will be shipped beginning in mid-1982.

- By the second half of 1982, Datapoint will be able to deliver local area networks with local graphics and color graphics capability, as well as the ability to receive and deliver traditional facsimile transmissions in unattended mode.

- The thrust of Datapoint's ARC system evolution is becoming more apparent.

  - Starting with the simple interconnection of small processors in 1977, the array of products introduced for integration into ARC places Datapoint in the competitive arena for office information systems.

- While ARC permits a non-Datapoint product to participate in the network, it appears that ARC operates most efficiently as an all-Datapoint complex. But even this was changed when Datapoint and Tandy jointly announced in

September that their systems could be interconnected by adding a $400 interface board to the TRS-80 Model II.

C. WANGNET

- Wang Laboratories, Inc. introduced a broadband local area network system called WangNet in July 1981, for phased delivery in 1982.

  - A diagram of the WangNet architecture is shown in Exhibit IV-3.

- The transmission medium is a dual CATV cable, which supports a bandwidth of 340 MHz. WangNet can be used to transmit over distances of several miles.

  - As shown in Exhibit IV-4, WangNet uses FDM to provide:

    - Sixteen 64 kbps dedicated data channels.

    - Thirty-two 9.6 kbps dedicated data channels.

    - 256 switched data channels operating at 9.6 kbps.

    - A 12 Mbps CSMA/CD channel, called Wangband.

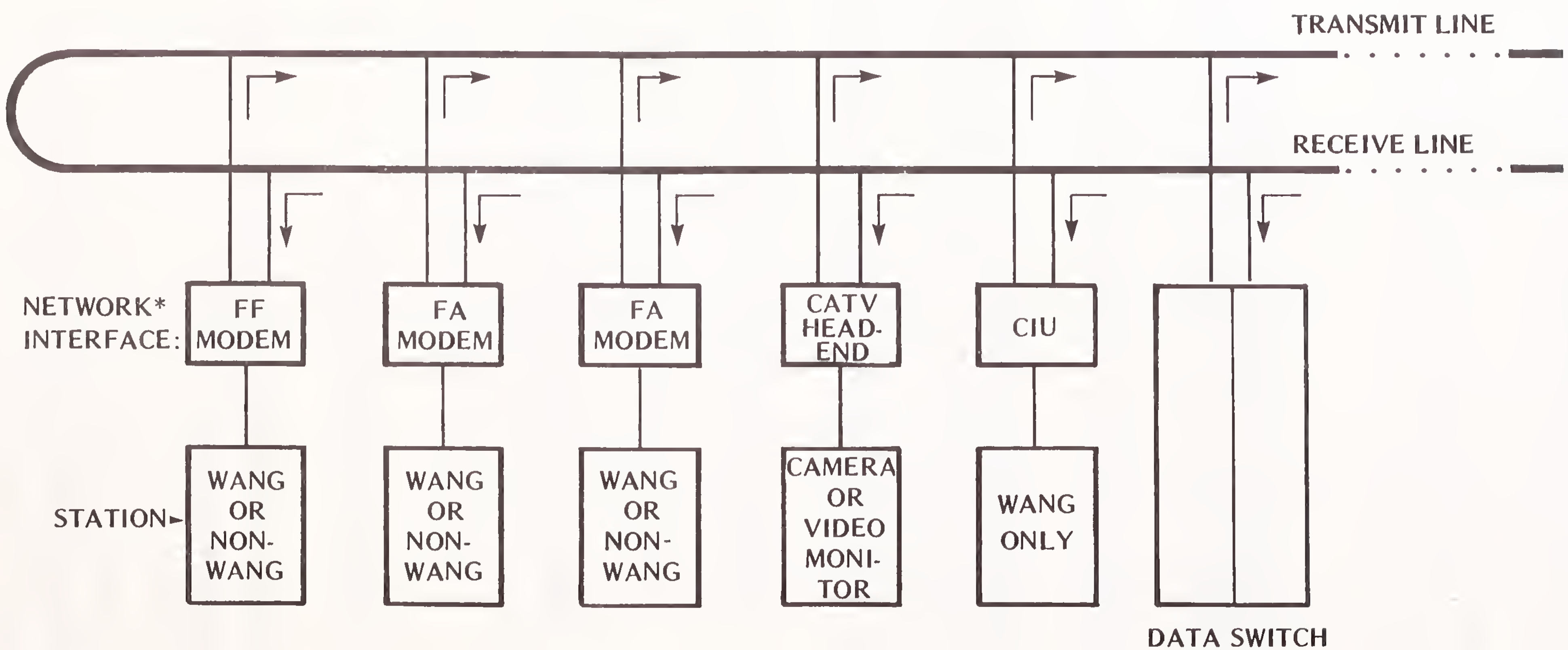
    - Seven television channels.

  - All these channels together only take up roughly one-third of the total available bandwidth.

- Since the transmission technique employed is frequency division, RF modems are required to interface each non-Wang device with the cable.

EXHIBIT IV-3

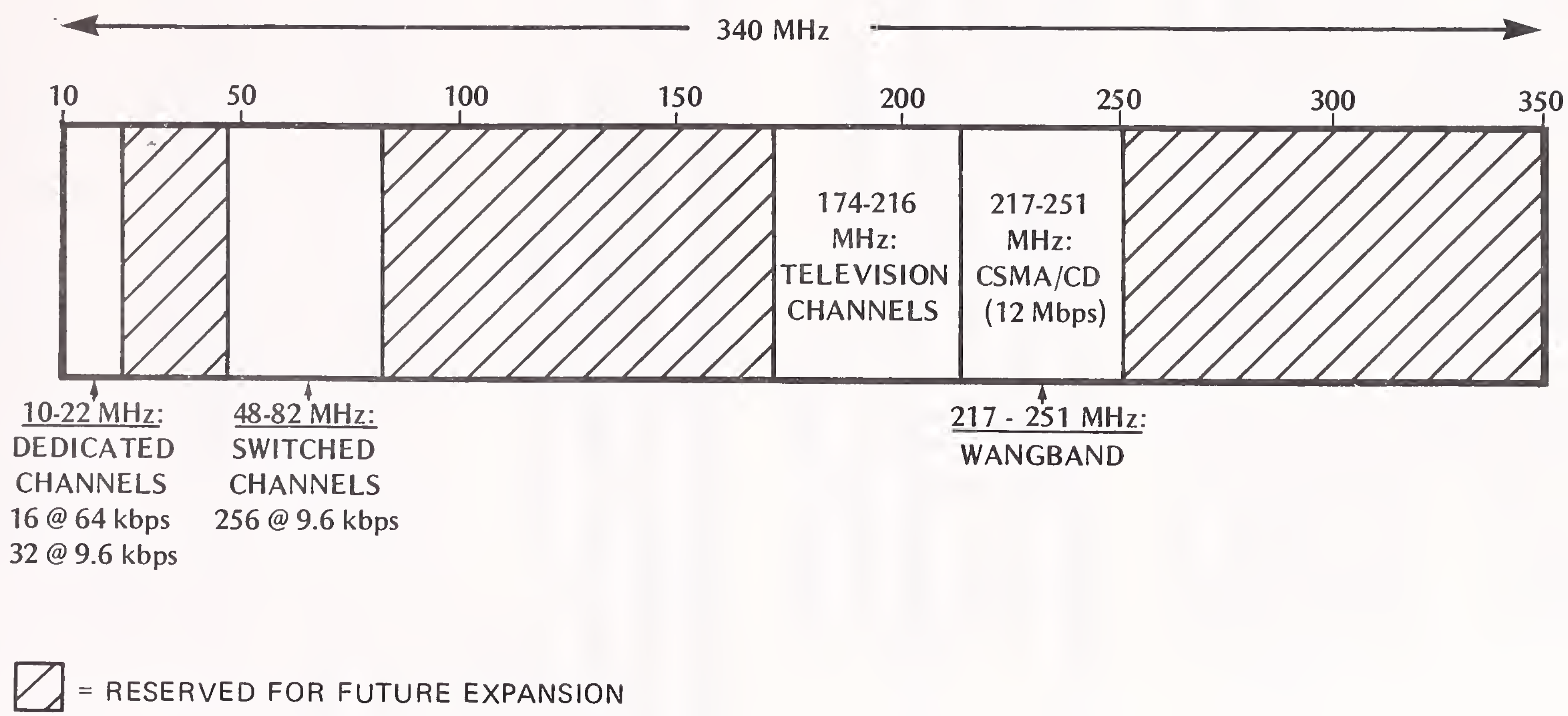
WANGNET ARCHITECTURE



* FF = FIXED FREQUENCY (DEDICATED CHANNELS)
FA = FREQUENCY AGILE (SWITCHED CHANNELS)
CIU = CABLE INTERFACE UNIT (WANGBAND)

EXHIBIT IV-4

WANGNET FREQUENCY ALLOCATIONS



- The devices at either end of a dedicated WangNet channel require attachment via a fixed frequency modem permanently set to the channel's carrier frequency. Such modems are priced at $850 and $1,200 each for 9.6 kbps and 64 kbps channels respectively.

- Devices attached to the switched 9.6 kbps channels require "frequency agile" modems, which are set to an allocated channel's frequency for the duration of a connection by a switching unit that controls the 256 switched channels. The switching unit has a purchase price of $12,000 while each frequency agile modem sells for $1,250.

- Each Wang system attached to the 12 Mbps CSMA/CD channel requires a Zilog Z80-based cable interface unit (CIU) with 128K of memory, which is shared by all users of the attached system. The CIU, which sells for $3,800, interfaces the cable to each Wang system, formats the data packets, detects errors, controls the traffic flow, and performs the CSMA/CD function.

• While WangNet provides substantial transmission channel capacity, it represents a significant expense, especially for attaching non-Wang devices. The dual cable also represents an additional cost element to be considered, although it provides higher capacity and reliability than single cable based systems.

• Announced delivery schedules for various hardware components indicate that WangNet will be delivered in three distinct stages.

- In the first quarter of 1982, support for the 9.6 and 64 kbps dedicated channels will be provided with initial shipments of the fixed frequency modems.

- Hardware for the switched channels (the data switch and the frequency agile modems) will be shipped beginning in June 1982.

- Use of the CSMA/CD channel will be possible when the CIU becomes available in the autumn of 1982.

D. SPECIALIZED LOCAL AREA NETWORK SYSTEMS

- HYPERchannel, Z-Net and Net/One are local area network systems that do not appear to be aimed at the same office automation market as Ethernet, ARC, and WangNet.

  - Stations on a HYPERchannel network are minicomputers, large scale mainframes, and storage subsystems.

  - Z-Net and Net/One were designed to interconnect personal computers.

1. HYPERCHANNEL

- HYPERchannel, supplied by Network Systems Corporation of Brooklyn Park, Minnesota, is a specialized local area network system which permits the interconnection of computers of different manufacturers, as diagrammed in Exhibit IV-5.

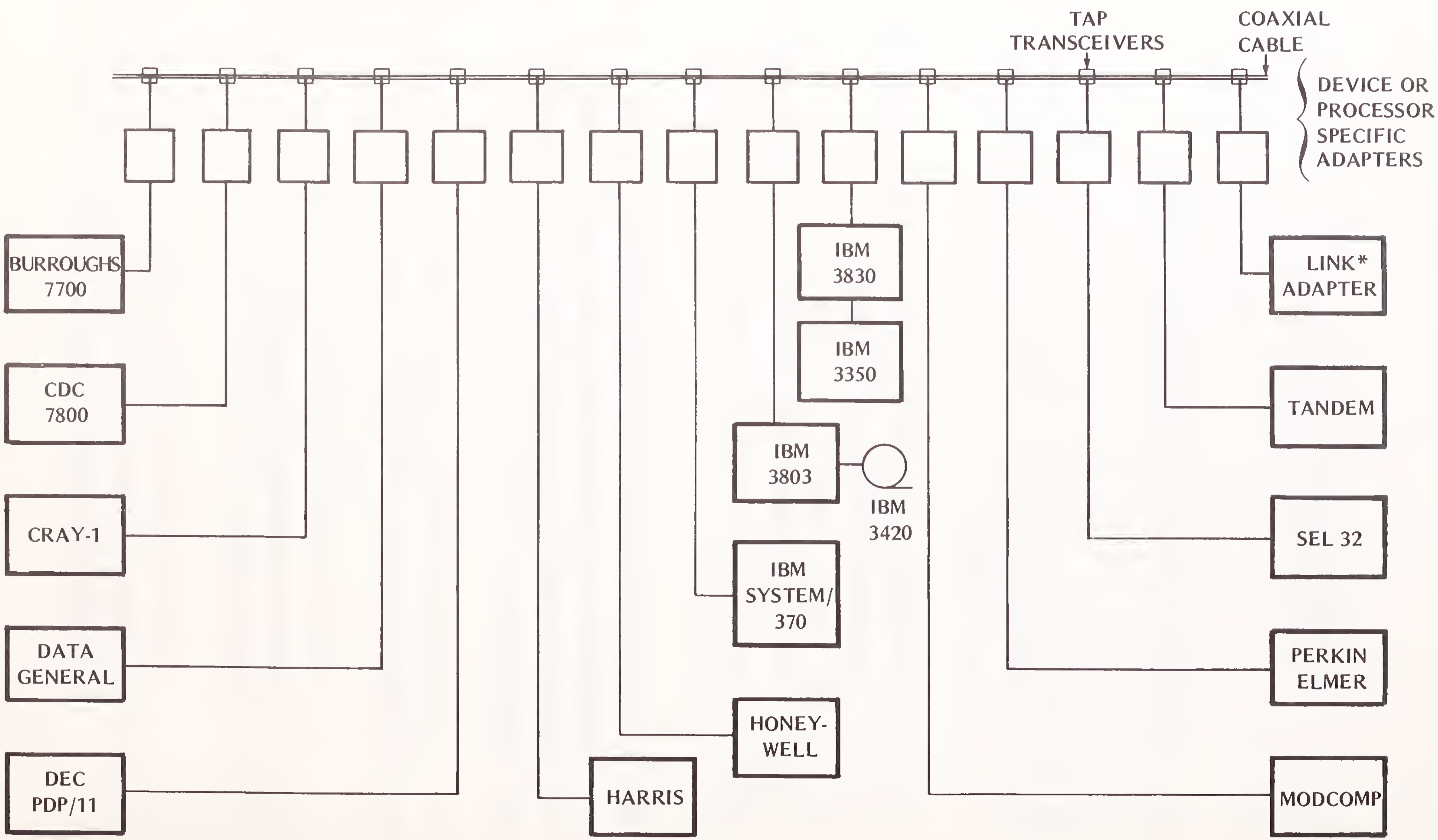
- HYPERchannel consists of a coaxial cable and network adapters, and enables transmissions of up to 50 Mbps for one mile.

  - Network adapters contain a microprocessor, perform control and data buffering functions, and interface individual pieces of equipment to the coaxial cable.

  - Different adapter models are available. Each provides an electrical and logical interface to specific CPUs and peripheral systems. Adapters are presently offered for IBM, Control Data, Cray, Burroughs, Univac,

EXHIBIT IV-5

HYPERCHANNEL



* TO A COMMON CARRIER OR SATELLITE COMMUNICATIONS FACILITY

Honeywell, Harris, Data General, Digital Equipment, Modcomp, Perkin-Elmer, SEL, and Tandem systems.

- HYPERchannel is most commonly used to extend mainframe channels to permit the attachment of controllers such as the IBM 3803 and 3830 controllers above the maximum permitted by the manufacturer.

- With HYPERchannel, CPUs of different vendors can be interconnected for interprocessor communication. Additionally, a link adapter is available to connect with a high-speed common carrier facility that enables long-distance communication between geographically separated HYPERchannel facilities.

- Network Systems Corporation has a complementary, lower speed product called HYPERbus under development to handle lower speed office systems or any other digital communications now being accomplished through common carrier facilities and other data links.

2. Z-NET AND NET/ONE

- Z-Net and Net/One are local area network systems that are similar to Ethernet and are based on the Zilog Z80A microprocessor.

- Z-Net is supplied by Exxon's Zilog subsidiary. It supports up to 255 stations connected by coaxial cable over a two-kilometer distance at 0.8 Mbps.

- Z-Net involves three types of stations, each of which consists of a Z80A microprocessor, an RS-232-C interface, a parallel interface, and a Z-Net interface.

    - A user station includes a CRT display, and may also include a printer and/or a diskette drive.

    - A shared resource station controls disk drives, printers, and other peripherals to be shared among several user stations.

- A universal controller station either interconnects with a common carrier network or supports communication with a processor.

- Net/One employs coaxial cable to support up to 250 stations at a transmission speed of up to 4 Mbps for 4,000 feet. With repeaters, a Net/One system can be extended beyond 4,000 feet. Net/One is supplied by Ungerman-Bass, Inc. of Santa Clara, California.

  - Net/One employs passive transceivers, two types of network interface units, and optional development and administrative stations.

    - One model of the network interface unit handles up to four devices connected via RS-232-C connectors or up to two parallel interface devices, while the other model is used to interface up to 16 RS-232-C devices or 8 parallel interface devices.

    - The network development station is used for program development. It includes a network interface unit (NIU), a disk file, and a CRT display. The station is used for program development and testing, and for downloading of NIU programs and interactive testing of remote NIUs.

    - The administrative station is used to monitor the performance of the network and to execute diagnostic programs that can trace malfunctions down to the PC board level in a particular network interface unit.

E. OTHER LOCAL AREA NETWORK SYSTEMS

- Gould-Modicon has a bus network called MODWAY which transmits at 1.5 or 6 Mbps over CATV coaxial cable. A maximum of 256 stations can be connected over a distance of up to five kilometers. MODWAY uses a token-passing scheme and time division multiplexing.

- Cluster/One, offered by Nestar Systems of Palo Alto, California, interconnects up to 65 stations at 0.25 Mbps for a distance of 0.3 kilometers. It was designed to interconnect personal computers such as the Apple II, hence the low transmission speed relative to other offerings.

  - Cluster/One employs a 16-wire flat cable and, unlike the faster networks, employs parallel transmission (multiple bits of a frame are transmitted simultaneously over separate lines). The system is much simpler to implement, and therefore costs much less than other systems described in this report.

  - Parallel transmission is difficult to implement at higher speeds because the signals tend to arrive at slightly different times, whereas at low rates it is relatively easy to deal with the bit skew. Conversely, at transmission speeds that are measured in millions of bits per second, the data rates are so high that there is no advantage to be gained from parallel transmission.

- Ring networks currently in use include the following (it is noteworthy that this topology tends to be employed in laboratory environments):

  - Cambridge University in England uses a token-passing technique for time division multiple access (TDMA) at 10 Mbps over a distance of 0.1 kilometers (without repeaters) using twisted pair wire.

  - The Ford Aerospace network also uses tokens to implement TDMA, and achieves speeds of up to 125 Mbps over optical fiber.

  - The University of Illinois implements its ILLINET ring network over optical fiber links at 32 Mbps. Token passing is employed to implement TDMA.

  - The LCS ring at the Massachusetts Institute of Technology uses tokens to achieve a 10 Mbps rate over twisted pair wire.

F. DIGITAL EPABX SYSTEMS

- Digital electronic private automatic branch exchanges (EPABX) offer a partial alternative to local area network systems such as those described in this report.

- EPABXs such as Datapoint's ISX system or Northern Telecom's SL-1, which switch digitized voice signals, can just as easily switch digital data signals because the switching function does not depend on; i.e., is not sensitive to, the contents of the digital data stream.

    - Since digital EPABXs are cost justifiable for certain corporations or locations on the basis of their support of voice switching, they have the potential of providing a low-cost, low-risk alternative for local area networking.

- The ideal time to consider the digital EPABX alternative is during the planning stages of a move to a new location, particularly when a new building is planned. Ample provision can be made for internal wiring to support local data as well as voice transmission needs. Obviously, such preplanning would maximize flexibility and reduce installation costs.

- However, digital EPABXs are designed to switch 64 kbps of digitized voice signals, and thus cannot support data transmission in excess of about 56 kbps (switching requires about 8 kbps of overhead).

    - One characteristic of the megabit rates of cable-based local networks is the elimination of the necessity for circuit control. Since circuit control is already incorporated into a digital EPABX, 56 kbps appears to be more than adequate to support most digital office devices likely to be introduced over the next several years.

- The 56 kbps speed limitation is adequate to support most devices in use today, up to and including medium speed (600 lines per minute) line printers.

- It should not be forgotten that, despite the technological advances occuring in the field of data (and voice) communications, the bulk of the installed telecommunications plant remains voice-grade circuits, and is likely to remain so through the end of the century.

  - Designers of new office equipment cannot afford to exclude consideration of voice-grade circuit compatibility when developing their products.

- The only form of data transmission for office systems currently under consideration, that cannot be supported by EPABX systems, is video transmission. Video transmission within a local geographic area would not be necessary except for security surveillance and monitoring of restricted area accesses, or to support local requirements for long-distance video teleconferencing.

  - This limitation should therefore not preclude consideration of the EPABX alternative for standard office systems.

- A potentially more serious limitation of the 56 kbps transmission rate is a situation that requires heavy transfer of large files.

  - Conversely, baseband cable networks could be easily overloaded by only a few voice conversations, besides being very uneconomic for this application.

- One major attraction of EPABX systems is their proven reliability.

  - The telephone equipment market, which EPABXs were originally designed to serve, have extremely high reliability standards. Equipment specifications for switches call for less than two failures every twenty years.

- Established vendors of interconnect equipment clearly meet this standard. Newer vendors will obviously try even harder.

G. SUMMARY

- Implementation of local area network schemes has taken a number of alternative paths.

- A single network standard satisfying every user's needs is probably possible only in a perfect world.

  - However, the activity of the IEEE and the American National Standards Institute (ANSI) in developing local area network standards is a significant move toward achieving most of the benefits that could be realized from a single industry standard.

  - From a vendor's standpoint, there is very little to be gained, and quite a lot of business to lose, if a standard is adopted.

- Nevertheless, vendors have been quite realistic in providing either the hardware and software components or the tools to interface their networks with other vendors' product offerings.

- Without an industrywide standard, information systems management must address the possibility of having to integrate one or more local area networks with the systems that are under their control.

  - At the very least, the problems related to interfacing must be addressed, and this cannot be done intelligently without a knowledge of what interfacing will entail in terms of manpower, time, and equipment resources.

- The next chapter discusses what IBM has done to keep office automation within the IBM fold, and what its strategic direction is likely to be over the next several years.

  - The IBM way is not possible or acceptable to all users, as the emergence of local area networks has attested; but it is the most likely environment with which local area networks will be interfaced, as well as the one with which they will compete.

V THE IBM ALTERNATIVE TO LOCAL AREA NETWORKS

V THE IBM ALTERNATIVE TO LOCAL AREA NETWORKS

A. IBM'S APPROACH TO NETWORKING

1. SNA: IBM'S STRATEGIC ARCHITECTURE FOR NETWORKS

- IBM's support for networks remains oriented toward the concept of large central hosts controlling network traffic.

- Systems Network Architecture (SNA), announced in September 1974, is the architectural concept under which this support will be provided over the next several years.

  - Each new release of an IBM telecommunications-related product depends on SNA for its operation, and support of non-SNA telecommunications methods is gradually being withdrawn.

- SNA involves four key components:

  - Synchronous Data Link Control (SDLC), the bit-oriented line discipline developed by IBM for SNA, which supports transmissions at speeds of up to 56 kbps.

  - The concept of layers of transmission control, under which the functions of interfacing with an application program (the application layer), the routing and queueing of messages (the function management layer), and the movement of data between network elements (the transmission subsystem layer) are clearly separated. This functional separation provides an advantage over prior systems in that a change to one function does not require changes to the others.

- The requirement for intelligence at the network stations to execute terminal-related control functions. The intelligence needed includes the ability to recognize specific bit patterns, to insert and delete bits, to perform error checking, and to format data and control files.

- The requirement for a programmable communications processor to relieve the host processor of network control functions. If the host fails, the communications processor can reroute traffic to another host, and can provide limited network control functions. In larger system configurations, the communications processor might service more than one host.

- Exhibit V-1 is a representation of an SDLC message frame. By convention, the bit pattern for the framing character is 01111110. Since this bit pattern may legitimately occur in the data portion, through an SDLC convention called "zero bit insertion," the data stream is modified so that, while a message is in the transmission channel the bit patterns cannot be confused with the framing character. Bits must be inserted by the transmitting station and deleted by a receiving station.

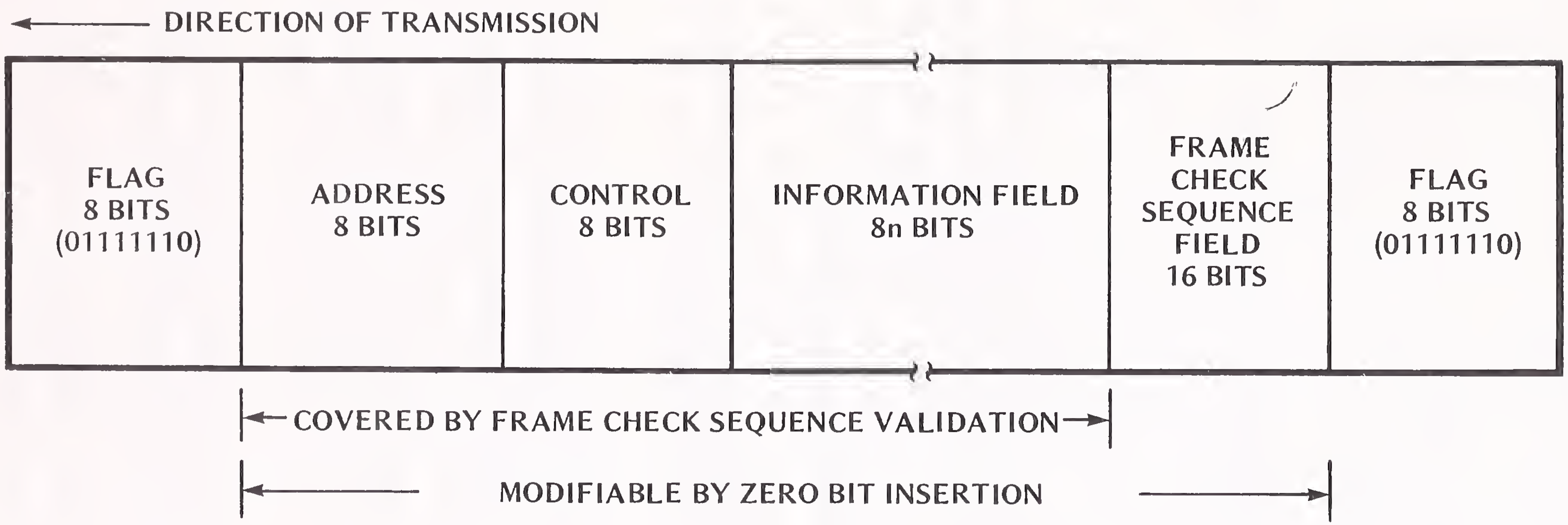
  - Support of this convention requires bit-manipulation capability (intelligence) at every SNA station.

  - Additionally, processing of the address, flag, and cyclical redundancy check bits requires intelligence at the station.

  - Another SDLC convention is that a station may transmit a maximum of seven consecutive frames at a time, whereupon it temporarily relin-

EXHIBIT V-1

IBM SDLC TRANSMISSION FRAME FORMAT



quishes the line to the next station in a preestablished sequence. This convention ensures that no single station will monopolize the line. Thus, low-, medium-, and high-volume terminals can be intermixed on a single multidrop line, and each eventually receives an opportunity to transmit, enabling more efficient line utilization and reducing the number of lines required to support a terminal network.

- Polling is accomplished by sending a request to transmit to the logically most distant station down the line. If that station has nothing to transmit, it does not respond directly to the network controller (the primary station) but passes the request to the adjacent station up the line. This process continues until the poll returns to the primary station. If a station has something to transmit, it sends up to seven frames to the primary station and then passes the poll to the adjacent station. Should a message need more than seven frames, the additional frames are transmitted, in groups of up to seven at a time, during subsequent polling cycles.

- From the foregoing, it is easy to see that a fair amount of intelligence is required at each SNA station.

- Initially, acceptance of SNA was slow because it required significantly more memory and disk storage resources than the binary synchronous communication (BSC or bisync) protocol that preceded SNA. Additionally, when it was first introduced, SNA only supported terminals that incorporated the necessary hardware for performing the SNA transmission subsystem functions, thereby excluding BSC and asynchronous terminals from participating in an SNA network.

  - As memory and disk storage costs declined during the intervening years, the inherent advantages of SNA grew more attractive.

  - Also, IBM reconsidered its initial posture of not supporting terminals that lacked the requisite intelligence. Non-intelligent terminals are now supported, provided that they are attached to an intelligent device that is capable of performing the necessary control functions.

- The combination of continued declines in hardware costs, increasing SNA dependency built into new software releases (accompanied by concurrent withdrawal of non-SNA transmission options), and broadening support of SNA conventions by other hardware vendors, is providing the motive force that will make SNA the de facto network architecture standard for IBM systems over the next several years.

2. ACF: THE SNA NETWORK INTEGRATOR

- In 1976, IBM introduced its Advanced Communication Function (ACF) concept. The ACF program products enable separate networks to talk to each other through ACF's Multi-System Network Facility (MSNF).

  - In an SNA network, only one primary station may exist. Generally the communications controller is so designated. All other stations in the network are designated secondary stations. Together, the primary station and its associated secondary stations constitute the domain of that network.

  - With ACF, the primary station of a network may also function as a secondary station within the domain of another SNA network.

- Use of ACF involves installation of appropriate ACF telecommunications access methods (ACF/VTAM, ACF/VTAME, ACF/TCAM) in each network host, and an ACF network control program, ACF/NCP/VS, in each primary station.

- ACF permits the sharing of resources across network domains. With ACF, a terminal within the domain of any network has access to the resources of any other network in the complex, just as if the terminal belonged within the other network's domain.

- ACF supports the largest System/370 models, the 4300 and 3000 series processors, and the 8100.

B. THE 3600, 4300 AND 8100 DIRECT LOOP ATTACHMENTS

- IBM has "direct loop" attachment options for the 4300 and 8100 processors. They are not loops in the same sense as the term is used in the context of local area networking, although they may serve some of the same functions.

  - These loops are the equivalent of byte multiplexer channels, and are used only to attach input/output devices, usually display devices and printers.

- The 3600 series of systems are special purpose systems that use industry or application-specific terminals.

  - One system supports a variety of banking terminals: passbook terminals, automated teller machines, and others.

  - Another system is provided for plant floors, and attaches badge readers and sensor-based devices.

  - Other systems control supermarket scanners, merchandise ticket readers, magnetic wand readers, and cash registers.

- These systems are too limited in nature to be included in a discussion of general purpose local area networks.

C. THE SERIES/1 RING NETWORK

- In January 1981, IBM announced the ability to interconnect up to 16 Series/1 processors in a ring configuration, transmitting at up to 2 Mbps along a twinaxial cable.

- The ring network, which does not depend on the use of a master controlling station, enables the various systems to communicate using a peer-to-peer full duplex protocol.

- Users can access common files, data, or resources. User-written programs can also direct messages to any other unit on the ring, and can selectively broadcast to any or all other units. For a one-time charge of approximately $5,300, a communications monitor is available that supports the ring protocol as well as SNA, BSC, and asynchronous protocols. This monitor has a minimum residence requirement of 192KB, which means that only the larger models of the Series/1 processors may be incorporated into the ring.

- Each Series/1 on the ring must have a local communications controller attached to one of its I/O slots. The controller is priced at approximately $4,000.

- Initial shipments of the monitor and the controller were scheduled for March and August 1981, respectively.

- The announced SNA support suggests that a Series/1 ring network can be easily integrated with an SNA network.

D. THE ADMINISTRATIVE SYSTEMS

- In February 1980, IBM's then General Systems Division (GSD) introduced the IBM 5520 Administrative System, designed to provide not only text processing, but also file processing and document distribution functions to the office environment.

- Several months later, the then Office Products Division (OPD) announced its Displaywriter, which offers many of the same capabilities on a single station basis.

- Both systems are "user friendly" in that they provide labeled function keys (including a "help" key), menus, doublecheck procedures on dangerous (e.g., "delete") actions, ergonomic engineering, and so forth.

  - Both can attach peripheral devices directly or remotely.

  - Both can function as 3270 terminals in an SNA environment.

- Additional stations are attached to the 5520 either through the display controller or the distribution controller (which can also attach another 5520 system).

  - Cable lengths may extend up to 5,000 feet from the system unit, and up to seven devices may be attached to the cable. Twinaxial cable is used.

- Digital Research Incorporated, developers of the microcomputer based CP/M operating system, has announced a version of CP/M for the Displaywriter that should enable many software packages to be used on the system, including the common microcomputer programming languages.

E. IMPLICATIONS OF THE IBM PERSONAL COMPUTER

- The IBM Personal Computer was introduced in August 1981, and first customer shipments began in the 1981 fourth quarter. Although the product announcement did not specifically refer to local area networks, an option for asynchronous ASCII communications was announced, and a statement of intent was made to the effect that a subset of full 3270 emulation capability would be provided.

- One significant aspect of the announcement was that it represented a departure from tradition in that it is a product aimed specifically at the end user.

- Another departure from past practice was that the product is not hostile to non-IBM hardware and non-IBM software.

  . A standard interface is provided for the physical attachment of "foreign" devices, and a distribution system was announced for user-developed software.

- While these characteristics do not necessarily encourage the development of local area networks around the product, they do not prevent such development or the attachment of the machine to a local area network.

- The announced and promised communications support indicates that the computer can be used as a terminal on a network - not as easily as installing a SNA device on an SNA network - but the capability nevertheless exists.

• INPUT believes that the IBM Personal Computer will enjoy rapid acceptance in a corporate environment. As applications develop, the need for access to corporate data bases will generate the type of resource support requirements that integration of a local area network will impose on corporate information systems.

F. SUMMARY: THE STRATEGIC IBM FRAMEWORK FOR NETWORK SYSTEMS

- IBM remains committed to the star topology for network systems, with network control residing at a central host.

- SNA is the glue that binds network elements together, and ACF is an extension of the SNA concept to the interconnection of two or more networks through MSNF to permit internetwork resource sharing.

- IBM's administrative and personal computer systems come closer to the concept of a local network, but still require all-IBM or plug compatible devices on the cable.

  - Communication is limited to a total throughput of 19,200 bps per controller, using bisync or SDLC protocols only. Usually this is in the form of several lower speed lines, such as four 4,800 bps lines.

- Integrating non-IBM local area networks with an IBM network requires that at least one device will be common to any two networks that are to communicate with each other.

  - Since SNA is the architecture for the IBM system, this device must perform the re-formatting of data from SDLC format to local area network format, and vice versa.

  - Additionally, this device must be capable of supporting both SNA protocols and the local area network protocols.

- Support of this interface is no trivial matter. The skills required to develop and maintain such an interface may not exist within an organization.

VI INDEPENDENCE VERSUS INTEGRATION

VI INDEPENDENCE VERSUS INTEGRATION

A. THE ISSUES

- Should there be one or many local networks? Should they be all the same or different? Should they combine text and data? Should they be able to access the main corporate data base? Should they combine text processing with administrative functions? Should they combine voice and data? Should they provide for video transmission?

- In order to answer these questions, every organization needs to examine its own objectives, style, and resources. There are no apparent arbitrary factors which would always lead to the same set of conclusions.

- By definition, a local area network is limited to a relatively small geographic area. It is entirely possible that a local area network may never need to go beyond its geographic and functional domain.

  - One example of a local area network system that may never need to become global is a system in a bank that is installed to support time series analyses for the economics and market research departments. In such a system, there would be a need for local on-line storage of substantial amounts of detailed historical data. Such data do not belong in the organization's operational data bases.

- Consideration of whether or not a local area network should be integrated into a corporate network system must include a determination that there is indeed a useful objective that integration will accomplish.

    - Systemwide complexity will be increased considerably where local networks are integrated with the main corporate systems.

    - But local complexity could be considerably reduced, as well as local costs.

B. FACTORS INFLUENCING INTEGRATION OF LOCAL AREA NETWORKS

- One reason why integration might be considered is that, although the local area network can be cost justified for the initial application (typically word processing), substantial system capacity remains for other applications.

- Another reason is that the demographic trends that are exacerbating the shortage of skilled programming personnel are also affecting the worker pool available for office jobs.

    - Increasingly, additional office work resulting from corporate growth will have to be done by the same or a smaller number of workers, requiring each worker to assume a greater workload.

    - The assumption of greater responsibility implies increased information handling needs that may be serviced through occasional, but ready, access to corporate data processing resources from existing local area network stations.

- Going in the other direction, a corporate network system might benefit from the use of facilities that are available on a local area network.

- A very obvious benefit would be the use of a local area network to extend the on-line storage capacity of a system. Virtually every organization maintains logically layered data: a layer that must be on-line at all times for operations support, a second layer that must be on-line only at certain processing cycle intervals, and an archival layer to which sporadic, infrequent reference may be made.

- Depending on the costs and performance of the specific devices involved, a local area network could be a cost effective alternative to upgrading a processor simply because additional channels and on-line capacity are required. Certain layers of corporate data might be maintained on-line more effectively on an integrated local area network's file storage subsystem.

- Another benefit that a large system may obtain from integration of a local area network is increased flexibility in producing hard-copy output. If an installation does not have the output volume to justify an expensive on-line laser printer, a lower performance Xerox 5700 on a local area network may offer an attractive alternative for the preparation of high-quality, relatively low-volume output from interactive applications.

• In short, integration of local area networks and corporate network systems could be mutually advantageous, but this is not necessarily true.

C. THE TECHNOLOGY OF NETWORK INTEGRATION

• The major technological issues associated with integrating an SNA (or similar) network and a local area network are the incompatibilities that are virtually guaranteed to exist between the two in terms of:

- Transmission control: centralized control versus no control.

- Message formats.

- Transmission speeds.

- Resolution of these incompatibilities represents the major technological hurdle for dissimilar network integration, but the nature of the problem is such that it can be contained very cleanly.

- A general approach is suggested by IBM's solution to a part of the problem; i.e., the control problem, when IBM provided SNA support for the CCITT X.25 packet switching interface standard. (The CCITT, or Consultative Committee for International Telephone and Telegraph, is an advisory body established under the aegis of the United Nations to recommend worldwide telecommunications standards.)

  - It is easy to criticize IBM, from the vantage of hindsight, for developing SNA in preference to supporting the X.25 protocol. However, it should be realized that IBM announced SNA in September 1974, while the CCITT first recommended X.25 for adoption as a standard in July 1976, almost two years later. IBM had valid business reasons to continue along the SNA path: in response to users' needs for improved telecommunications products, IBM could design products based on a solid specification, whereas the X.25 standard, most recently refined in 1980, has not yet been finalized, and therefore remains a moving target.

- The rationale for the development of X.25 was that a worldwide standard was needed for data communications that would make a data network as easy to use as a voice network.

- The X.25 standard presupposes the existence of a public packet switched network, which manages the delivery of data packets from one subscriber's terminal to another. (Participants in the development of the X.25 standard included the operators of planned or existing packet switching networks, notably GTE Telenet, the Trans-Canada Telephone System (TCTS), and the PTTs of France, Japan, and the United Kingdom.)

- A subscriber's responsibility under this concept would merely be to deliver a data packet or frame, properly formatted, to the network. The network would then assume the responsibility for routing the packet to its destination, which is determined by the network from information contained in the packet itself.

- The X.25 standard defines the interface between the network and the terminal, or network station.

  - The X.21 standard is a subset of X.25 and defines the physical, electrical, and functional procedures that a 15-pin connector, defined by the standard, must perform. Pending commercial availability of X.21 connectors, the CCITT accepts the use of an interim standard, X.21-bis, which is identical to the Electronic Industries Association RS-232-C physical interface.

- X.25 specifies the software functions that, in conjunction with X.21, deliver properly formatted frames to the network, and identify and receive frames addressed to the station.

• The major operational differences between SNA and X.25 lie in the control of the network: the concept of a primary station, as defined in SNA, does not exist in switched packet networks such as those for which the X.25 standard was developed.

  - Although SNA has been enhanced to support dial-up lines, it is still primarily an architecture for private line, multipoint networks, and thus the concept of polling is integral to SNA.

- On the other hand, in a switched network polling is not possible, and therefore the host system has no control over the arrival of transmissions.

- To reconcile the conceptual difference between SNA and X.25, IBM in its announcement of X.25 support in July 1981 provided software for a 3705 controller that enables the 3705 to act as an X.25 terminal station.

  - From the perspective of the SNA system, the 3705 remains a primary or secondary SNA station.

  - When a frame is to be delivered to the packet switched network, it is delivered as an SNA frame to the 3705, which then builds the requisite X.25 control information (as presently formulated) and wraps it around the SNA frame.

  - Conversely, an X.25 frame received by the 3705 from the packet network is expected to contain a full SNA frame surrounded by X.25 control information. The 3705 processes the X.25 information, then strips it from the message, leaving the SNA frame, which is then entered into the SNA traffic in line with SNA conventions.

- While not exactly an elegant solution, until the X.25 standard is finalized this may be the only practical way to interface X.25 with other networks.

  - IBM's interim solution to interfacing X.25 with SNA may represent a conceptual approach for interfacing any network with SNA.

- The incompatibility of message formats appears to be a relatively minor problem, especially since many vendors appear to be standardizing on the frame format of the X.25 High-Level Data Link Control (HDLC) protocol, which is patterned after its chronological predecessor SDLC. Format conversion should be trivial, given the intelligence available at network stations.

- Exhibit VI-1 shows a variety of frame formats supported by vendors.

- The imbalance of transmission speeds, between the megabit rates available on most local area networks and the kilobit rates that characterize common carrier-based networks, poses a problem that resembles the data rate mismatch between the IBM 3380 disk drive, with its 3-megabyte transfer rate, and the 1.5-megabyte capacity of the System/370 Model 168 block multiplexer channels.

  - IBM's solution to this transfer rate imbalance problem, the Speed Matching Buffer, is, however, simplified by the fact that the pace of data transfer is controlled by the processor.

- Message pacing, for instance, between a 10 Mbps Ethernet network and a 9.6 kbps private line network would represent more than a 1,000-to-1 speed differential, compared with the 2-to-1 differential between the 3380 and System/370 channels. Moreover, devices on an Ethernet network transmit at will rather than on demand.

  - Thus, under certain circumstances traffic from a local area network can overload a conventional network unless adequate buffering is provided.

  - However, a given network may never be transmitting for more than a fraction of the time. In the prototype Ethernet system described earlier, actual transmission time for 2.2 million packets with a maximum length of approximately 12,200 bits each on a 3 Mbps line, required the line to be in use for slightly more than two and a half hours, or 10.3% of the 24-hour period. Increasing the line speed to 10 Mbps would reduce the transmission channel utilization to 3.1% of a 24-hour period.

EXHIBIT VI-1

FRAME FORMATS FOR VARIOUS DATA LINKS

IBM SDLC

Flag 8 Bits (01111110)	Address 8 Bits	Control 8 Bits	Information Field 8n Bits	Frame Check Sequence Field 16 Bits	Flag 8 Bits (01111110)

ISO HDLC (X.25)

Flag 8 Bits (01111110)	Address 8 Bits	Control 8 Bits	Packet 24 Bits = Control 1-1024 Bits = Data	Field Sequence Check 16 Bits	Flag 8 Bits (01111110)

Ethernet

Preamble 64 Bits	Destination Address 48 Bits	Source Address 48 Bits	Type Field 16 Bits	Data Field 0-12,000 Bits	Cyclical Redundancy Check 32 Bits

Burroughs BDLC

Flag 8 Bits (01111110)	Address 8n Bits	Control 8 or 16 Bits	Data or Information Field (Variable)	Frame Check Sequence 16 or 32 Bits	Flag 8 Bits (01111110)

Univac UDLC

Flag 8 Bits (01111110)	Address 8n Bits	Control 8 or 16 Bits	Data or Information Field (Variable)	Frame Check Sequence 16 or 32 Bits	Flag 8 Bits (01111110)

D. NETWORK INTERFACES

1. GATEWAYS

- Most local area network systems provide optional facilities known as "gateways," through which network stations can communicate with devices not incorporated into the network.

  - One example of a gateway is a RIM in a Datapoint ARC system that simulates a Datapoint input/output device on a non-Datapoint computer.

  - Another example is the optional data link adapter available on HYPER-channel.

- Gateways provide a convenient focal point for all off-network interfaces.

  - Depending on the specific local area network system, the problem of making a station seem as if it belongs on a traditional communications network is sometimes resolved by the vendor.

    - An option on the Xerox 8010 Star workstation, for example, allows the Star to simulate an IBM 3270 CRT terminal. Thus, various IBM program products can be initiated from a Star to extract data from corporate data bases for transmittal to the Star, where it can be stored on the Star's disk for further local processing.

  - Additional effort is required to enable stations on traditional networks to participate in the local area networks.

- For example, direction of most IBM program products' output to a Xerox 5700 will require programming the gateway to transform System/370 spool files to Ethernet packets.

- Nevertheless, it is a problem that is solvable.

2. ACF AS AN IBM NETWORK GATEWAY FACILITY

- From the standpoint of an IBM system, ACF can be viewed as the gateway into a local area network.

  - The Network Control Program (NCP) that controls internetwork communication can be installed in a variety of machines, including the 4300 and 8100 processors and 3705 communications controllers.

  - The optimum hardware will differ with each system.

3. MINICOMPUTER ALTERNATIVES

- Digital Equipment Corporation's participation in the development of Ethernet strongly suggests that minicomputers may represent the smoothest vehicle for integrating local area networks with IBM communications networks.

  - While Digital's orientation is toward Ethernet, the similarity of packet transmission schemes implemented in local area networks indicates that a minicomputer that can support Ethernet is likely to be capable of supporting comparable networks.

  - Additionally, most minicomputer vendors provide support for HASP emulation, allowing the interface to be configured for operation under IBM's JES 2 or JES 3.

- Digital Equipment to date has not announced a specific product with an Ethernet interface, but INPUT believes that such an announcement is simply a matter of time.

- For now, the Series/1 ring network is the only available method from IBM for providing the SNA half of the interface. However, the interface with the local area network remains the user's responsibility.

E. IMPLICATIONS OF NETWORK INTEGRATION

- When considering the desirability of integrating local area networks with EDP systems, as well as the impact of integration on hardware acquisition plans, it is worthwhile to speculate on why each individual vendor developed its particular local network alternative in the first place.

1. IBM

- IBM obviously wants to sell more terminals, more hardware, and more software.

  - Use of Information Center products may not burden the central processor complex for a time, but as more interactive users use these products more frequently, response times will degrade. Maintaining response times at acceptable levels may force CPU, peripheral, or communications subsystems upgrades sooner than anticipated.

  - The implementation of a ring rather than a bus network protocol for the IBM Series/1 probably stems from two reasons.

    - IBM likely is more comfortable with the concept of communications under software control than with the concept of uncontrolled transmission that characterizes most bus networks.

- IBM has more experience implementing ring networks than bus networks, specifically the 3600 series of special purpose subsystems.

2. DATAPOINT

- Datapoint sells small data processors, word processors, and computer-based communications equipment.

  - While non-Datapoint equipment can be attached to an ARC system, ARC is obviously optimized for Datapoint hardware.

  - Datapoint's design philosophy entails the simultaneous execution of programs in small processors rather than concurrent execution on time-shared large systems. Applications programs may be developed centrally and distributed to the processors, but the intention is decentralized applications development.

  - Use of a Datapoint ARC system instead of IBM's products might aid in controlling the rate at which the EDP complex is expanded, but involves hardware expense for ARC stations. Depending on an individual corporation's needs and plans, an ARC system could be much less expensive than the alternative large central host.

3. XEROX

- Xerox's Ethernet system is friendly to other vendors' hardware. Xerox appears to be interested in increasing the demand for intelligent xerographic products as system output devices and not in total system responsibility.

  - Although Xerox makes its products available on a purchase basis, it prefers to rent to customers. Xerox understands the dynamics of managing a rental base, and is singularly adept at devising pricing structures for its equipment that are biased toward generating growth in equipment usage and consequently in earnings.

4. WANG

- Wang sells word processors and small data processors. Its bias is similar to Datapoint's.

  - It appears that WangNet is an attempt to provide a data switch oriented specifically for data communications on both a switched and a dedicated basis among its processors.

  - The choice of the transmission medium and transmission technology enables Wang to offer an Ethernet-like baseband channel and seven television channels in addition to the data switch, within roughly one-third of the capacity of the transmission medium.

VII THE ROLE OF INFORMATION SYSTEMS DEPARTMENTS IN LOCAL NETWORKS

VII THE ROLE OF INFORMATION SYSTEMS DEPARTMENTS IN LOCAL NETWORKS

A. OVERVIEW

- The technology involved in selecting, implementing, and operating a local area network is both complex and changing.

  - For most organizations it will be obvious that the Information Systems (IS) department will have to play at least a leading role, if not the leading role, in choosing a local network.

- However, the temptation will be great to have the IS role limited to advising on, or perhaps selecting, the local network technology to be employed.

  - In a few cases, this may be the correct approach.

  - For many other organizations, local networks would only be advisable after a great many other preconditions have been met (which will be discussed in this chapter).

  - For still others, it may turn out that to install local networks would be a pointless, wasteful exercise that would end only in recrimination and personal and organizational loss.

- The remainder of this chapter will analyze some of the key management issues involved in local networks and the likely impact on the IS department (and vice versa).

B. PLANNING ISSUES

- Exhibit VII-1 summarizes the major issues involved in planning for a local network. Before examining these issues individually, attention should be paid to an important factor that runs through them all:

  - Judgments made about any factor may be changed significantly by downstream events. Constant monitoring of such events so that corrective action can be taken implies not only ongoing management and technical staff time and additional cost, but quite possibly, user dissatisfaction.

- Technology: Constant change will be the watchword throughout the first half of the 1980s. Large numbers of vendors are entering the marketplace; some surviving, others failing, and others making slower progress than expected.

  - For the next few years, it will be a horse race: one can handicap, but cannot guarantee victory.

- Physical Considerations: These are so obvious as to be immediately delegated to junior technicians. However, there is the critical question of office movement that is most decidedly not technical.

  - What major moves are planned? Does the organization have a pattern of making major moves without warning?

  - From the standpoint of local networks, "minor" moves could be as unsettling. Only the rare organization has not already seen quarters

EXHIBIT VII-1

LOCAL NETWORK PLANNING ISSUES

- Technology
  - Flexibility
  - Upward compatibility with new generations
  - Vendor commitment
- Physical considerations
  - Building construction
  - Existing ductwork, cables
  - Planned construction, moves
- Capacity needed
  - Present
  - Future
  - Unforeseen impacts
- Devices supported
- Costs/benefits
  - Initial
  - Ongoing
- Interconnections
  - Other local networks
    - . Same architecture
    - . Different architecture
  - Host computer(s)
  - External Connections
- Compatibility
  - Local
  - Other

elaborately wired for terminals abandoned as a result of intrabuilding moves.

- Especially the growing, aggressive departments (the ones more likely to seize on technology) are liable to be forced to change buildings/floors.

- Capacity: Initially, this should be a fairly straightforward exercise. Beware of the straight line, however. It appears about equally likely that use of the network will be considerably lower than projected (i.e., office automation does not catch on) or much higher than projected, as shown in Exhibit VII-2.

  - Increases, though, are likely to be discontinuous, reflecting the introduction of still newer technology. Examples in the exhibit include videodisk and videoconferencing. (For further background, see INPUT's December 1980 Management Issue Brief, The Impact of the Office of the Future, and the August 1981 Technology Brief, New Storage Systems and Their Implications.)

  - As in any network planning exercise, it is not so much the volumes or the rate of increase that are the problem as the predictability. (For further discussion on capacity planning issues, refer to INPUT's June 1981 Impact Report, Performance Measurement and Capacity Planning.)

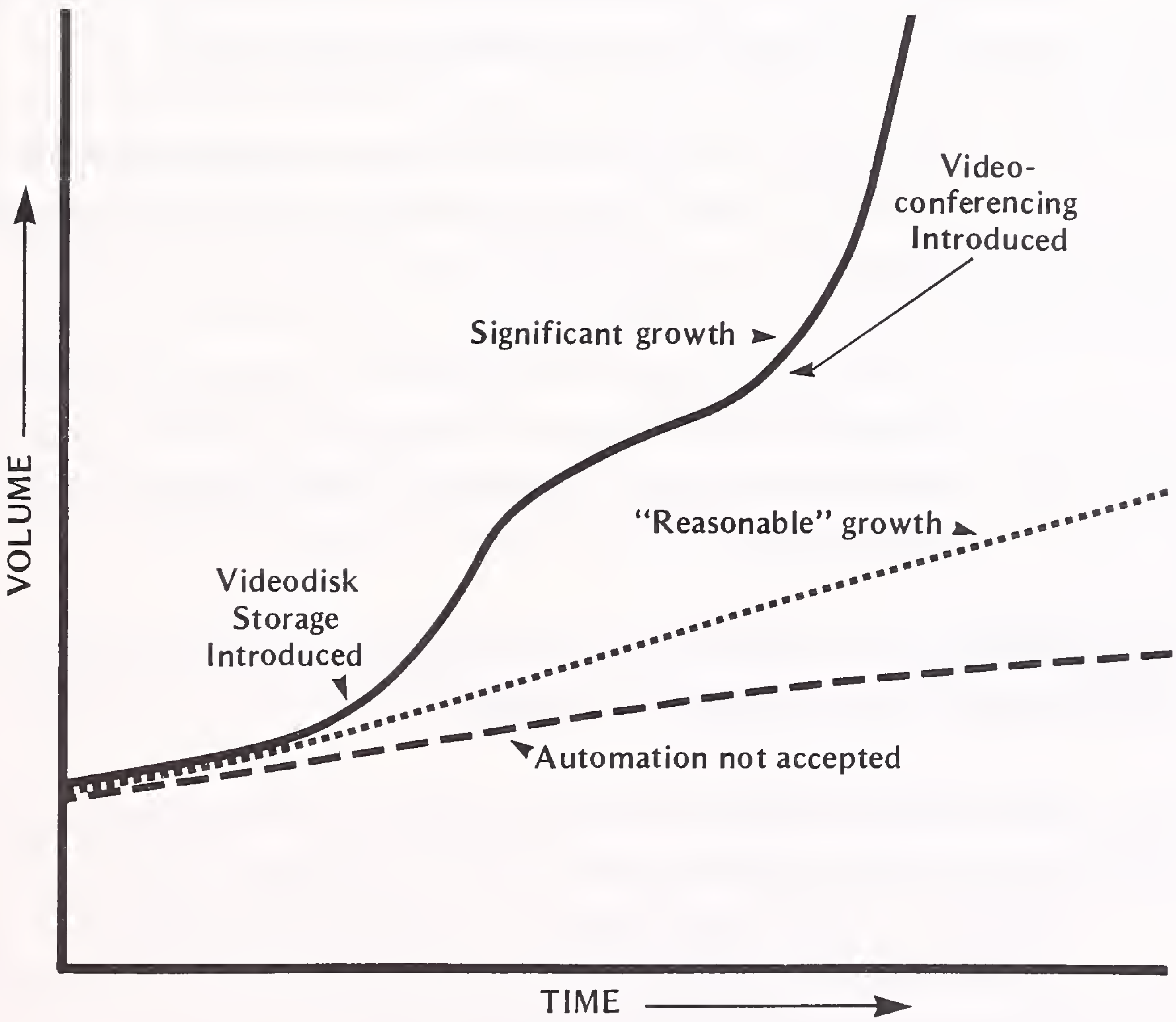
  - The key for success is to make sure that planning for local networks goes hand in hand with that being done for office automation, assuming that there is any effective office automation planning going on.

- Devices Supported: This includes the obvious devices like word processors, personal computers, management workstations, printers, etc. Hopefully, these are already chosen to be compatible (see below).

  - What about not so obvious devices? For example:

EXHIBIT VII-2

LOCAL NETWORK CAPACITY PROJECTIONS - ALTERNATIVE SCENARIOS



. Page printers, facsimile transmitters, or even video transmitters/receivers (for teleconferencing - fast or slow frame).

. On a lower, but perhaps equally difficult level, what about voice communication?

- These might seem unfair questions, since Ethernet, for example, cannot yet handle the previous generation of Xerox word processors.

- However, users will legitimately expect local networks to do just that: to serve every electronic-looking device in their locale.

. If image processing/videodisk storage becomes attractive, it will have to be added to the local network, rather than as a separate system.

. To have more than a few standalone, independently communicating devices remaining in the office will undermine much of the economic and, more importantly, the political justification for local networks.

- <u>Costs/Benefits</u>: The problem here is straightforward - the costs are easily enumerated, but most of the benefits are not.

  - The high dollar benefits will come from what might be termed "second order" office automation (first order automation is considered to be efficiency things like standalone or shared word processors). Second order automation addresses effectiveness issues, such as being able to search and index previously digitized text.

  - Quantifiable benefits from office automation are very difficult to measure. Most organizations do not even try. Will organizations be inclined to finance highly visible, high risk undertakings based on soft dollar benefits?

- Interconnections: At what point is a local network no longer local? How should it coexist with the outside world? This is discussed in Section C, below.

- Compatibility: This is one of the two key technical issues. It is sufficiently complex and important to have Section D, below, devoted to it.

C. INTERCONNECTIONS

- It may seem premature to be raising the issue of interconnection outside the local network, when the issue facing most firms is whether (and how) to start local networks.

- However, there will be great logical, political, and economic pressure to "open up" the local network so that it becomes the universal interface at the local level.

  - These possible connections are shown in Exhibit VII-3. They are, however, shown as question marks.

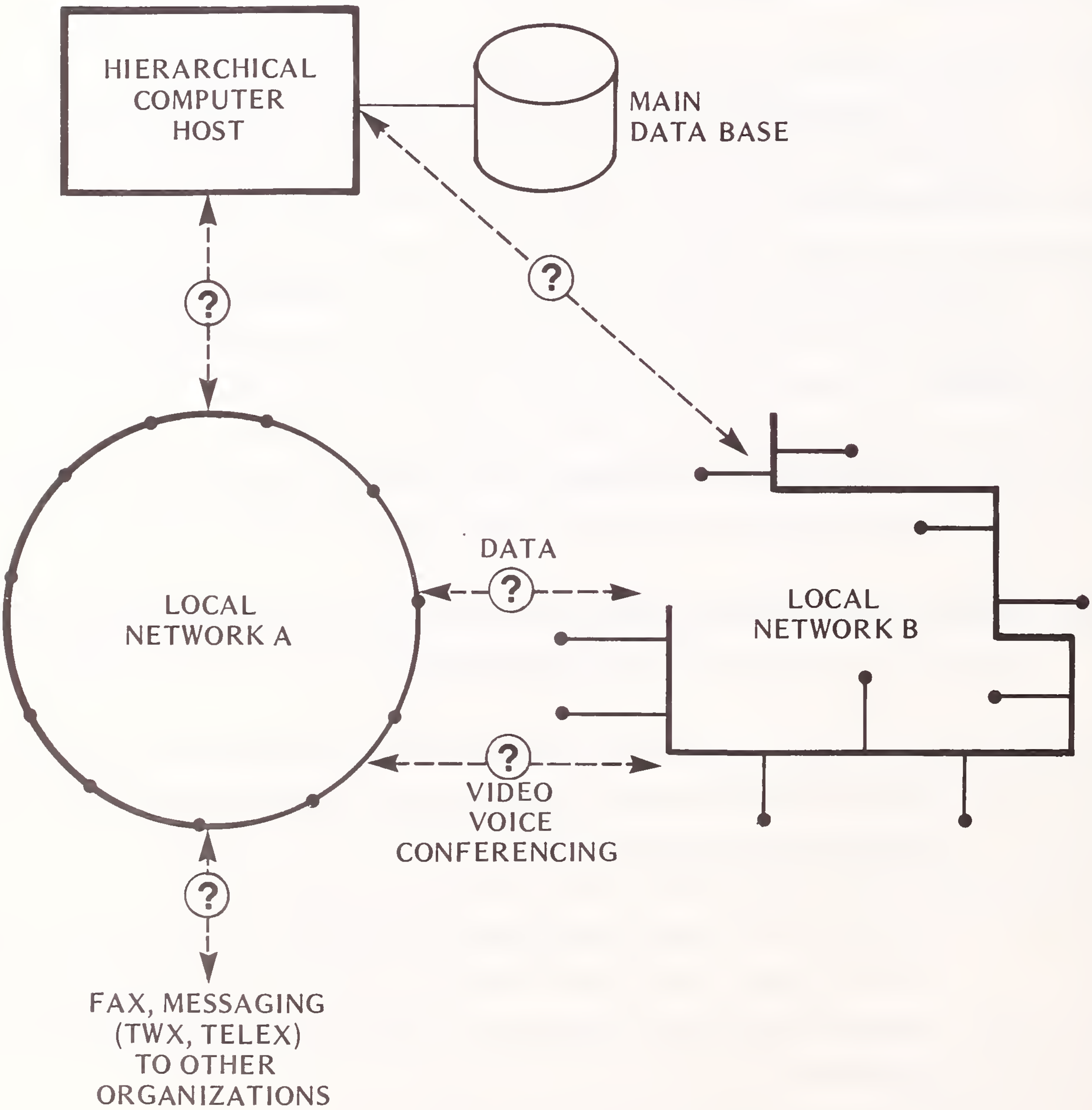
- Host computer-network hookups are very circumscribed now, and are limited primarily to particular host vendor's equipment.

  - The great pre-emptive Ethernet strike is neither the de jure nor de facto standard. Wang is farther behind, and no other vendor is even close to having a corner on the market.

  - However, this does not lessen the desirability of such hookups. If they are not done, current host computer terminal networks will continue to expand, and much of the economic justification for a local network will evaporate.

EXHIBIT VII-3

LOCAL NETWORK INTERCONNECTIONS: QUESTION MARKS



- The importance of data exchange between local networks will probably be small at first (about 60% of current messages are confined to the same building).

    - However, these hookups will become obligatory when electronic mail becomes the rule within local networks.

- Voice links will certainly be important. The question is: How will they be implemented?

    - Only 15% of large organizations currently have an integrated voice-data network.

    - Local integration of voice and data does not carry the same magnitude of cost savings associated with the integration of long-distance networks.

    - Videoconferencing is still experimental, but will exert strong pressure for integration when it does arrive.

- Finally, there are the two standalone orphans - Facsimile and Telex/TWX. They usually exist outside of other networks and, in the case of FAX, outside of any central control.

    - FAX is growing rapidly, and integration into an overall communications network would undoubtedly produce economies and, probably, better service.

    - Local network-based image processing (when it arrives) could replace FAX in many cases.

D. COMPATIBILITY

Those involved in word processing within a company have learned the hard way that most different makes of word processors are not compatible: A diskette of work produced on one cannot be used as is on another.

- Current translators are about as effective as computer language translators; i.e., 100% is needed, but only 70-80% is attainable.

- This sort of "nuts and bolts" problem has, if nothing else, spurred the creation of office automation task forces.

  - Local company standards for future word processing procurements are being or have been set.

  - Still, not much progress has been made on attacking the basic problem of existing incompatibilities.

- The issue of compatibility is much broader in scope than word processing, even on the local level, as shown in Exhibit VII-4.

- Local network architecture currently addresses the problem by only "admitting" favored hardware, usually the vendor's own.

  - This is as much for marketing as for technical reasons.

- As multiple local networks grow, based on different vendors' systems, there will be increased needs and pressures to have the different networks transparent to each other.

- The compatibility issues within the local network almost pale into insignificance compared to some of the other issues involved, as shown in Exhibit VII-5.

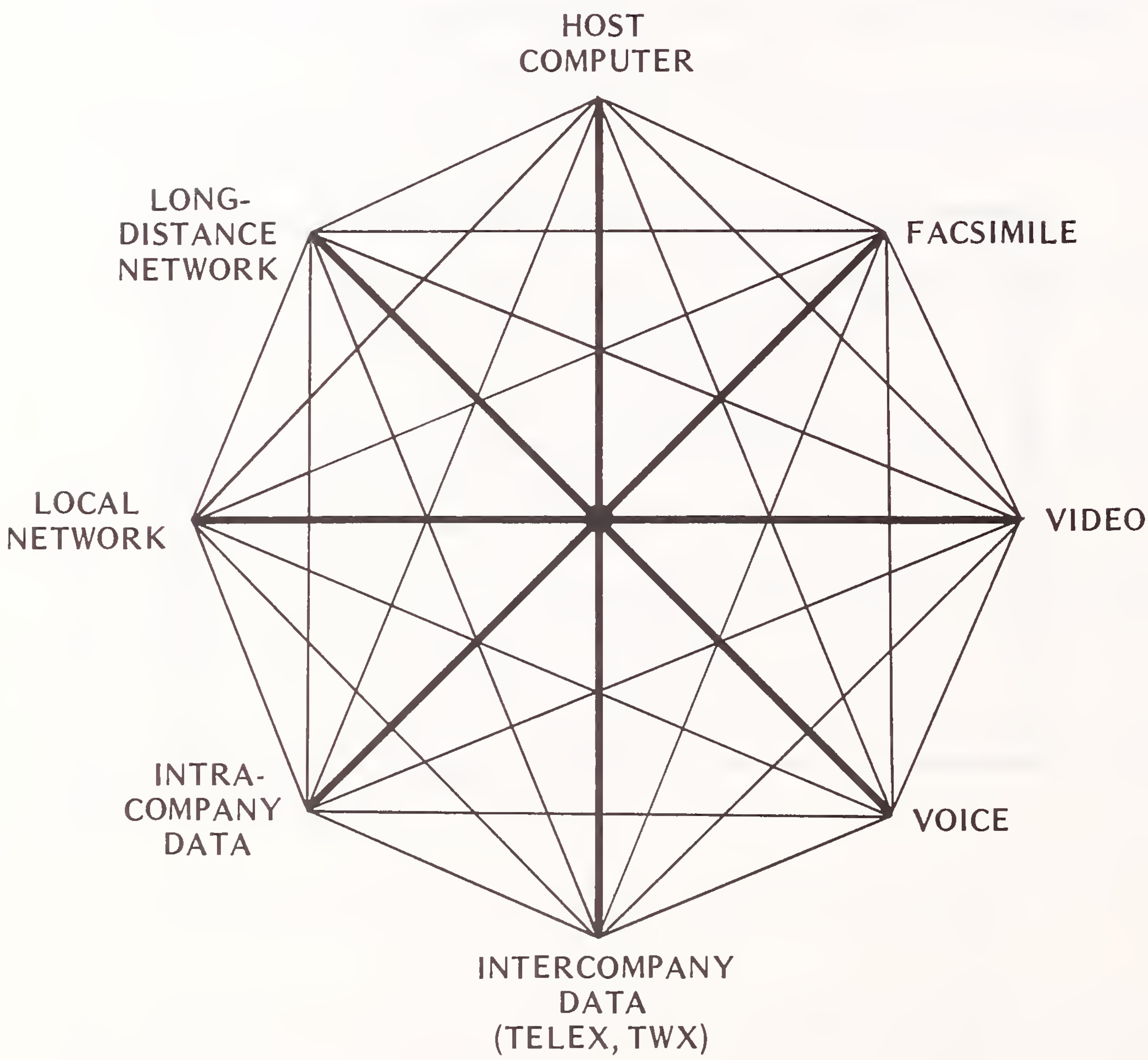
EXHIBIT VII-4

LOCAL NETWORKS: LOCAL COMPATIBILITY

- Word processor compatibility
  - Diskette level
  - Shared storage/peripherals
  - Communications
- Word processor/personal computer compatibility
- Data and voice integration
- Multiple local network compatibility

EXHIBIT VII-5

OTHER COMPATIBILITY ISSUES



- How should the local network be tied into existing long-distance networks? These other networks are themselves still evolving. Yet much of the benefits of local networks would be lost without the possibility of integration.

- If local networks and host computer systems are linked beyond a logical terminal relationship and actually share data there will be a large number of problems (and opportunities) created:

    - Local data must be clean, from the host's standpoint, if it is to be used systemwide. This means centrally specified edit logic and error handling.

    - Data must have the same meaning wherever used, if they are to be shared with other local networks. This will have a significant impact on data base administration.

- The current independent "islands" of facsimile and Telex/TWX should either be ignored or integrated. Pressures will be great in both directions.

    - If integrated, they will have to be compatible, at least to the extent they can be translated.

    - Image processing (if compatible between companies) could reduce or eliminate FAX.

    - Intercompany electronic mail could similarly eliminate Telex/TWX.

E. BARRIERS TO INFORMATION SYSTEMS DEPARTMENTS' INVOLVEMENT WITH LOCAL NETWORK PLANNING

- The biggest barrier to IS departments playing an active role in planning (or successfully implementing) local networks is that the local network question cannot be looked at in isolation. There are two important preconditions for local networks.

  - Office automation.

  - Integrated communications.

- Local networks are:

  - At the mercy of equipment developments in office automation.

  - Totally dependent (in the larger sense) on the organization's total communications activities, as shown in Exhibit VII-6.

- This situation by itself does not present a difficulty, it merely widens the scope of the planning needed.

- At a minimum, a company should have a single data communications network. Only 35% of large organizations do, as shown in Exhibit VII-7. Only 15% (at most) have an integrated voice/data network, which is what should exist if effective planning is to be carried out.

- The situation is equally bleak in office automation.

EXHIBIT VII-6

LOCAL NETWORK PLANNING
DOES NOT STAND ALONE

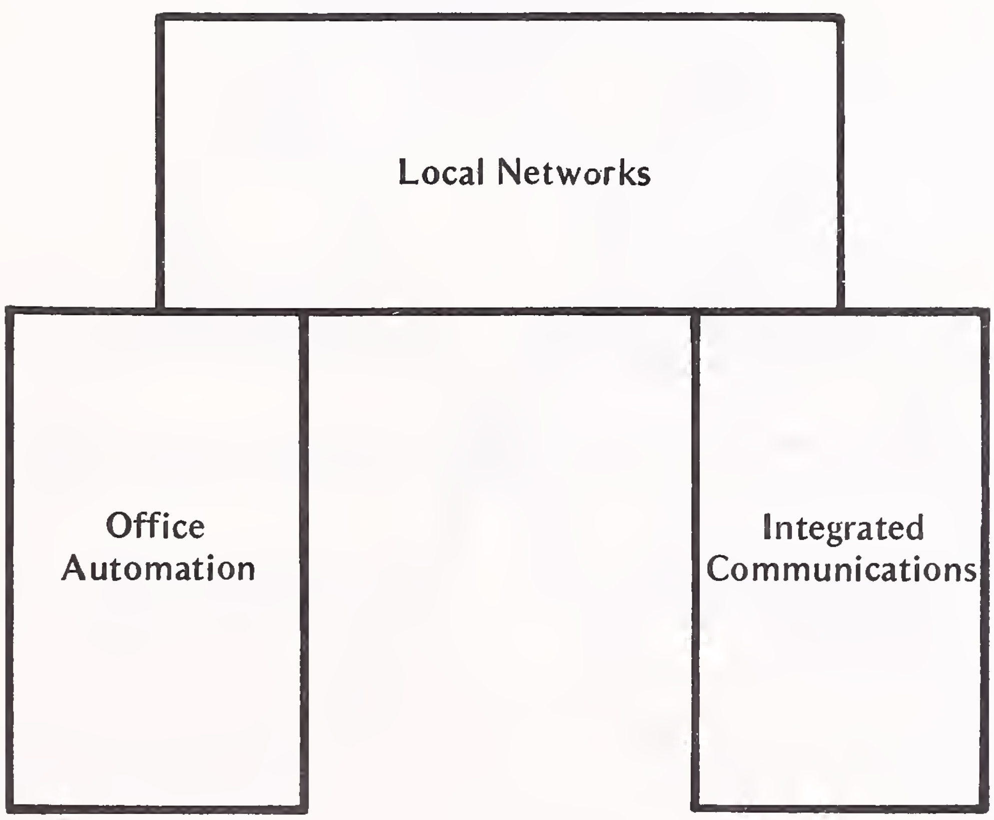
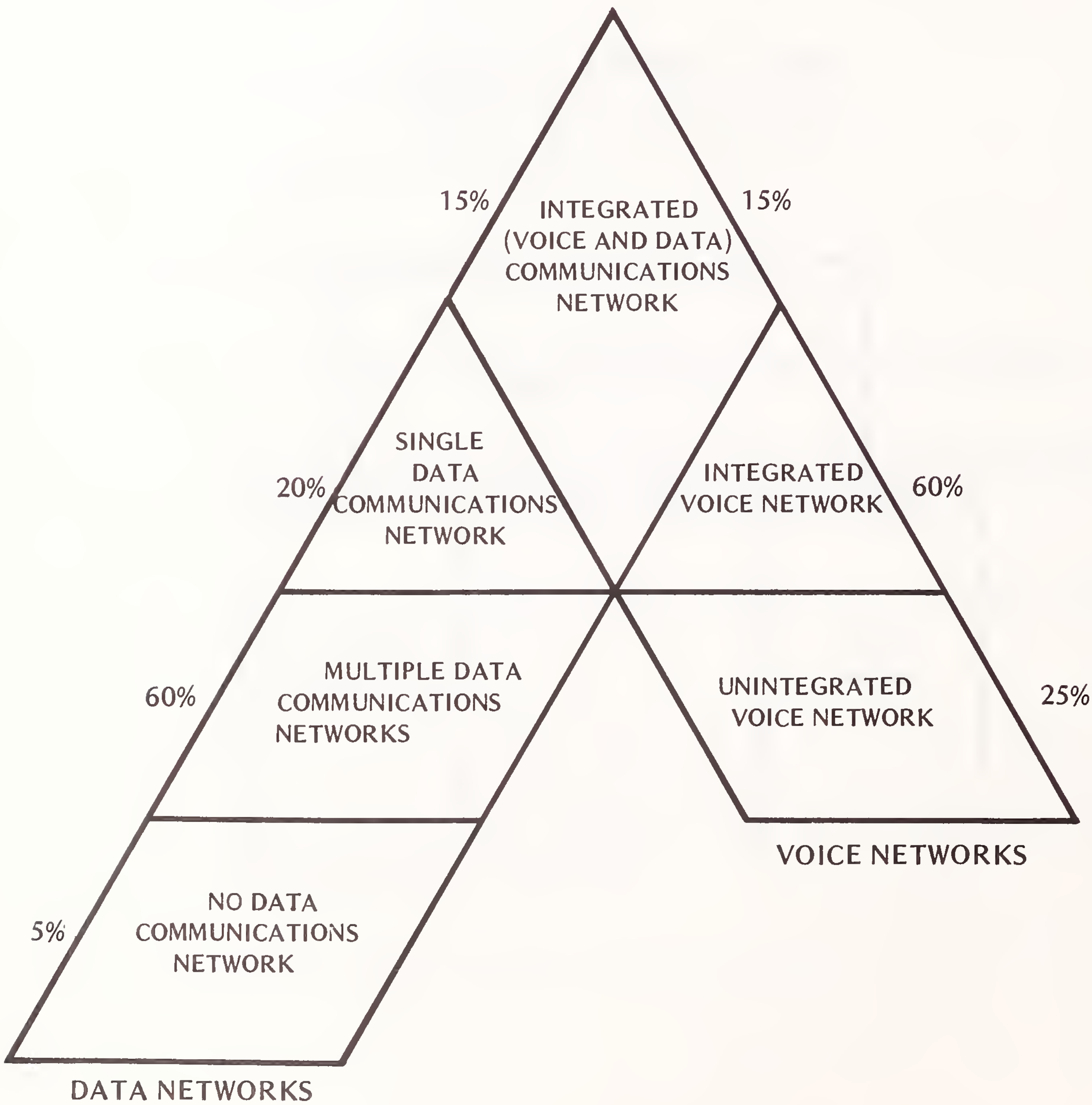


EXHIBIT VII-7

CURRENT STATUS OF INTEGRATION OF LONG-DISTANCE COMMUNICATIONS NETWORKS



NOTE: INPUT ESTIMATES FOR PERCENTAGE OF LARGE COMPANIES IN EACH STAGE

SOURCE: INPUT STUDIES

- At most, only 20% of large companies are now engaged in even limited central planning, as shown in Exhibit VII-8. No more than 5% have office automation centrally directed. (The task force approach shows consciousness of issues, but is rarely equipped to go beyond experiments and recommendations.)

- Even good office automation plans rarely go beyond the basics, as shown in Exhibit VII-9. Consequently, local networking is not being dealt with effectively.

EXHIBIT VII-8

STAGES IN OFFICE AUTOMATION MANAGEMENT

STAGE	OBJECTIVE	METHODOLOGY	RESPONSIBLE ORGANIZATIONAL UNIT	PERCENT ATTAINED (EST.)*
INDEPENDENT EFFORTS	DISASTER AVOIDANCE	NONE	OFFICE/ DEPARTMENT	90%
COOPERATIVE PLANNING	CHAOS AVOIDANCE	EDUCATION	DIFFUSED (TASK FORCE)	50
LIMITED CENTRAL PLANNING	COST MINIMIZATION	HARDWARE SELECTION	USUALLY EDP	20
CENTRAL DIRECTION	EFFECTIVENESS MAXIMIZATION	SYSTEMIZATION	EDP (RESTRUCTURED)	<5

* CUMULATIVE, BOTTOM TO TOP

EXHIBIT VII-9

ELEMENTS IN OFFICE AUTOMATION PLANNING

- Word processing needs evaluation
  - Associated storage devices, printers
- Evaluation of enhanced word processor alternatives
  - "Management" workstation
  - Computational add-ons/personal computer
- Hardware acquisition procedures
  - Discounts
- Office automation justification guidelines
- Allocating budgetary responsibility

VIII CONCLUSIONS AND RECOMMENDATIONS

VIII CONCLUSIONS AND RECOMMENDATIONS

- Local area networks are likely to gain in popularity as corporations seek to increase the degree to which office functions can be automated.

- From the way in which vendors have developed their systems, it is clear that local area networks are aimed primarily at departments other than the Information Systems department.

- Relations with management and end users can be enhanced by initiating a dialogue for addressing longer-term plans to integrate local area networks into the corporate computer-based information system.

  - Out of this dialogue can evolve a set of corporate standards for network interfacing, as well as a policy definition of responsibility for supporting the interfaces from both a budget and a resource point of view.

  - Interaction with management and end users at an early stage can lead to their continued active involvement beyond the feasibility study activity into the phases of alternative definition, alternative selection, prototype development, pilot test, operational implementation, and post-implementation review.

- Planning and review sessions with management and end users at the end of each of these phases are likely not only to maintain their involvement but also to heighten their awareness and understanding of the problems involved.

- There are too many interrelated variables involved in planning any network system to permit alternative evaluation to be done by hand. Information systems managers and their planning staffs should become aware of, and develop proficiency in, using network performance and cost models.

  - Most hardware vendors have network models that they either make available to a customer or a sales prospect, or execute to provide analyses to their customers or prospects. Regardless of whether the modeling is done on a fee basis or without charge as part of the sales effort, these models are a valuable planning resource that must not be overlooked.

  - Since models require quantitative input, they impose a stringent discipline on the development of traffic estimates, and can therefore preclude decisions based on fuzzy guesses.

- Deciding whether or not local area network subsystems are to be integrated with corporate DP systems requires not only traditional systems and cost benefits analysis with respect to the DP-based alternative, but also an analysis of each local area network subsystem alternative, which should include detailed assessments of the following:

  - Cost. What incremental hardware purchases are required to implement the desired subsystems and to interface then with the DP network? What are price trends for these components likely to be?

  - Performance. Is integration absolutely necessary in order that the subsystem will operate? If so, will integration cause any degradation of performance in either or both networks?

- Flexibility.

  - How easy, and how desirable, is it to attach or detach devices? Can this be done, and is this likely to be done, while transmission is in progress?

  - What is the theoretical limit on the number of devices that can be attached to the subsystem? What is the practical limit? How soon will this limit be reached?

  - What new network technologies will become available in the short term and in the longer term? Can they be incorporated easily? Can they be incorporated at all?

  - Can the corporation benefit from newer technologies: from current technologies? Will selection of one alternative place the subsystem on a path toward a technological dead end?

- Function.

  - Within the local area network, should voice, data, and other types of traffic be integrated? If so, which alternatives provide the necessary level of integration? How will such integration affect the interface with the DP network?

  - Does each alternative provide, as a standard feature, support for functions that will never be needed? If so, are the benefits from needed functions sufficiently large to more than offset the implicit cost of unneeded features?

- Ease of Use. How long does the vendor claim it will take for a user to learn to operate the system? What are users' actual experiences, and how do they compare with vendor claims?

- Availability. Are local networks that have been announced available today, or is there planned availability set for a date that is too far in the future for worthwhile consideration?

- There is one, most important consideration that must be heeded in any evaluation of any local area network alternative. Most alternatives are still taking shape, and therefore a projection of office automation technology of more than two years out would be highly speculative.

  - Payback analysis of office automation systems should be viewed cautiously if the subsystem life assumption extends beyond two years.

    - The electronic content of office equipment continues to increase, and INPUT believes that the trend of 24% annual price declines in electronics components will persist for the foreseeable future.

    - Comparable declines in the nonelectronic components of office equipment are not expected, but the influence of electronics technology is likely to be reflected in declining costs per function.

  - As a corollary, plans for local area networks must be reviewed on a much more frequent basis than for other computerized systems to ensure that cost/performance objectives will be met.

  - INPUT believes that no single local area network vendor will achieve a pre-eminence in office automation comparable to IBM's position in the data processing field, primarily because the initial costs of entry into the local area network field are low. Therefore, competition is likely to accelerate the flow of products related to office automation and local area networks in much the same way that the minicomputer and microprocessor industries experienced a virtual explosion of competing hardware and software components.

- It is also important to understand the business objectives of each local area network vendor when evaluating that vendor's specific product offering. These business objectives provide significant clues regarding the aspects of the network that are most likely to be emphasized both in the sales literature and in the products.

- All vendors of local area networks recognize a major business opportunity in automating office functions, but their approaches differ widely.

    - IBM's strategy is to extend the power of a corporation's computing resources to all office workers. The philosophical basis lies in the traditional timesharing concept. Unfortunately, the related skills required of a user remain complex. The Series/I product does not appear to INPUT to be the precursor of a change in IBM's central host strategy.

    - Xerox is the unquestioned leader in xerographic imaging. Although it has faced increasing competition over the past decade, Xerox has produced an impressive array of systems-related products for non-impact printing that is difficult for competitors to match.

    - Wang was the first major vendor of office equipment products to combine word processing with data processing. Thus, its expertise is biased toward the manipulation of character streams.

    - Datapoint has used the term "dispersed processing" to describe its approach to office automation. This concept involves the dispersal of small computers to process data, with occasional access to large disk files and volume printing facilities.

    - Net/One, Z-Net, and HYPERchannel are specialized forms of local area networks. Net/One and Z-Net are aimed at interconnecting personal computers, while HYPERchannel is generally used for interconnections with large-scale processors supplied by the traditional mainframe manufacturers.

- Manufacturers of private automatic branch exchanges (PABXs) address a very specific problem, namely, the switching of voice circuits. The fact that PABX manufacturers are increasingly employing digital transmission techniques allows consideration of the use of PABX circuits to support data transmission within a fairly circumscribed area.

- Although local area network alternatives all strive to provide automation of office functions, no single alternative can be considered superior outside of the context in which it is to be applied.

- Finally, unless an executive mandate leaves no choice, a very real alternative to integrating local area networks into corporate EDP networks is allowing them to coexist independently of each other.

  - Telephone systems, typewriters, and copiers have coexisted, and are likely to continue doing so, in millions of offices, and their integration in most cases would make no economic sense.

  - Similarly, there may be no justification at all for integrating local area networks.

  - The ability to make an informed judgment that integration is unnecessary or undesirable, however, requires as much analysis as arriving at the conclusion that integration is indicated.