OFFICE COMMUNICATION NETWORKS

JUNE 1982

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CONTENTS

EXHIBITS

I OVERVIEW

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- Local area networks (LANs) 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; hence the title of this report is Office Communication Networks. The names are used interchangeably in this report.

- The productivity of office communication 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.

- 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 I-1.

- 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:

EXHIBIT I-1

RELATIVE GROWTH IN SELECTED OFFICE SYSTEMS EQUIPMENT

OFFICE SYSTEM	1980-1985 AAGR (percent)
Word Processing	38%
Copiers	15
Computerized Telephone Services	38
Image Processing	
Facsimile	25
Microfilm	15
Personal Computers (In Large Corporations)	48

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

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

- Word processing output may be sent by facsimile device to another organizational unit where it is reentered 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:

  - One 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 other is the "peer level" approach where different pieces of office equipment communicate directly with each other, as in the Xerox Ethernet, Datapoint Attached Resource Computer (ARC), and WangNet systems.

II PRODUCT OFFERINGS

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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.

- 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, ten 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 6 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 II-1.

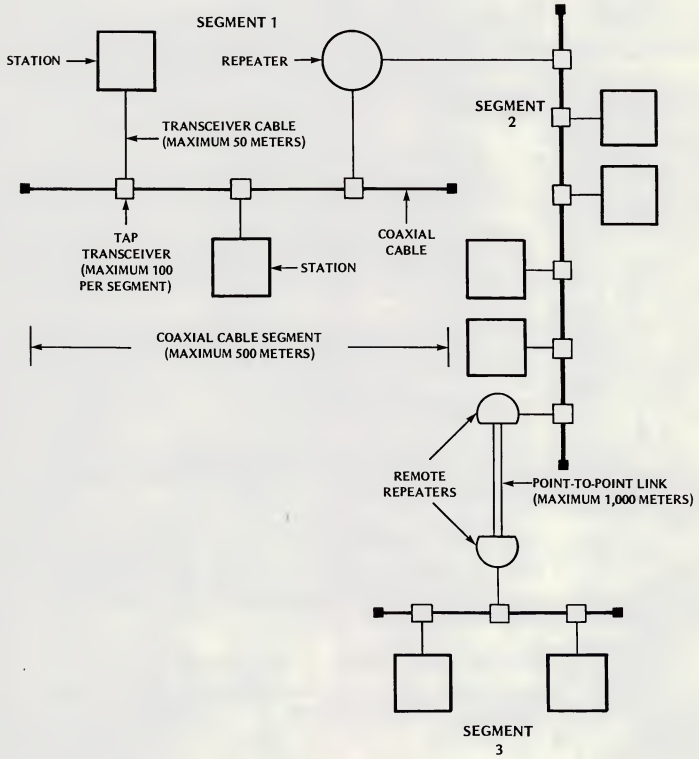
  - Ethernet transmissions occur at rates of 10 Mbps over distances of up to 2.5 kilometers (1.5 miles).

  - 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.

EXHIBIT II-1

SAMPLE ETHERNET CONFIGURATION



- When a trasmitting station detects a collision, it abruptly terminates the transmission in progress and sends a short burst of noise. Each 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, 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 than to adapt their requirements to fit a relatively inflexible hardware configuration.

  - The 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. Ethernet support will be incorporated in DEC net, supporting both the VAX-11 and PDP-11 product lines. A gateway product and other offerings will appear beginning in mid-1983.

  - 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 II-2, are:

  - Applications processors, usually located in an office environment.

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

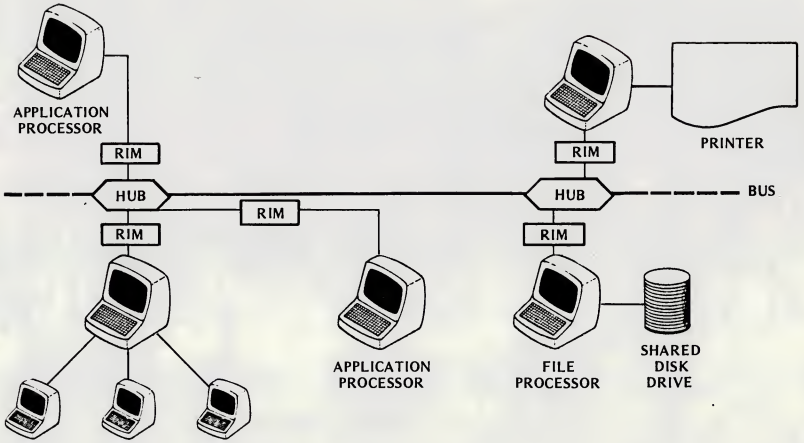
  - An interprocessor bus that carries the transmission among processors.

- 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 II-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 sheet.

- 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 network, 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.

- Datapoint is thus 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

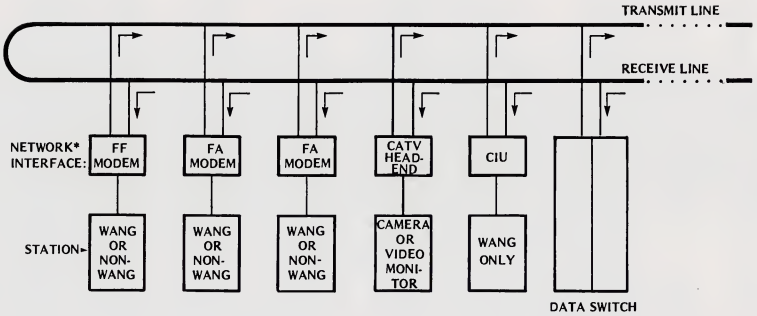
September 1981 that their systems could be interconnected by adding a $400 interface board to the TRS-80 Model II.

C. WANGNET

- Wang Laboratories, Inc. introduced a broadband local area network system called WagNet in July 1981, for phased delivery in 1982.
  - A diagram of the WangNet architecture is shown in Exhibit II-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 II-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 II-3

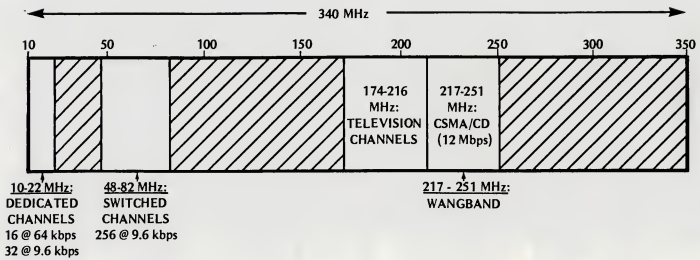
WANGNET ARCHITECTURE



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

EXHIBIT II-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:

  - Fixed frequency modems providing support for the 9.6 and 64 kbps dedicated channels.

  - Hardware for the switched channels (the data switch and the frequency agile modems).

- 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 II-5.

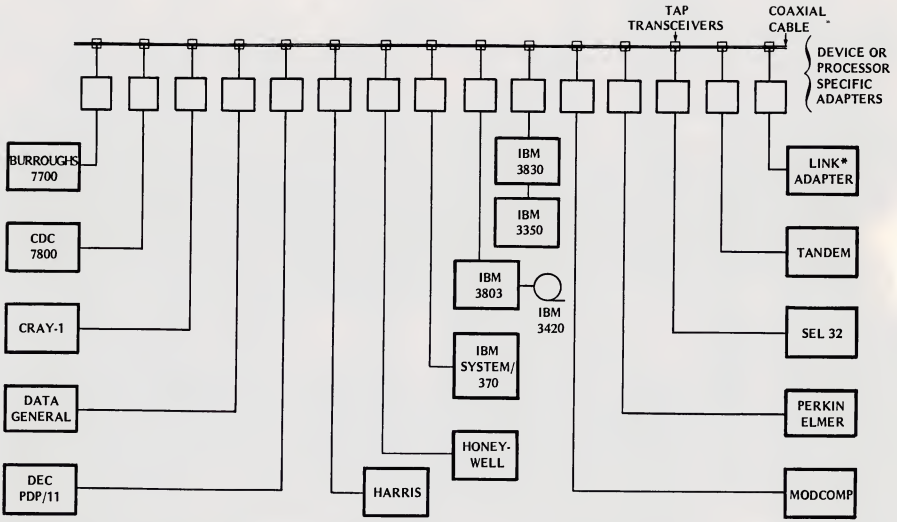
- HYPERchannel consists of a coaxial cable and network adapters, and enables transmission of up to 50 Mbps for one mile.

  - 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 II-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 eight 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

- Almost every month, another new local area network is announced. A representative, but by no means comprehensive, product list includes the following offerings.

- 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 occurring 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 sytems currently under consideration, which 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, has 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.

III THE IBM ALTERNATIVE TO LOCAL AREA NETWORKS

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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 III-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.

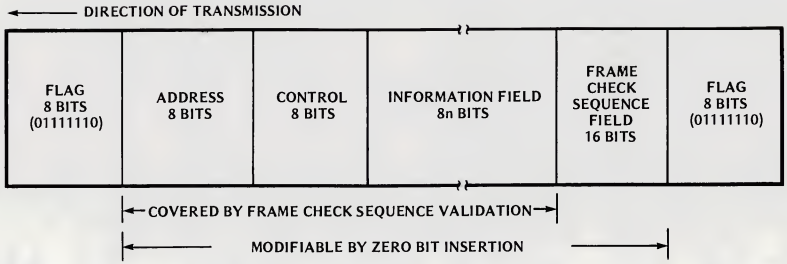
  - Support of this convention requires bit-manipulation capability (intelligence) at every SNA station.

  - 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 III-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.

  - The 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 announce-

ment 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 an 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.

IV CONCLUSIONS AND RECOMMENDATIONS

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- 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 involve-

ment 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 them 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 their 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 preeminence 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/1 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 loacl 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.