# XNS Ethernet Connections for the IBM PC XT

STATUTORILY EXEMPT

*The IBM PC XT and the Xerox Network Systems (XNS) Ethernet are both well established in the data processing environment at NSA. This paper explores three different alternatives for connecting these two components. These alternatives offer a variety of functions at various interconnection costs. One of these connection alternatives has recently been announced and was tested in R5 during a β-test of the latest version of the XNS software (O.S.5.0).*

## 1. INTRODUCTION

The Xerox 8000 Network System (XNS) environment has evolved into a diverse family of resources that users of non-Xerox personal computers have repeatedly attempted to tap. Prohibitive costs, lack of software, and a fear of the supposed excessive complexity involved have limited the personal computer to a remote user capacity with restricted access to network resources. However, recent developments in very large scale integration (VLSI) data-link controllers have made possible an affordable connection that allows the personal computer to access network services as a fully privileged network citizen. Although networking is no longer a new idea, the ability to access the high quality and rather costly services available on the Agency's several XNS Ethernet environments with the Agency standard terminal/workstation, the IBM PC XT, is an important development.

This paper documents testing and subsequent evaluation of three different connections for the IBM PC XT to the XNS Ethernet environment. The three connections to be discussed are (*a*) a direct physical connection to an 8000 communications processor, (*b*) a logical connection to the same processing capabilities via an 873 Communication Interface Unit (CIU) physically connected to the Ethernet coaxial cable, and (*c*) the recently announced method of directly connecting the IBM PC XT to the Ethernet coaxial cable as a fully privileged network citizen. As the IBM PC XT is now the Agency standard terminal/workstation, methods of connecting it with the XNS Ethernet environment should be of interest to those Agency elements wishing to most efficiently use the expansive array of network services available on the XNS Ethernet while also providing a number of low cost, fully networked workstations to office personnel.



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## 2. ETHERNET BACKGROUND

Ethernet processing power is derived from Xerox 8000 processors running a multitasking operating system known as Pilot. It is this operating system that contains the communications software to put data into segments, known as packets, and to sequence, address, and transmit those packets, providing the foundation for the operation of the network services. Communication between servers (processors supporting network services available to the network community (Xerox 1984b)) and workstations (processors dedicated to serving the individual user) on the network is achieved by a system of layered protocols required to construct and transmit packets within and between networks.

More specifically, Ethernet is a multiaccess, packet switching communications system. Digital data is sent in small packets (from 72 to 1526 bytes), and these packets are routed independently through the network to the destination(s) (Xerox 1983). Ethernet has a bus topology, which is readily expandable and not necessarily plagued by entire network shutdown when a single workstation or server fails (figure 1). The communications channel, generally a coaxial cable, is shared among the network citizens and remote users. The channel is a passive broadcast medium with no central control: effective communication is made possible by the unique addressing of all network elements and all transmitted packets. Packets on the channel are available to every network element, but successful communication occurs because the intended destination recognizes its unique address on a packet and accepts it from the communications channel. Generally, a device on the network will only receive packets containing its unique address. The destination responds to the transmitting element with an acknowledgment packet indicating whether or not the packet was received without error. The transmitting element then either retransmits the previous packet or continues transmission of packets in sequence.

The Ethernet packet switching protocol employs a control procedure known as CSMA/CD (carrier sense multiple access with collision detection), which resolves contention for the single bus by multiple servers or workstations (Xerox 1983). Each network element is connected to the coaxial cable through a transceiver, a hardware interface responsible for the transmission and reception of the packets. An element's transceiver listens to the channel to detect if a packet is being transmitted. If the carrier is not sensed (i.e., no packet is being transmitted), any network element is free to attempt transmission of a packet. All network elements compete equally for communications channel time; there is no master device or processor controlling network communications. When two elements attempt to transmit at once, known as a collision, each aborts its attempt to transmit for a random number of milliseconds and then all elements are again free to compete for control of the communications channel. A collision situation is detected by a network element if, while that element is transmitting a data packet, it reads back data that differs from what it is sending out (Tanenbaum 1981). This control procedure is quite efficient in distributing communications channel time among all network elements; collisions and waiting are not readily apparent to network users.

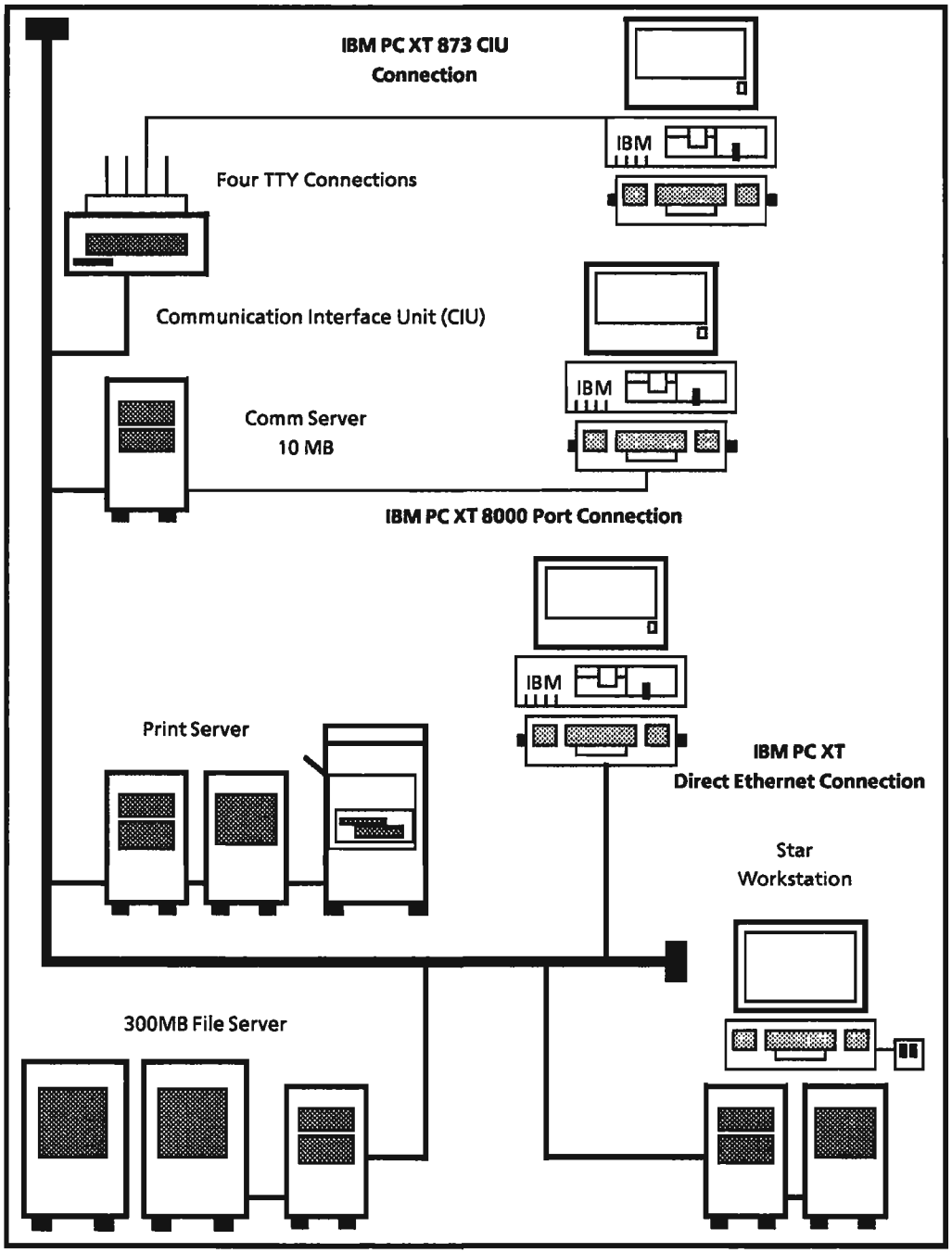


**Fig. 1. Typical XNS Ethernet Environment Illustrating the Three Types of Connections for the IBM PC XT**

**Note that in only one of these three connections is the PC directly connected to the Ethernet coaxial cable.**

3. CONNECTING NON-XEROX EQUIPMENT TO THE XNS ETHERNET

There are over twenty existing XNS Ethernet environments currently active at NSA within several major Agency elements. Although the XNS environment offers users a diverse range of resources, including high quality graphics, extensive document formatting capabilities, and access to costly peripherals such as high speed disks and high resolution laser printers, network equipment cost has in the past been prohibitive for some potential customers. A promising solution for the cost consideration problem is a connection that provides access to the XNS Ethernet resources from a more moderately priced workstation, i.e., the IBM PC XT. Three methods are currently available for such an IBM PC XT-Ethernet connection. Two of these connections limit the personal computer to remote user status on the network, permitting access to network resources only through the Asynchronous Communication Protocol package, which is available as part of the network external communication service (ECS). Such a connection permits access to the electronic mail system, to network file service, and to system administration commands (if the user is so privileged) from the remote personal computer. However, an integral part of the latest release of XNS software (O.S.5.0) is the third method, the connection of the IBM PC XT to the Ethernet coaxial cable as a fully privileged network citizen. Like the two prior connections, this new direct connection facilitates access to network file and mail services; but it also permits the personal computer to access network print service and the standard communication support equivalent to that provided for Xerox workstations on the network..

Each server on the network is dedicated to support one or more of the Xerox 8000 Network Services. Of these services, the ECS is the most pertinent to this discussion. It is this service, through its Asynchronous Communication Protocol option, which permits and controls the two more limited connections of personal computers such as the IBM PC XT to the XNS Ethernet environment. First and foremost in the consideration of these connections, it must be remembered that an 8000 processor running ECS is required. The current cost of a 10MB 8000 communications processor is approximately $15,000 for the TEMPESTed model, $8000 for the nonTEMPESTed model.

The most freedom for the remote personal computer is afforded when the communication ports are configured to include the Greeter services. Without the Greeter interface, the remote user is limited to logging into one particular Interactive Terminal Service (ITS) specified at the time of the initial port configuration. This restricts the user to that ITS's mail and filing resources. The ECS Greeter is an interface that "greets" incoming asynchronous calls to a 8000 communications processor from a remote terminal or personal computer. The Greeter interface permits remote users to choose one of two types of connections: a connection to any network ITS (there may be more than one) or a connection to Services Executive. An ITS connection permits users from remote ASCII (American National Standard Code for Information Interchange) devices to access the network electronic mail service and the file service. A connection with the Services Executive permits the user to select and logon to a particular network server and, if he possesses the necessary privileges, perform system administration tasks from his remote workstation.

4. CONNECTION VIA 873 CIU

One method of connecting a non-Xerox personal computer to the XNS Ethernet environment is through a port on an 873 CIU. A CIU connected to the Ethernet cable extends communication services to remote terminals, personal computers, and mainframes which can communicate via the RS-232-C standard. The CIU circuit board's four full-duplex RS-232-C ports are limited to a total maximum throughput of 19200 baud. An optional, second four-port circuit board with the same throughput limitation may be added to the CIU. Both synchronous and asynchronous full-duplex communication are available, with varying restrictions on line speed, dependent upon the number of active ports on the CIU circuit board. Actual line speed restrictions are also dependent upon whether synchronous communication (permitting one 9600 bps., two 4800 bps., three 2400 bps., or four 1200 bps. ports per board), asynchronous communication (requiring that all ports be within a specific line speed range, with the four ports not exceeding the previously mentioned 19200 bps. maximum throughput), or both are configured on an 873 CIU board (Xerox 1983).

In order for the personal computer to communicate with the XNS Ethernet through this type of connection, a terminal emulation software package must be loaded into the personal computer. With this type of connection to the XNS Ethernet environment, a remote personal computer user is "greeted" with a choice between ITS and the Services Executive. Through ITS a user can retrieve mail and send messages to any user known to the associated network mail service. ITS also provides file service options which include the capability to create, display, edit, and delete files, as well as the ability to create, copy, and move file directories. If the software package used by the personal computer to communicate with the XNS Ethernet supports the XModem protocol for data transfer (Jordan 1983), the personal computer user also has the ability to retrieve and store files from/to a network file server. Retrieving files using ITS permits text translations from 860 format (i.e., the format of a document created on a Xerox 860 word processor workstation) to ASCII text. Storing files to a network file server via ITS provides the capability to translate personal computer files into 860 format or Xerox file note format, or the file may remain in an unspecified (its original) format with no translation being performed. The Services Executive connection permits remote system administration capability. This capability is convenient when a system administrator's work area is not local to the processor/hardware area and/or does not house an 8010 (Star) workstation.

Costs involved in this method of connection include approximately $5000 for a nonTEMPESTed 873 CIU with one four-port board. The TEMPTESTed version is currently unavailable. We will see as we examine the second method of connection that this cost is justified, for not only does this method permit personal computer users to access XNS Ethernet resources, it also provides four or more such communication paths rather than the one path that the next method is limited to.

5. CONNECTION VIA 8000 COMMUNICATIONS PROCESSOR'S LOCAL RS-232-C PORT

An 8000 communications processor is equipped with one local RS-232-C port. Ethernet communication connections that depend on bisynchronous protocols, such as the IBM 3270 emulation package and the 850/860 Gateway connection (the method by which standalone Xerox word processors can access the network's electronic mail service), can only be made available through a communications processor's local port. However, a remote personal computer can also be connected through a physical connection to a processor's local RS-232-C port via an Asynchronous Modem Eliminator, known as an AME or null modem (figure 2).

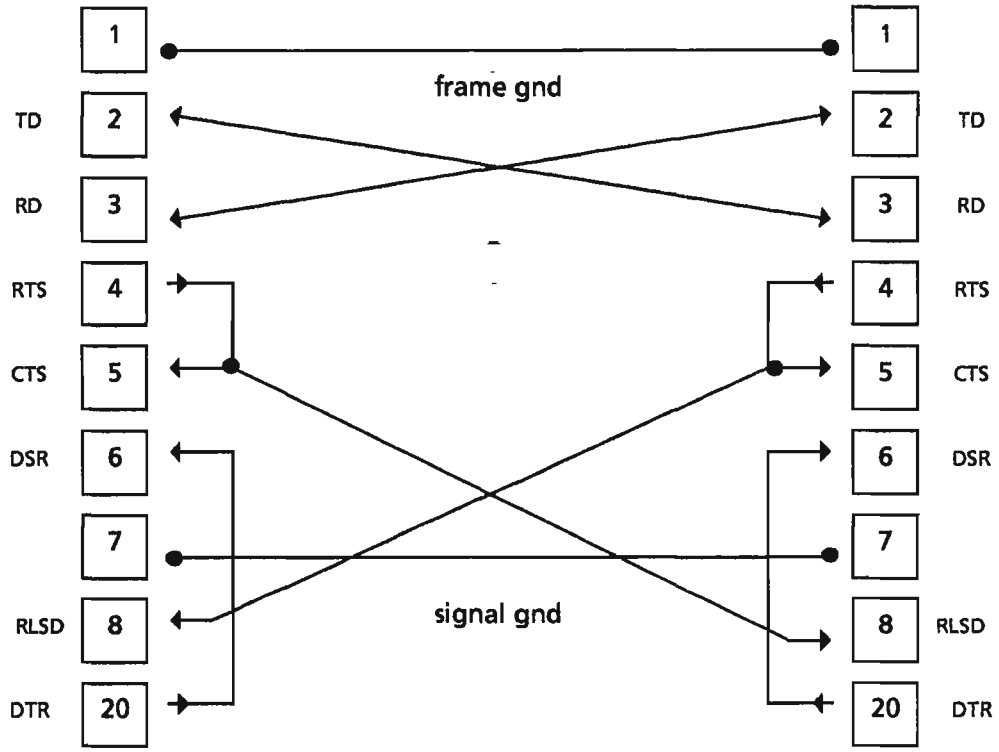


**Fig. 2. Asynchronous Modem Eliminator**

**There is no set standard for AME wiring. However, this is the AME configuration that successfully connected an IBM PC XT to an 8000 communications processor's local RS-232-C port on the R5 Ethernet.**

Like the 873 CIU connection, this connection requires that terminal emulation software be loaded at the personal computer and offers the user the same services as the 873 CIU connection, but without any line speed restriction. The personal computer connected via this method would have access to the same network services, but would be free to communicate at speeds up to 9600 bps. To insure the same line speed freedom with the 873 CIU connection, only one port per board

could be operational, which would defeat the purpose of that 4-port communications extension.

A comparison of the time required for mail message retrieval between this direct connection to a communications processor and the connection via the 873 CIU previously examined reveals no significant difference between similar line speeds (table 1).

**Table 1. Average Time Required to Retrieve a Full Screen of Mail Message Text**

| Port Speed | 873 Connection | 8000 Port Connection |
|---|---|---|
| 300 bps | 44.25 sec | 44 sec |
| 600 bps | 23.37 | 23.75 sec |
| 1200 bps | 12.4 sec | 13 sec |
| 2400 bps | N/A | 8.5 sec |
| 4800 bps | N/A | 5 sec |
| 9600 bps | N/A | 4 sec |

Because the 873 CIU connection is restricted by the maximum throughput per circuit board when more than one port is used, no comparison was made in such cases at the greater line speeds. However, even with the potential for greater data transmission speed, it does not appear to be sensible to dedicate a costly processor to serve one remote personal computer in view of the fact that certain other types of communication connections (e.g., network-to-network communication and network-to-host communication) require the use of the communications processor's single RS-232-C port. For approximately $5000, four communication connections to remote personal computers and non-networked systems can be facilitated, and additional 873 CIUs can be added to the network as more ports are needed. In the rare situations where no more than one communications port is desired, the 873 CIU would be unnecessary and the processor's local port could justifiably be used for a single remote personal computer.

## 6. DIRECT CONNECTION OF IBM PC XT TO ETHERNET COAXIAL CABLE

Although the two previous connections to the XNS Ethernet environment permit limited access to network resources, the non-Xerox personal computer remained restricted on the network. With either of these two connections the

personal computer still had no access to network print services or communication capabilities such as TTY emulation. The demand grew for a direct XNS Ethernet connection for personal computers such as the IBM PC XT, a connection that would permit the personal computer to communicate and share resources as a fully privileged network citizen. Only such a connection would permit personal computers to be able to take full advantage of the XNS Ethernet peripherals, such as laser printers and high speed disks, and various communication links to mainframes, including TTY emulation and Remote Batch Service. A result of this growing demand for a direct connection prompted 3Com Corporation to define and subsequently implement a hardware/software interface suitable for integrating the IBM PC XT into the XNS Ethernet environment.

### *6.1 Hardware*

Previous attempts to develop a direct connection had been abandoned as too costly and/or requiring too much space or power. But 3Com Corporation successfully collaborated with Seeq Technology in the development of the first commercialized Ethernet chip (Metcalfe 1983). Due to advancements in VLSI data-link controllers, the Ethernet Data Link Controller has reconciled the space and power problems without aggravating cost concerns. The new data-link controller is functionally equivalent to about 50 standard integrated circuits, but it consumes only 20 percent of their power. This network adapter card contains standard Ethernet logic circuits and firmware necessary to implement the physical and data link layers of data communications (layers 1 and 2 of the 7-layer ISO (International Standards Organization) standard). This hardware interface is responsible for, among other things, formatting data into Ethernet packets for transmission, passing received data packets to the personal computer's operating system, data error checking, data encoding and decoding, and acquiring access to the communications channel according to the Ethernet CSMA/CD control procedure (Jordan 1983). Hardware design has colocated the transceiver and controller on the Ethernet printed circuit board which fits into an open slot in the IBM PC XT system unit. A transceiver select switch on the circuit board can be set to designate either an on-board or external transceiver.

The on-board transceiver is capable of driving cable referred to as Thin Ethernet. This cable is a 50 ohm RG-58 coaxial cable that is more flexible and less expensive than the standard Ethernet coaxial cable. This thinner cable does run the risk of greater electrical attenuation, and, as a result, the length of a single segment of the thin coaxial cable is limited to 300 meters, compared to the 500 meters permitted with the standard Ethernet coaxial cable. When an external transceiver is used, the personal computer is connected via the standard Ethernet drop cable, which is currently available in a TEMPESTed form. Regardless of the type of transceiver connection that is selected, the result is the same: the IBM PC XT becomes a fully privileged network citizen at a connection cost of approximately $800 or $1500, depending on the choice of internal or external transceiver, respectively.

*6.2 Software*

The software provided with this direct connection provides access to a full range of network services. The PC-installed software packages, known individually as XFILE, XPRINT, XMAIL, and the soon to be announced optional package XTERM, provide easy access to network services with commands in a familiar DOS (desk operating system)-like format. The personal computer user can define a default user name, domain, organization, and print service in a user profile file which is used by the software packages. Certain selections, such as login requests for XFILE and XMAIL, can be coded into the automatic batch file which is automatically executed each time the software is booted on the personal computer.

The XFILE software package provides the networked IBM PC XT the same access privileges as Xerox workstations for the direct storage and retrieval of documents. Using XFILE commands, a text file created at the IBM PC XT can be transmitted to the network file service and later accessed from an 8010 (Star) or other Xerox workstation for enhanced formatting. Likewise text files created on Xerox workstations can be retrieved from an IBM PC XT and converted from Xerox 860 format to Wordstar format by the software in the process of transmission. Wordstar, by MICROPRO, is a popular full-screen text editor for the IBM PC XT. The current version of XFILE software features automatic text translation as part of file transmission for just two text formats: Wordstar format to Xerox 860 format and vice versa. Personal computer text files of other formats must be converted to Xerox 8010 (Star) format or 860 format at an 8010 (Star) workstation before the text file can be displayed at a Xerox workstation for enhanced formatting. Such text conversion is possible due to the text converter capability of the 8010 (Star) workstation.

Perhaps the most significant resource available to the personal computer through XFILE is the access of disk storage from the network file servers. Such access permits the personal computer user to store a great number of personal computer programs and/or text files on one or more network file service disk packs and later access the files from his personal computer using the XFILE software. Thus the personal computer user's file storage capacity is increased many times over. Another capablity available to the personal computer as a user of the network File Service is the Remote Batch Service, designed for the interchange of information with IBM mainframes.

With just a single command string, the XPRINT software permits the personal computer user to print MS-DOS files on high quality Xerox laser printers with the ability to select a variety of printing specifications. XPRINT software translates MS-DOS files into an Interpress master, a file written using the Interpress™ Electronic Printing Standard which is supported by all XNS printing equipment (Xerox 1984a). The Interpress master defines the digital representation of a file which the network print service is to print. Software features include the ability to select a particular font, line size, paper size, copy count, portrait/landscape paper orientation, and the optional retention of the Interpress master on local personal computer disk. Printing specifications may be selected two ways. The XPRINT user may specify the choice(s) on the XPRINT command line from which the software will match the command line argument

with the corresponding item in the user profile file, or specific selections may be entered with an appropriate DOS Set command prior to the execution of the XPRINT command. Figure 3 illustrates Xerox laser printing capabilities for Wordstar text files.

Text composed using the WORDSTAR editor
as printed on the Ethernet Xerox printer.

**SPECIAL PRINTING CAPABILITIES INCLUDE:**

**This line is in boldface.**

*This line is written in italic print.*

***This line is written in bold italic print.***

This line is underscored.

~~This line is written in strikeout characters.~~

This line contains a superscript as in ($x^2$).

This line contains a subscript as in $H_2O$.

This line contains an overprint character as in Renè

In this line, the printer switches from the normal
12-pitch setting,

then toggled to 24-pitch,

then back to normal.

**This line is 24-pitch**
**Underscored & in boldface.**

**Fig. 3. Text Composed Using the Wordstar Editor, as Printed on the Ethernet Laser Printer**

Using XMAIL the personal computer user can communicate, by way of high speed electronic mail, to any registered network user. Plaintext messages can be created, edited, saved, and mailed. Incoming mail messages are stored in a local mail folder and may be displayed and/or printed by the personal computer if in a PC-compatible format. Messages may then be deleted, copied, forwarded, or replied to. Attachments (files) may be sent with mail messages originating from the personal computer. Messages containing text which cannot be dislayed at the personal computer are distinguished for the user. Such messages must be viewed from a Xerox workstation.

A soon-to-be-released fourth software package, XTERM, will provide standard communications support for Internetwork Routing Service and the ECS, permitting access to resources anywhere on the internetwork (two or more networks may be "networked" together). With this terminal emulation package, networked personal computers will be able to communicate directly with networked Digital Equipment Corporation (DEC) mainframes and access services anywhere on the internetwork just as Xerox workstations currently can. This terminal emulation option is to support VT100 mode, VT52 mode (for emulation of respective DEC terminals), and ASCII TTY terminal emulation.

The current cost of the Ethernet board and the accompanying software is approximately $800 (excluding the XTERM package). When an external transceiver is used, as is currently the case at NSA due to the lack of a TEMPTESTed version of the Thin Ethernet cable, one must also include the cost of an external transceiver and standard Ethernet drop cable, for a total of approximately $1500. Compared to the $29,000 price tag for a 42MB 8014 (TEMPESTed Star) workstation, the cost of an IBM PC XT connection to the Ethernet would be money well spent in those areas where the high cost Star workstations could be shared by office personnel desiring its enhanced graphics, mathematics, and formatting capabilities. Thus, much of a person's work could be performed at his more affordable personal computer, with the same high quality finished product/report resulting as if the entire report generation process took place at an 8010 (Star) workstation.

## 7. CONCLUSION

While the newly announced direct connection the the Ethernet affords the personal computer user access to the greatest variety of network services, each of the three types of connections for the personal computer offers a useful range of services well beyond its innate capabilities (table 2). Note that although the optional terminal emulation package for the direct connection to the Ethernet coaxial cable does not currently support IBM 3270 emulation, neither of the other two connections is capable of permitting the IBM PC XT such access.

**Table 2. IBM PC XT – Ethernet Connections**

| | Direct Coaxial Connection | 873 Connection | 8000 Port Connection |
|---|---|---|---|
| **Connection Cost** | $800 or $1500 | $1250 per 4 ports* | $0* |
| **Capability** | Access to network file services, mail services, print services; Optional terminal emulation capability | Access to network file services and mail services; Remote system administration capability | Access to network file services and mail services; Remote system administration capability |
| **Limitations** | Optional terminal emulation package does not yet provide for IBM 3270 emulation | No Access to Xerox Print Service; No TTY or 3270 Emulation Capability; Restriction on line speed for multiple ports per board | No Access to Xerox Print Service; No TTY or 3270 Emulation Capability |
| **Best Use** | Offices that include PCs and Xerox workstations in a technical or programming environment | Offices that include PCs and Xerox workstations in an administrative and/or report generating environment | Since other connections require the use of this port, such a connection for the PC is *Not Recommended* |

**Note: One must also assume $15,000 cost for TEMPESTed 10mb communications processor running ECS.*

The increasing number of IMB PC XTs at NSA could tap into the wealth of resources available to office personnel from the XNS Ethernet environment to provide a cost efficient system of office communication, document processing, and peripheral sharing. Additionally, one should not ignore the future possibility of tapping into the Star's internal processing power when the now turn-key system becomes user programmable. A personal computer connection in that case could provide a most enviable situation for the personal computer user: personal computer convenience combined with access to a potentially powerful distributed computing environment (Mock 1984).

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