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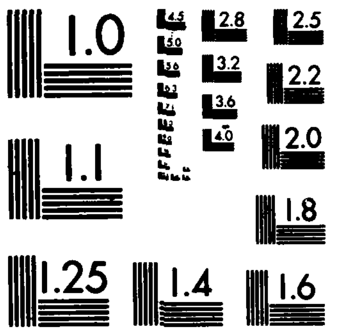

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NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

A LAYERED COMMUNICATION SYSTEM FOR ETHERNET

by

Mark D. Stotzer

September 1983

Thesis Advisor: U. R. Kodres

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This thesis presents a set of hierarchical program modules written for use on any INTELLEC MDS microcomputer development system, running the CP/M-80 operating system, to allow the

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A Layered Communication System for Ethernet

by

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Captain, United States Marine Corps
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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

Connecting heterogenous computer systems via local area networks presents a challenge to software designers for the development of effective, reliable, and modifiable network communication software.

This thesis presents a set of hierarchical program modules written for use on any INTELLEC MDS microcomputer development system, running the CP/M-80 operating system, to allow the system to become part of an Ethernet local area network. These program modules were written to not only obey the principles of software engineering, but to also reflect the same functional hierarchy as the International Standards Organization Open System Interconnection (ISO OSI) architectural reference model for computer networks.

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I. INTRODUCTION

A. DISCLAIMER

Many terms used in this thesis are registered trademarks of commercial products. Rather than attempt to cite each individual occurrence of a trademark, all registered trade marks appearing in this thesis are listed below following the firm holding the trademark:

Digital Research Incorporated, Pacific Grove, California

- CP/M-80 Operating System
- CP/M-86 Operating System
- PL/I-80 Programming Language
- PL/I-86 Programming Language
- LINK-80 Linking Utility
- XLT-86 Code Conversion Utility

Intel Corporation, Santa Clara, California

- INTELLEC MDS Microcomputer Development System
- Multibus Bus Architecture
- 8080/8086 Microprocessors
- 8080 Assembly Language Programming Language
- ISIS-II Operating System
- IAPX-432 Development System

Digital Equipment Corporation, Maynard, Massachusetts

- VAX 11/780 Minicomputer

VAX/VMS Operating System

Interlan Corporation, Chelmsford, Massachusetts

NI3010 Ethernet Controller Board

Xerox Corporation, Stamford, Connecticut

Ethernet Local Area Network

B. BACKGROUND

The connection of heterogeneous computer systems via some form of network, to perform various data processing tasks where data or resource sharing is important, is an extremely active topic for both hardware and software designers.

The International Standards Organization Open System Interconnection (ISO OSI) architectural refererce model provides the general framework in which computer network systems are designed to operate. This seven-layered, hierarchical description of functions was developed to provide a vehicle for the later development of a set of specific network protocols. The hierarchical nature of this model compares favorably with the techniques of hierarchical, structured design of software that are being taught and implemented today. The logical conclusion of the above comparison is to use the functionally layered framework provided by the ISO OSI model as a guide for deciding how to modularize the communication software necessary to allow host computers to be connected via a network.

C. PURPOSE

The main purpose of this thesis is to construct a software interface to the CP/M-80 operating system so that files and messages can be transported between various host systems via a Local Area Network. The structuring of this software, to reflect the layers of the ISO model, allows modifications to the network software to be more easily made.

This thesis presents a set of PL/I-80 and Intel 8080 Assembly Language modules that, when linked together, allow INTELLEC MDS users to communicate via an Ethernet Local Area Network. The complete set of software developed also includes two programs that can be used to troubleshoot or test the Ethernet hardware. The communication program allows INTELLEC MDS computers connected to the network to:

1. Send messages or files to other hosts.
2. Receive messages or files from other hosts.
3. Become a terminal of the VAX 11/780.
4. Command file transfers to or from the VAX.

Additionally, the communication software will provide faster data transfers between host machines than the direct host-to-host serial communications methods currently used.

This thesis is divided into four chapters. Chapter II discusses computer networks in general. The Ethernet is presented as a specific example of a Local Area Network. The Interlan hardware is also discussed as an implementation of the Ethernet. Chapter III deals with the details of the

Ethernet communications software. The topological, hardware, software and performance issues are presented in detail. Chapter IV presents the conclusions drawn from the network realization and discusses possible areas of future growth and performance enhancement.

II. COMPUTER NETWORKS

A. DEFINITION

Computer networks are defined to be collections of interconnected, autonomous computers. A computer network can also be a grouping in which the required processing functions are dispersed among several of the attached hosts. [Ref. 1: p. 2]

Computer networks are classified by their length. Networks whose attached hosts are farther than a few kilometers apart are considered Long Haul, while shorter networks are considered Local Area. Networks are also classified by the nature of the hosts connected to them. Homogeneous networks consist of like hosts, while heterogeneous networks consist of dissimilar hosts.

B. PURPOSE

The main reason that the subject of computer networking has rapidly achieved prominence is that networking provides a workable solution to data processing problems where the sharing of data or other resources is important. Networking can also enhance the fault tolerance of an activity's computational assets. Loss of any host, connected to most Local Area networks, would not affect either the other hosts or the network itself. [Ref. 1: pp. 3-4]

Current trends seem to point to the merging of personal computers with Local Networking to form what one author calls "community microcomputing" [Ref. 2: p. 60]. This refers to the interconnection, via a Local Area Network, of a set of microcomputers that may, as a networked group, enhance the price/performance ratio for the using activity when compared to installing a single, large mainframe computer [Ref. 1: p. 5].

C. THEORY

The most generally accepted model of computer network architecture is the International Standards Organization Open Systems Interconnection Model (ISO OSI) model. This model is a set of hierarchical functions and protocols that are necessary to allow computers to communicate via a network. The seven layers and their definitions are listed below: [Ref. 1: pp. 15-21]

1. Physical Layer - This layer provides the actual connection between hosts. It provides the bit stream transmission across the network medium.

2. Data Link Layer - This layer performs error detection and correction, address recognition and flow control. This layer also provides data framing if necessary.

3. Network Layer - The network layer provides logical channels between two endpoints in a network. This layer forms the data into packets for transmission.

4. Transport Layer - The transport layer provides the network with single, group, or broadcast addressing modes and sets up virtual circuits between hosts.

5. Session Layer - This layer contains the functions necessary to perform address conversion. This layer

initiates, binds, and terminates the dialogue between hosts.

6. Presentation Layer - The presentation layer is mainly concerned with converting and transforming the data passed to a user. This layer also contains the file transfer and virtual protocols.

7. Application Layer - The application layer, the highest in the model, is where the user interface to all the network services resides. The lower layers exist only to support this layer.

Many computer networks with layered protocols exist, but their layers may not match the ISO model exactly because some of the ISO functions may not be necessary. The development of the model came about due to the need to standardize network description. The main factors that motivated the designers were: [Ref. 1: p. 15]

1. To create a layer where abstraction was necessary.
2. To give each layer a well defined function.
3. To keep the information passed between layers to a minimum.
4. To create only a minimum number of layers to decrease complexity.

The above design principles are the same as the software engineering principles of abstraction and modularity. The hierarchical structure also compares favorably with the structured programming techniques of software design that are currently being advocated. [Ref. 4: pp. 58-60]

The ISO OSI model is shown in Figure 2.1. The main concepts of the model are: [Ref. 8: pp. 28-29]

1. Each layer only interacts with the vertically adjacent layers through well defined interfaces.

Changes to any layer can thus be accomplished without changing the other layers.

2. Two basic protocols exist per layer. The first is the vertical protocol between layers. The second is the horizontal or peer protocol between transmitting and receiving layers of different hosts that allows virtual communication to occur between those hosts.

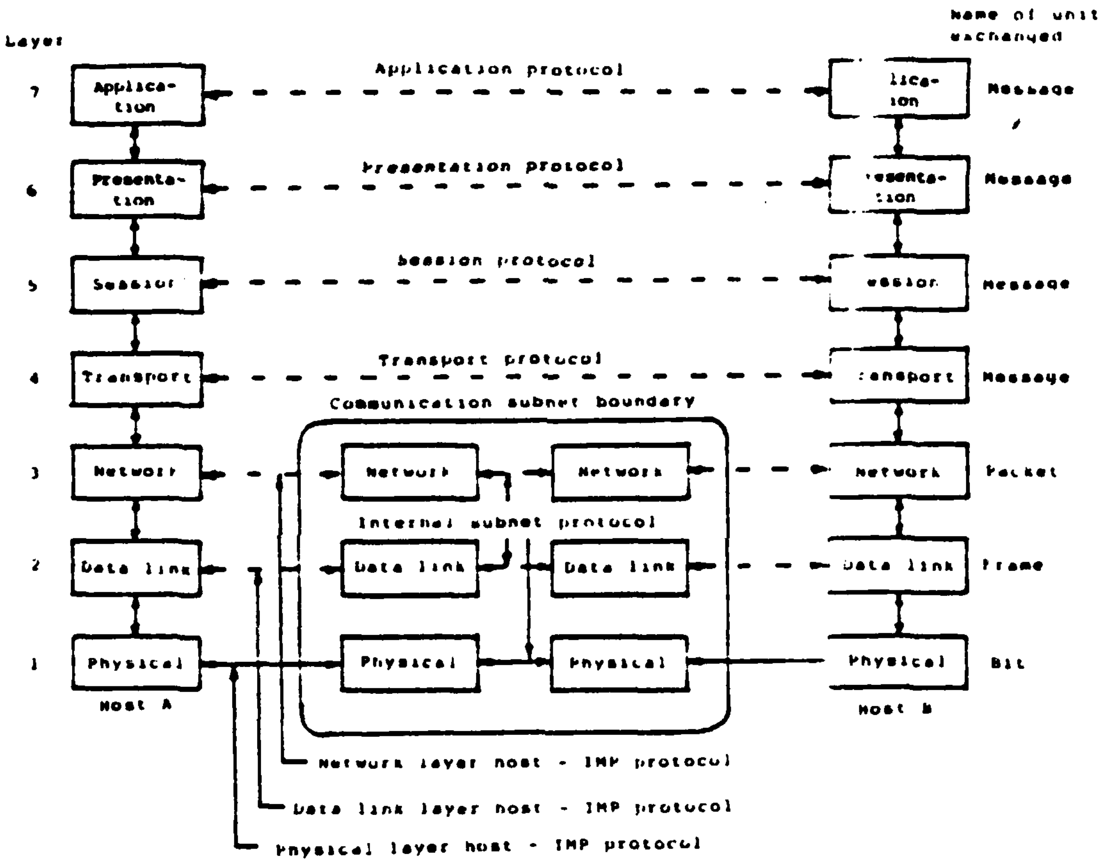

Figure 2.1 ISO Reference Model

The flow of data in the network model begins at the top layer of the sending host. As the data is passed down the sending host's layers additional information, either bits or bytes, is added to the original data until the lowest layer is reached. At the lowest layer, the data and added information is sent on the network medium. The receiving host then performs the reverse process on the received information by passing it up the ISO layers until all that remains, after again reaching the top layer, is the original data.

D. LOCAL AREA NETWORKS

Computer networks, as previously mentioned, are classified as either Long Haul or Local Area. Local Area networks are characterized by: [Ref. 1: p. 286]

1. A length of no greater than a few kilometers.
2. A data rate in excess of one million bits per second (1 Mbps).
3. Ownership by a single organization.

Two techniques of transmission medium access are being considered for standardization by the Institute of Electrical and Electronic Engineers (IEEE). The proposed IEEE Standard 802 endorses both the token passing and carrier sense methods of Local Area Network medium access. Token passing consists of not allowing any host on the local network to transmit on the medium unless it has possession of a token that is passed in a predetermined order from one host to another. The carrier sense method allows each host equal access to the network. This scheme allows each host to detect the occurrence of any other transmissions on the network and allows the host to wait until the medium is clear before transmitting. If two hosts try to transmit simultaneously, they will each detect the collision and wait an independent, random interval before attempting another transmission. Ethernet is an example of a carrier sense network. [Ref. 5: p. 31]

E. ETHERNET

Specific details of Ethernet Standard - Version 1.0 are: [Ref. 6: p. 1]

1. A data rate of 10 Megabits per second (10Mbps).
2. A maximum host separation of 2.5 kilometers.
3. A transmission medium consisting of a shielded coaxial cable.
4. A topology consisting of an unrooted tree.
5. Link control via fully distributed peer protocol with statistical contention resolution.
6. A message protocol of variable size frames.

Additionally, it must be noted that the Ethernet Standard does not provide for either error correction, data encryption, or priority access to the network medium. At any point in time, only one transmission can occupy the medium. [Ref. 6: p. 5]

One current implementation of an Ethernet network is the E-BUS system developed by E-Systems Incorporated. The E-BUS implementation differs from the Ethernet Standard in that it provides for transmitted frames to be acknowledged. The E-BUS also provides multiple coaxial cables to increase both the effective bandwidth and the overall fault tolerance of the network. [Ref. 10: pp. 77-78]

III. NETWORK IMPLEMENTATION

A. TOPOLOGY

The Ethernet Local Area Network implemented at the Computer Science Department of the Naval Postgraduate School consists of three connected systems:

1. The VAX 11/780 (VMS operating system) minicomputer.
2. An INTELLEC MDS system (CP/M-80 operating system), with attached double density disk drives, that functions as the input/output processor for the Intel IAPX 432 32 bit microcomputer system.
3. A second INTELLEC MDS system with attached single density disk drives. (Also CP/M-80)

This thesis presents the software necessary to allow the above CP/M-80 based systems to communicate via the network. The software necessary to allow the VAX 11/780 the same communication capabilities was written by Lt. Thawip Netniyom [Ref. 9].

B. HARDWARE

All the hardware needed to implement the above network was provided by the Interlan Corporation. The hardware needed to connect each INTELLEC system to the network was installed as follows: [Ref. 7: pp. 7-13]

1. The base port address switches and the priority and interrupt jumpers were set on the NI3010 Ethernet controller board as shown in Figure 3.1.
2. The NI3010 was then inserted into the INTELLEC system in an odd-numbered slot in the Multibus.

3. The NT10 transceiver was installed across the Ethernet coaxial cable and the cabling that connects the NT10 to the NI3010 was connected as shown in Figure 3.2.

The above mentioned hardware provides the ISO layer one and two functions. The Physical Layer functions provided by the transceivers and connecting cables are: [Ref. 7: p. 2]

1. Support of a 10 Mbps data rate.
2. Bit stream generation through Manchester encoding.
3. Media access control.

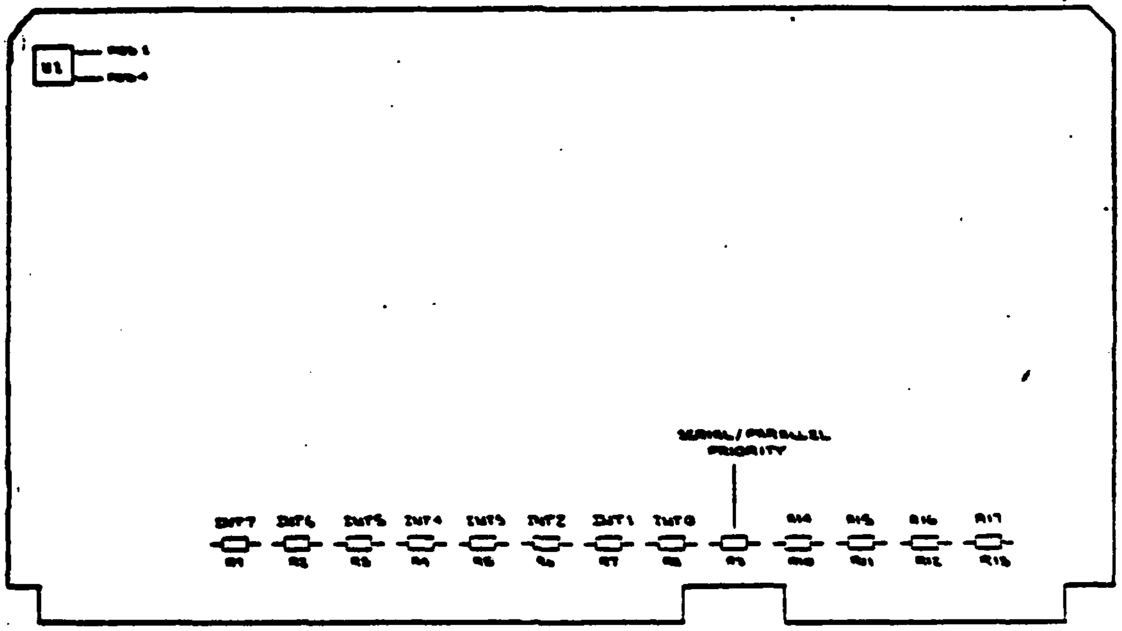

Figure 3.1 NI3010 Switch and Jumper Locations

The Data Link Layer functions provided by the NI3010 board are: [Ref. 7: p. 2]

1. Data encapsulation/decapsulation (framing).
2. Address recognition.
3. Transmit and receive data link management.

The NI3010 operates both as a slave to the host computer and as a master processor when controlling the direct memory access (DMA) operations between the NI3010 buffers and the host computer's memory. The transmit function is command driven by the host, while the receive function is interrupt driven. Control of the NI3010 by the host is accomplished by programming the host to load commands, addresses, byte counts and interrupt enable values into registers onboard the NI3010. [Ref. 7: pp. 69-75]

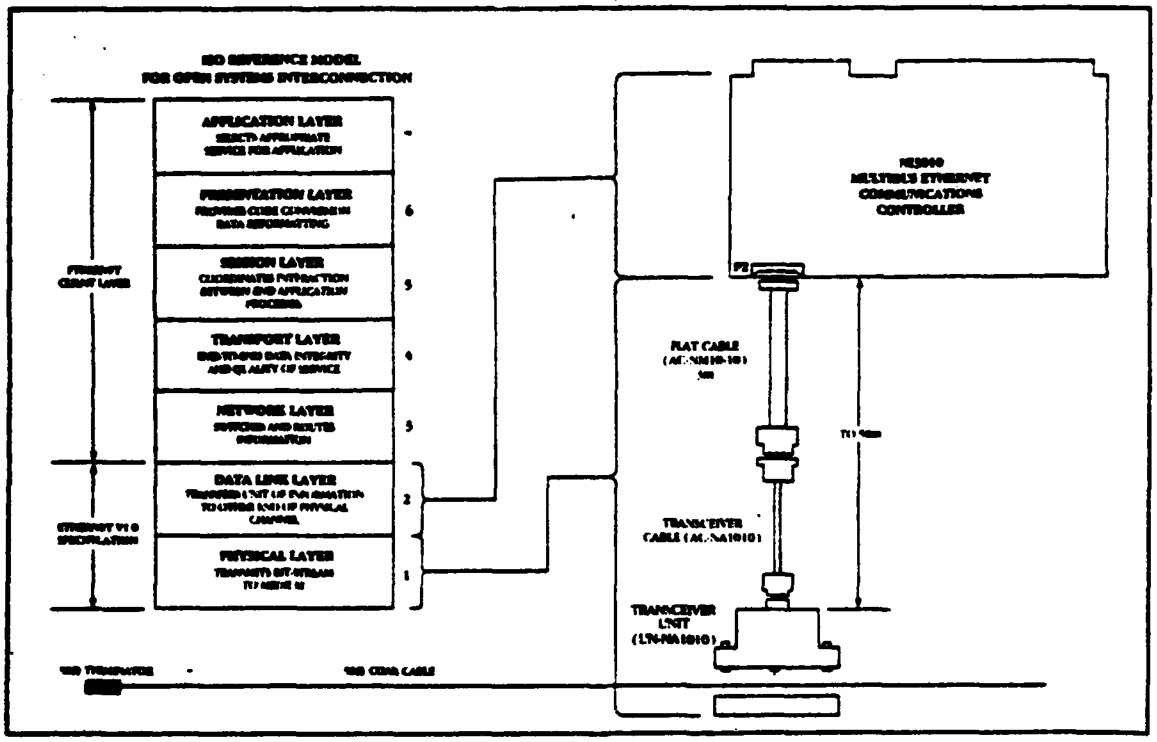

Figure 3.2 Ethernet Architecture and NI3010 Implementation

A complete list of NI3010 commands is located in Appendix A. A table of the NI3010 registers can be found in

Appendix B. After issuance of any command, the host must check for a value in the Command Status Register. The execution of the command only occurs after this read operation has been accomplished. The details of the read operation are as follows: [Ref. 7: pp. 70-72]

1. The host issues a command.

2. The host checks the Interrupt Status Register to check if the least significant bit is a one. If the least significant bit is a one, then the host reads the value in the Command Status Register.

3. If the value in the Command Status Register is a zero then the command executed successfully. After the host has issued a Load, Transmit, and Send command, a value of one is also considered a success. Any other value represents a failure. A listing of Command Status Register values is located in Appendix C.

The Command Status Register must also be read at the beginning of any program written to control the NI3010. This register must be read at this time because the NI3010 automatically performs it's built-in diagnostic routines each time the board is powered up or reset. The automatic testing places a value in the Command Status Register that must be read to clear the register before any other commands can be given to the NI3010.

The NI3010 transmit function is accomplished in the following manner: [Ref. 7: p. 85]

1. The host loads a block of memory in the format shown in Appendix D for each frame to be transmitted.

2. The host loads the three NI3010 address registers with the first address of the host memory block.

3. The host then loads the two NI3010 byte count registers with the number of bytes in the data block.

4. The host then enables a Transmit DMA Done (TDD) interrupt by writing a value of 6 Hex into the Interrupt Enable Register.

5. The NI3010 interrupts the host once the memory block has been transferred into the NI3010 transmit buffer.

6. The host then enables a Receive Block Available (RBA) interrupt by loading the Interrupt Enable Register with a value of 4 Hex. This step allows any pending received frames to be handled.

7. The host then commands the NI3010 to send the frame by writing a value of 29 Hex into the Command Register and subsequently reading the Command Status Register as previously discussed.

The NI3010 receive function is accomplished as shown below: [Ref. 7: p.90]

1. The host enables an RBA interrupt as shown above.

2. The NI3010, upon receiving a frame, interrupts the host to notify it of frame receipt.

3. The host then writes a value of 0 Hex into the Interrupt Enable Register to disable any other NI3010 interrupts.

4. The host writes values into the three NI3010 address registers to inform the NI3010 where, in host memory, to transfer the data.

5. The host then loads the two NI3010 byte count registers.

6. The host then enables the DMA transfer of the data by writing a value of 7 Hex into the Interrupt Enable Register.

7. The NI3010 then interrupts the host upon completion of the transfer. The format of received data in the host memory is shown in Appendix E.

The above steps are repeated for each received frame. The host is then responsible for whatever further operations must be done with the data. For example, the data could be displayed on the console or written to a disk file.

The NI3010 also has built-in test features and can also support the concepts of broadcast and multicast transmission. Broadcast transmission allows a host to transmit to all other hosts simultaneously, while multicast allows transmission to only a few selected hosts.

C. SOFTWARE

The software necessary to implement ISO layers three through seven was originally written entirely in 8080 Assembly Language. The final version of the communication program consists of PL/I-80 modules that perform the functions of ISO layers six and seven and an Intel 8080 Assembly Language module that performs the functions of ISO layers two and three. The ISO layer two functions performed by the software supplement the functions of this layer performed by the NI3010. The primary goals of the software were:

1. To allow users to run, if necessary, test programs that will verify the functioning of the hardware.
2. To allow the INTELLEC systems to communicate via the Ehternet to any other hosts connected to the network.

1. Test Programs

The basic software design process began by first determining the major functional divisions or modules into which a program should be divided. A primary consideration, since implementation using the NI3010 is interrupt dependent, was a simple interrupt handling routine. This routine was the basis of the first working test program, ETHTESTA. The interrupt handling module is the basis around which all the succeeding programs were written. ETHTESTA, an 8080 Assembly Language program, commands the NI3010 to perform built-in tests, one of which sends test data to the NI3010 Transmit buffer and back through the NI3010 Receive Data Register. This process is called the NI3010 Module Interface Loopback mode. Use of this test mode does not permit the interrupt handling to be done in the same manner as a normal communication program, nor does this mode allow data to be sent onto the network. The source code listing of ETHTESTA.ASM is located in Appendix F.

A process of gradual enhancement was then applied to upgrade ETHTESTA into a program that utilized the complete interrupt capability as that of a functional communication program. The follow-on test program, ETHTESTB, performs all the tests of ETHTESTA and, additionally, sends a small block of data to itself via the network using the NI3010 Internal Loopback mode. A source code listing of ETHTESTB.ASM can be found in Appendix G.

2. Communication Between Network Hosts

The test programs discussed previously involved the utilization of only one INTELLEC system with installed Ethernet hardware. The next logical step was to again upgrade the software to allow the INTELLEC systems to communicate via the network.

In order to give hosts, especially of different architectures and operating systems, the ability to communicate via a network involves the development of higher level protocols to handle any differences that may arise due to the above factors. Specifically, differences between hosts related to file storage and frame transmission speed are the kind of issues that must be handled by the use of protocols. In an Ethernet network, the nature of each frame sent onto the network must also be encoded so that the receiving host can determine what further operations must be performed on the received frame data.

The primary operating system file storage mismatch in this network implementation occurred between the VAX/VMS and the CP/M-80 operating systems. The VAX stores text files as variable length records by text sentence. The VAX, also, does not explicitly store the carriage return and line feed characters in the record. On the other hand, the CP/M-80 operating system stores all the characters, including the carriage return and line feed, in one long continuous file. This file storage incompatability was resolved by adding format conversion routines to both the VAX and INTELLEC software to convert the data prior to transmission on the network.

A transmission versus reception speed mismatch was discovered in the early testing between the VAX and the INTELLEC systems. The VAX can send data much faster than the INTELLEC systems can receive it. The solution to this problem was to add a "stop-and-wait" [Ref. 1: pp. 143-145] protocol to the ISO layer two functions already performed by the NI3010. This protocol was implemented in software and assures the sending host that the last frame sent was correctly received. This protocol also prevents a faster sender from inundating a slower receiver.

The frame encoding protocol adopted for our network is as shown in Table 3.1. These codes are written into the two Type Field bytes in the transmit data block as shown in Appendix D. The receiving hosts interpret these two bytes, once the data block is in their memory as shown in Appendix E, to determine what operations must be done to the data.

Table 3.1 Type Field Protocol

Type Field		Interpretation at Receiver
Byte 1	Byte 2	
00H	00H	Message frame
00	0F	Last frame of terminal reply
00	FF	Acknowledge frame
0F	00	File transfer-first frame
0F	01	File transfer-middle frame
0F	FF	File transfer-last frame

The other protocol adopted was to use fixed data block sizes per Ethernet frame. The choices available to the user are:

1. 128 Bytes. (Must be used for all file transfers)
2. 256 Bytes.
3. 512 Bytes.
4. 1024 Bytes.
5. 1500 Bytes. (Used in VAX terminal service mode)

A set of programs, written exclusively in 8080 Assembly Language, was first developed to send short, single sentence messages from one INTELLEC system to another using the above protocols. Next, the file transfer modules were developed and tested. Throughout the entire process, close attention was paid to maintaining software modularity that was analogous to the functional modularity of the ISO model. Software modules that compared directly to ISO layers were maintained as separate modules and, whenever possible, rewritten in PL/I-80, a high level language. The final communication program consists of three PL/I-80 modules and one 8080 Assembly Language module. These modules were linked together, using LINK-80, into the final product. The final program, ETHERNET.COM, contains calling sequences that directly reflect the ISO OSI model structure as shown in Table 3.2. The source code for all modules can be found in Appendices H through K. Modules were not written for ISO layers four and five because these layers are primarily concerned with Long Haul network functions that are unneeded by our network. Modules RECEIVE,SENDFRAM,RECFRAM,TRMSG and AWAIT are contained in the assembly language module because the functions they are required to perform are more efficiently programmed in that language. The actual calling sequence for the transmit process occurs as follows:

1. ETHERNET: Asks for user to select type of network service desired and calls SENDATA.

2. SENDATA: Encodes the transmit type field for the user selected service and calls internal routines to control the transmission. This module calls SENDFRAM as each frame is ready for sending.

3. SENDFRAM: This module sends each frame onto the network then calls AWAIT to wait for the acknowledge frame to arrive from the destination host.

Table 3.2 Comparison of Program Modules and the ISO Model

ISO	Transmit			Receive	
LAYER	File	Message	VAX Modes	File	Message
7	ETHERNET.PLI		Same	RECEIVE(ETHER2.ASM)	
6	SENDATA.PLI		Same	RECDATA.PLI	
5	Not Implemented		Same	Not Implemented	
4	Not Implemented		Same	Not Implemented	
3	SENDFRAM(ETHER2)		Same	RECFRAM(ETHER2)	
2	AWAIT(ETHER2)/Hdwe		Same	TRMSG(ETHER2)/Hdwe	
1	NT10 Hardware		Same	Same	Same

The calling sequence for the receive process is in the order shown below:

1. ETHERNET: The user selects the receive mode of network service and this module calls RECEIVE.

2. RECEIVE: This module waits in a loop for the module RECFRAM to receive a frame from the network. Once the receive data is placed in host memory by RECFRAM, a flag is set and RECEIVE calls RECDATA.

3. RECDATA: This module decodes the type field of the received frame and calls internal modules that handle each different type of received data and, as part of this process, calls TRMSG which send the acknowledge frame back to the source.

The four major functions that the final program performs are:

1. Transmission of files or messages to any other network hosts.

2. Reception of files or messages from any other hosts.

3. The ability to become a terminal of the VAX 11/782 via the Ethernet.

4. The ability to send specially coded messages to the VAX to command it to either upload or download files.

D. OPERATION

The operation of test programs, ETHTESTA and ETHTESTB, consists primarily of invoking either program using normal CP/M-80 procedures and following the directions presented by the program. Detailed instructions for use of the test programs can be found in Appendix L.

Operation of the communication program, ETHERNET, also involves invoking the program using normal CP/M-80 procedures and following the menus presented by the program. Detailed operating instructions for the use of the final communication program are located in Appendix M.

E. PERFORMANCE

The communication program provides faster data transfer between network hosts than currently employed methods. Table 3.3 demonstrates the improved performance realized in transferring data between single and double density INTELLEC systems.

TABLE 3.3 Performance Comparison for Data Transfers Between Single and Double Density INTELLEC Systems

Software Used (CP/M-80)	File Size (KBytes)	Time (Min:Sec)	Data Rate(bps) Medium	Effective
SDXFER	136	22:45	9600	797
ETHERNET	136	3:30	10M	5180

The data rate of the medium is the rate at which data is actually sent on whatever medium is being utilized. The effective data rate is the number of bits of useful data that was sent divided by the total elapsed time of the data transfer. Data transfers between INTELLEC systems were not the only ones that showed a significant improvement over methods that were previously utilized. Transfers of data to and from the VAX 11/780 were also accomplished significantly faster as shown in Table 3.4.

The below presented data shows the improved performance of data transfers when the Ethernet network is employed. Lastly, a series of experiments was performed to investigate the performance limits of data transmission and reception of the CP/M-80 based programs. The conditions of the

Table 3.4 Performance Comparison of Transfers Between VAX 11/780 and INTELLEC Systems

Software Utilized (VAX to INTELLEC)	File Size (KBytes)	Time (Min:Sec)	Data Rate(bps) Medium	Effective
IAPX 432 Pkg	136	6:40	9600	2720
ETHERNET (To disk file)	136	2:05	10M	8704
ETHERNET (To memory buffer)	136	1:35	10M	11452

experiments were:

1. The stop-and-wait protocol was not employed.
2. The frames would be sent as fast as possible using the minimum amount of 8080 Assembly Language code.
3. The receiver would not perform any extra operations on received data other than that done by the NI3010. No data was either written to any disk files or displayed on the console.
4. Testing was done on data block sizes of 128 and 1500 bytes per ETHERNET frame.

Testing was performed between two INTELLEC systems and and data was collected for both the above data block sizes. The results of the experiments are shown in Table 3.5.

As shown below, the highest data rate achieved was 1.764 Megabits per second. The time taken in each 6.8 millisecond period was accounted for as follows:

1.2 msec Actual Data Transmission of 1500 Bytes

0.5 msec	Instruction Execution to Restart Transmit
3.5 msec	DMA Operation of 1500 Bytes at 428 KBps rate
1.6 msec	Execution Time of NI3010 Send Command

6.8 milliseconds total

Table 3.5 Maximum Performance Data

Data Bytes per Frame	Frame Transmission Interval	Data Rate (Effective)
128	2.7 Milliseconds	379 Kbps
1500	6.8 Milliseconds	1.764 Mbps

The conclusions reached about the Ethernet performance were:

1. The transmission speed is limited by the NI3010 controller itself. The NI3010 Send command required longer to execute than either the actual transmission time of the data or the instruction execution during each transmit cycle.

2. Although the NI3010 literature claims a DMA data rate of 1 MBps, the board could only achieve a rate of 428 KBps. This limitation could be due to the method in which the NI3010 onboard microprocessor is utilized.

IV. CONCLUSIONS

This thesis has shown that functional Local Area Network communication software can be structured according to the ISO OSI network model. This thesis has also shown that the performance of the Ethernet substantially reduces the transfer time of data between connected hosts when compared to methods previously employed. The single to double density transfer rate improved by a factor of 7.5 while the VAX to INTELLEC transfer rate improved by a factor of 3.2. The data also shows that effective data rates can be improved by faster host processors, but that hosts will be limited by the rate at which the NI3010 can transfer data to and from host memory and then send it. INTELLEC hosts are also limited in actual network use by the rate at which data can written to or read from disk drives.

An improvement to the effective data transmission rate might be realized by synchronizing the speed between sending and receiving hosts by some method other than the stop-and-wait protocol utilized in this thesis. The transmission rate performance degradation noted above is only aggravated by using the stop-and-wait protocol.

The software written for this thesis can be adapted to run on an Intel 8086 based system by following the steps listed below:

1. The PL/I-80 source code files can be directly compiled using the PL/I-86 compiler.

2. The 8080 Assembly Language source code can either be hand-translated or translated by software such as the program XLT-86 into 8086 Assembly Language source code. It should be noted that there are differences between the 8080 and 8086 processors that have to do with how interrupts are handled that will require some rewriting of the converted code.

APPENDIX A

NI3010 COMMAND LISTING

Code(Hex)	Command Function	Returned Code(Hex)
01	Set Module Interface Loopback	00
02	Set Internal Loopback	00
03	Clear Loopback	00
04	Set Promiscuous Mode	00
05	Clear Promiscuous Mode	00
06	Set Receive on Error Mode	00
07	Clear Receive on Error Mode	00
08	Go Offline	00
09	Go Online	00
0A	Run Onboard Diagnostics	Diagnostic Codes as shown in Appendix C
18	Report/Reset Statistics	00
19	Report Collision Delays	00
28	Load Transmit Data	00,05
29	Load/Transmit/Send Data	00,01,03,05,06,08,0B
2A	Load Group Addresses	00,05,0A
2B	Delete Group Addresses	00,05,0A
3F	Reset	00

Notes: Promiscuous Mode receives all network traffic.
Receive on Error receives even bad frames.

APPENDIX B

NI3010 REGISTER LISTING

Register	Location
Command	Base Port Address
Status(Command)	Base Port Address+ 01H
Transmit Data	Base Port Address+ 02H
Receive Data	Base Port Address+ 03H
Status(Interrupt)	Base Port Address+ 05H
Interrupt Enable	Base Port Address+ 08H
Extended Bus Address	Base Port Address+ 09H
High Bus Address	Base Port Address+ 0AH
Low Bus Address	Base Port Address+ 0BH
High Byte Count	Base Port Address+ 0CH
Low Bus Address	Base Port Address+ 0DH

Note: The base port address is set on the DIP switch onboard the NI3010.

APPENDIX C

NI3010 STATUS REGISTER CODES

1. Normal Mode:

Code(Hex)	Command Status Result
00	Success
01	Success with Retries
02	Illegal Command
03	Inappropriate Command
04	Failure
05	Buffer Too Large
06	Frame Too Small
08	Excessive Collisions
0A	Buffer Alignment Error

2. Diagnostic Mode:

Code(Hex)	Returned Diagnostic Result
00	Success
01	NM10 Microprocessor Memory Checksum Error
02	NM10 DMA Error
03	Transmitter Error
04	Receiver Error
05	Loopback Failure

APPENDIX D

TRANSMIT DATA FORMAT

	7	Ø
BAR+ Ø	Destination Address A.	(Byte 1)
+ 1	Destination Address B.	(Byte 2)
+ 2	Dest. Addr. C.	(Byte 3)
+ 3	Dest. Addr. D.	(Byte 4)
+ 4	Dest. Addr. E.	(Byte 5)
+ 5	Dest. Addr. F.	(Byte 6)
+ 6	Type Field <7:Ø>	(Byte 1)
+ 7	Type Field <15:8>	(Byte 2)
+ 8	Data-First Byte	
	. . . .	
BAR+BCR-1	Data-Last Byte	

APPENDIX E

RECEIVE DATA FORMAT

	7	0
BAR+ Ø	Frame Status	
+ 1	Always Ø	
+ 2	Frame Length <7:Ø>	
+ 3	Frame Length <15:8>	
+4-9	Destination Address(6 Bytes)	
+1Ø-15	Source Address (6 Bytes)	
+16	Type Field <7:Ø>	
+17	Type Field <15:8>	
+18	Data-First Byte	
	. . .	
	Data-Last Byte	
	CRC <24:31>	
	CRC <16:23>	
	CRC <8:15>	
BAR+FRLTH+3	CRC <Ø:7>	
	~ ~	
BAR+BCR-1		

Note: Frame length is counted from first destination address byte up to and including the last CRC byte consecutively.

APPENDIX F

SOURCE CODE OF PROGRAM ETHTESTA.ASM

```
;**************************************************************
;**************************************************************
;  ETHERNET LEVEL ONE TEST PROGRAM--VERSION  1.13
;
;PROGRAM FILE NAME: ETHTESTA.COM- INVOKE COMMAND: ETHTESTA
;
;PROGRAM FUNCTION:(RUN CN 8080 BASED MDS SYSTEM)
;COMMANDS THE NI3010 BOARD TO GO ONLINE,PERFORM ITS'
;DIAGNOSTIC TESTS THEN TRANSFERS A 42 BYTE DATA BLOCK FROM
;ADDRESS 0608 HEX TO ADDRESS 0812 HEX VIA THE MODULE INTER-
;FACE LOOPBACK MODE.  TRANSFERRED DATA IS THEN DISLPAYED ON
;THE CONSOLE.  THESE TESTS ONLY REQUIRE THE NI3010 BOARD.
;THE CABLE TO THE TRANSCEIVER NEED NOT BE CONNECTED.
;
;TESTS PERFORMED:
;              1.) ONBOARD DIAGNOSTIC SELF TEST
;              2.) MODULE INTERFACE LOOPBACK TEST-VERIFIES THE
;                  FUNCTION OF THE NI3010 LESS THE RECEIVE
;                  BUFFER.
;
;NI3010 ETHERNET BOARD CONFIGURATION:
;                    1.) JUMPER SET TO INTERRUPT LEVEL 5
;                    2.) BASE PORT ADDRESS SWITCHES SET TO
;                        1011 (00B0H).
;                    3.) PARALLEL PRIORITY TO AN ODD NUMBERED
;                        MULTIBUS SLCT.
;
;ORIGINAL PROGRAM: 03/10/83
;
;LAST REVISION: 04/30/83
;
;WRITER: MARK D. STOTZER
;
;ADVISOR: PROF. U.R. KODRES
;
;**************************************************************
;**************************************************************
;MAIN PROGRAM:
          CRG     100H
; NI3010 REGISTER PORT ADDRESSES:
CREG      EQU     00B0H;CMD REG LOCATION
SREG      EQU     00B1H;CMD STATUS REG LOCATION
ISREG     EQU     00B5H;INTERRUPT STATUS REG
```

```
IEREG       EQU     00B8H;INTERRUPT ENABLE REG
EBAR        EQU     00B9H;EXTENDED BASE ADDR REG
HBAR        EQU     00BAH;HIGH BASE ADDR REG
LBAR        EQU     00BBH;LOW BASE ADDR REG
HBREG       EQU     00BCH;HIGH BYTE COUNT REG
LBREG       EQU     00BDH;LOW BYTE COUNT REG
;*****************************************************
;OTHER NEEDED ADDRESSES:
BDOS        EQU     0005H;BDOS ENTRY POINT
CEREG       EQU     0700H;COPY OF INTERRUPT ENABLE REG
LASTM       EQU     0900H;ADDR OF INIT STACK PTR
;*****************************************************
;NEEDED BDOS COMMANDS:
CONSIN      EQU     01H;CONSOLE CHAR INPUT
CONSOUT     EQU     02H;CONSOLE CHAR OUTPUT
PSTRING     EQU     09H;PRINT TEXT STRING
;*****************************************************
;CLEAR COMMAND STATUS REGISTER BY READING
            IN      SREG
;*****************************************************
;LOAD JUMP INSTRUCTION FOR INTERRUPT HANDLER: (INT 5)
            MVI     A,0C3H;JMP INST CODE
            STA     0028H :LOAD IT IN ADDR 0028 HEX
            LXI     H,INTHDL
            SHLD    0029H
;*****************************************************
;OUTPUT INITIAL MESSAGE:
            LXI     D,BMSG
            MVI     C,PSTRING
            CALL    BDOS
            CALL    CRLF
;SET UP INTERRUPT CONTROL:
            MVI     A,012H
            OUT     0FDH
            MVI     A,0DFH; ENABLE INTERRUPT 5-ETHERNET BOARD
            OUT     0FCH
;*****************************************************
;LOAD TRANSMIT DATA BLOCK-FIRST 3 BYTES ASSIGNED BY XEROX:
            MVI     A,02H
            STA     0600H
            MVI     A,07H
            STA     0601H
            MVI     A,01H
            STA     0602H
;LOAD INTERLAN ASSIGNED LAST 3 BYTES HERE:
DESTINP     CALL    CRLF
            LXI     D,DMSG0
            MVI     C,PSTRING
            CALL    BDOS
            CALL    CRLF
            LXI     D,DMSG1
```

```
                MVI     C,PSTRING
                CALL    BDOS
                CALL    CRLF
                LXI     D,DMSG2
                MVI     C,PSTRING
                CALL    BDOS
                CALL    CRLF
                MVI     C,CONSIN;READY FOR CHOICE
                CALL    BDOS
                CPI     31H
                JZ      DADDR2
                CPI     32H
                JZ      DADDR1
                CALL    CRLF
                LXI     D,DMSG3
                MVI     C,PSTRING
                CALL    BDOS
                CALL    CRLF
                JMP     DESTINP
DADDR1          CALL    CRLF ;IF ADDR 00-03-EA SELECTED LOAD IT:
                MVI     A,00H
                STA     0603H
                MVI     A,03H
                STA     0604H
                MVI     A,0EAH
                STA     0605H
                JMP     ADDIN
DADDR2          CALL    CRLF ;IF ADDR 00-04-0A SELECTED LOAD IT:
                MVI     A,00H
                STA     0603H
                MVI     A,04H
                STA     0604H
                MVI     A,0AH
                STA     0605H
;LOAD TYPE FIELD- 2 BYTES:
ADDIN           MVI     A,00H
                STA     0606H
                MVI     A,00H
                STA     0607H
;NOTE:FOR THIS TEST THE ACTUAL DATA IS IN ADDRESSES
;0608-0632HEX FOR TRANSMISSION
;*************************************************************
;READ IN THE TEST DATA:
                MVI     C,PSTRING
                LXI     D,FMSG
                CALL    BDOS
                CALL    CRLF
                CALL    CONIN
                CALL    CRLF
;GO ONLINE UPON POWER UP:
                LXI     SP,LASTM
```

```
          EI
          MVI     A,09H;CMD TO GO ONLINE
          OUT     CREG
          LXI     D,OLMSG
          MVI     C,PSTRING
          CALL    BDOS
          CALL    CRLF
          CALL    READ
;RUN ONBOARD DIAGNOSTICS TEST:
          MVI     A,0AH; CODE FOR SELF TEST COMMAND
          OUT     CREG
          LXI     D,STMSG
          MVI     C,PSTRING
          CALL    BDOS
          CALL    CRLF
          CALL    READ
;RUN MODULE INTERFACE LOOPBACK TEST:
          MVI     A,09H; GO BACK ONLINE
          OUT     CREG
          LXI     D,OLMSG
          MVI     C,PSTRING
          CALL    BDOS
          CALL    CRLF
          CALL    READ
;LOAD INTERRUPT ENABLE REGISTER=4. SET TO RECEIVE DATA.
          DI
          LXI     H,CEREG
          MVI     A,04H
          MOV     M,A
          OUT     IEREG
          EI
;RUN COMPLETE MODULE LOOP TEST:
          MVI     A,01H; ENTER MODULE LOOP TEST MODE
          OUT     CREG
          LXI     D,MLMSG
          MVI     C,PSTRING
          CALL    BDOS
          CALL    CRLF
          CALL    READ
          CALL    TRMSG;TRANSMIT TEST DATA BLOCK
          LXI     D,TRCMSG
          MVI     C,PSTRING
          CALL    BDOS
          CALL    CRLF
          CALL    READ
;****************** TEST ONLY-MODULE LOOPBACK **************
; THIS PATCH ENABLES DATA TRANSFER TO HOST MEMORY IN TEST
          DI
          MVI     A,07H
          LXI     H,CEREG
          MOV     M,A
```

```
                OUT     IEREG
                EI
;*********************************************************
                MVI     A,03H;CLEAR LOOP TEST MODE
                OUT     CREG
                LXI     D,CLMSG
                MVI     C,PSTRING
                CALL    BDOS
                CALL    CRLF
                CALL    READ
;GO BACK ON-LINE
                MVI     A,09H
                OUT     CREG
                LXI     D,OLMSG
                MVI     C,PSTRING
                CALL    BDOS
                CALL    CRLF
                CALL    READ
;DISPLAY DATA TRANSFERRED VIA ETHERNET BOARD TO CRT:
                MVI     C,PSTRING
                LXI     D,LMSG
                CALL    BDOS
                CALL    CRLF
                CALL    CONOUT
                JMP     0       ;RETURN TO OPERATING SYSTEM
; END OF MAIN PROGRAM
;*********************************************************
;*********************************************************
; TRANSMIT SUBROUTINE:
TRMSG           DI
;LOOP UNTIL INTERRUPT ENABLE REGISTER =0 OR 4:
LOOP            LXI    H,CEREG ; CHECK IF NI3010 BUSY
                MOV     A,M
                CPI     00H
                JZ      CONT
                CPI     04H
                JZ      CONT
                EI
                JMP     LOOP
CONT            DI              ;DISABLE INTS. AND CHECK AGAIN
                LXI     H,CEREG
                MOV     A,M
                CPI     00H
                JZ      CONT1
                CPI     04H
                JZ      CONT1
                EI
                JMP     LOOP
CONT1           MVI     A,00H
                LXI     H,CEREG; DISABLE THE NI3010 INTERRUPTS
                MOV     M,A
```

```
             OUT      IEREG; SET INTERRUPT ENABLE REG = 0
             EI
ADDR1        EQU      00H; LOCATION OF TRANSMIT DATA START=
ADDR2        EQU      06H; 600 HEX
ADDR3        EQU      00H
             MVI      A,ADDR1; LOAD TRANSMIT MESSAGE 1ST ADDR
             OUT      EBAR
             MVI      A,ADDR2
             OUT      HBAR
             MVI      A,ADDR3
             OUT      LBAR
             MVI      A,00H;LOAD BYTE COUNT
             OUT      HBREG
             MVI      A,032H
             OUT      LBREG
             DI
             MVI      A,06H; ENABLE NI3010 TDD INTERRUPT
             LXI      H,CEREG
             MOV      M,A
             OUT      IEREG
             EI
DONE         MOV      A,M; READ THE COPY OF IEREG=CEREG
             CPI      06H
             JZ       DONE
TEST3        MVI      A,029H; LOAD TRANSMIT AND SEND COMMAND
             OUT      CREG
             RET
;END TRANSMIT SUBRCUTINE
;**************************************************************
;READ STATUS SUBROUTINE:
READ         MVI       B,11111110B
             MVI       C,00H
RDLP         IN        ISREG
             ORA       B
             CPI       00FFH
             JNZ       RDLP;CONTINUE LOOP UNTIL STATUS REG READ
             IN        SREG
             CMP       C
             JNZ       ERMSG
             LXI       D,MSG
             MVI       C,09H
             CALL      BDOS
             CALL      CRLF
             JMP       RDONE
ERMSG        LXI       D,NMSG
             MVI       C,09H
             JMP       BDOS
             CALL      CRLF
RDONE        RET
;END READ SUBROUTINE:
;**************************************************************
```

```
;INTERRUPT HANDLER:
;SAVE CPU STATE:
INTHDL      EI
            PUSH      PSW
            PUSH      B
            PUSH      D
            PUSH      H
            DI
            LXI       H,CEREG
            MOV       B,M; SAVE ENABLE REGISTER COPY VALUE
            MVI       A,00H
            LXI       H,CEREG; DISABLE NI3010 INTS.
            OUT       IEREG
            MOV       M,A
            MOV       A,B
            MVI       B,04H; IS RBA INTERRUPT ENABLED?
            CMP       B
            JZ        RBA
            MVI       B,07H; IS RDD INTERRUPT ENABLED?
            CMP       B
            JZ        RDD
            MVI       A,04H; IF NEITHER OF ABOVE THEN WAS TDD
            LXI       H,CEREG; ENABLE RBA INTERRUPT
            MOV       M,A
            OUT       IEREG
            JMP       FINI
RADD1       EQU       00H; 1ST ADDR TO WRITE RECVD FRAME TO=
RADD2       EQU       08H; 0800 HEX
RADD3       EQU       00H
RBA         MVI       A,RADD1; LOAD THE ADDRESS REGISTERS
            OUT       EBAR
            MVI       A,RADD2
            OUT       HBAR
            MVI       A,RADD3
            OUT       LBAR
            MVI       A,00H; NOW LOAD BYTE COUNT REGISTERS
            OUT       HBREG
            MVI       A,040H
            OUT       LBREG
            LXI       H,CEREG
            MVI       A,07H; ENABLE RDD INTERRUPT
            MOV       M,A
            OUT       IEREG
            JMP       FINI
RDD         LXI       H,CEREG
            MVI       A,04H
;RECEIVE PROCESS WAKE UP IN HERE
            MOV       M,A
            OUT       IEREG
FINI        EI
;RESTORE CPU STATE:
```

```
                POP     H
                POP     D
                POP     B
                DI
                MVI     A,020H; RESTORE INTERRUPT STATUS
                OUT     0FDH
                POP     PSW
                EI
                RET
;END INTERRUPT HANDLER
;**********************************************************
CRLF            MVI     C,CONSOUT; GENERATES CARRIAGE RTN +LINE
                MVI     E,0DH
                CALL    BDOS
                MVI     C,CONSOUT
                MVI     E,0AH
                CALL    BDOS
                RET
;**********************************************************
CONIN           LXI     H,0608H; READ TEST DATA INPUT FROM CONSO
INLP            MVI     C,CONSIN
                PUSH    H
                CALL    BDOS
                POP     H
                MOV     M,A
                CPI     60H;COMPARE TO GRAVE ACCENT
                RZ
                INX     H
                JMP     INLP
;**********************************************************
CONOUT          LXI     H,0812H; OUTPUT TEST DATA TO THE CONSOLE
OTLP            MVI     C,CONSOUT
                MOV     E,M
                MOV     A,E
                CPI     60H;IF GRAVE ACCENT THEN RETURN
                RZ
                PUSH    H
                CALL    BDOS
                POP     H
                INX     H
                JMP     OTLP
;**********************************************************
BMSG            DB      'ETHERNET LEVEL ONE TEST PROGRAM: VERS'
                DB      'ION: 1.13: 04/30/83-MDS$'
OLMSG           DB      'ONLINE COMMAND ISSUED$'
STMSG           DB      'SELF TEST COMMAND ISSUED$'
MLMSG           DB      'MODULE LOOPBACK COMMAND ISSUED$'
CLMSG           DB      'CLEAR LOOPBACK COMMAND ISSUED$'
TRCMSG          DB      'TRANSMIT/SEND COMMAND ISSUED$'
MSG             DB      'COMMAND EXECUTED$'
NMSG            DB      'COMMAND FAILED$'
```

```
FMSG        DB        'ENTER TEXT(42 CHAR MAX) FOR MODULE'
            DB        'INTERFACE LOOPBACK(42 CHAR MAX)         '
            DB        '          (END WITH A GRAVE ACCENT=> `)$'
LMSG        DB        'THE DATA TRANSFERRED VIA MODULE INTER'
            DB        'FACE LOOPBACK IS:$'
DMSG0       DB        'ENTER ADDRESS OF INSTALLED NI3010'
            DB        ' BOARD$'
DMSG1       DB        'BOARD 00-04-0A:ENTER " 1 "$'
DMSG2       DB        'BOARD 00-03-EA:ENTER " 2 "$'
DMSG3       DB        'INCORRECT SELECTION-TRY AGAIN:$'
;****************************************************************
;****************************************************************
            END;ETHERNET LEVEL ONE TEST PROGRAM-VERSION 1.13
```

APPENDIX G

SOURCE CODE OF PROGRAM ETHTESTB.ASM

```
;*************************************************************
;*************************************************************
;  ETHERNET SECOND LEVEL TEST PROGRAM--VERSION  2.04
;
;PROGRAM FILE NAME: ETHTESTB.COM- INVOKE COMMAND: ETHTESTB
;
;PROGRAM FUNCTION:(RUN ON 8080 BASED MDS SYSTEM)
;SELF TEST.IT THEN TRANSFERS A 42-BYTE BLOCK OF TEXT FROM A
;BLOCK OF MEMORY STARTING AT ADDRESS 0700 HEX TO ANOTHER
;BLOCK AT 0900 HEX IN TWO SEPARATE TESTS VIA THE NI3010
;BOARD.  SUCCESSFUL COMPLETION OF THESE TESTS VERIFIES THE
;FUNCTIONING OF ALL THE HARDWARE NECESSARY TO COMMUNICATE
;WITH OTHER HOSTS ON THE NETWORK.
;
;TESTS PERFORMED:
;           1.) BOARD DIAGNOSTIC SELF TEST
;           2.) MODULE INTERFACE LOOPBACK-VERIFIES THE
;               FUNCTIONING OF THE NI3010 BOARD INCLUDING THE
;               NM10 PROTOCOL MODULE.
;           3.) EXTERNAL LOOPBACK-VERIFIES THE FUNCTIONING OF
;               ABOVE AND THE FLAT CABLE,TRANSCEIVER AND
;               NETWORK COAXIAL CABLE.
;
;NI3010 ETHERNET BOARD CONFIGURATION:
;                    1.) JUMPER SET TO INTERRUPT LEVEL 5.
;                    2.) BASE PORT ADDRESS SWITCHES SET TO
;                        1011 (00B0H).
;                    3.) PARALLEL PRIORITY TO AN ODD NUMBERED
;                        MULTIBUS SLOT.
;
;ORIGINAL PROGRAM: 03/31/83
;
;LAST REVISION: 04/30/83
;
;WRITER: MARK D. STOTZER
;
;ADVISOR: PROF. U.R. KODRES
;
;*************************************************************
;*************************************************************
;MAIN PROGRAM:
          ORG     100H
; NI3010 REGISTER PORT ADDRESSES:
```

```
CREG        EQU     00B0H;CMD REG LOCATION
SREG        EQU     00B1H;CMD STATUS REG LOCATION
ISREG       EQU     00B5H;INTERRUPT STATUS REG
IEREG       EQU     00B8H;INTERRUPT ENABLE REG
EBAR        EQU     00B9H;EXTENDED BASE ADDR REG
HBAR        EQU     00BAH;HIGH BASE ADDR REG
LBAR        EQU     00BBH;LOW BASE ADDR REG
HBREG       EQU     00BCH;HIGH BYTE COUNT REG
LBREG       EQU     00BDH;LOW BYTE COUNT REG
;************************************************************
;OTHER NEEDED ADDRESSES:
BDOS        EQU     0005H;BDOS ENTRY POINT
CEREG       EQU     0800H;COPY OF INTERRUPT ENABLE REG
STATUS      EQU     0801H;COPY OF CMD STATUS REG
;************************************************************
;NEEDED BDOS COMMANDS:
PSTRING     EQU     09H; PRINT STRING FUNCTION
CONSIN      EQU     01H; CONSOLE CHAR INPUT FUNCTION
CONSOUT     EQU     02H; CONSOLE CHAR OUTPUT FUNCTION
;************************************************************
;READ CMD STATUS REG ON POWER UP:REQUIRED FOR INITIALIZATION
            IN      SREG
;************************************************************
;OUTPUT INITIAL MESSAGE TO USER:
            LXI     D,BMSG
            MVI     C,PSTRING
            CALL    BDOS
            CALL    CRLF
;LOAD JUMP INSTRUCTION FOR INTERRUPT HANDLER: (INT 5)
            MVI     A,0C3H;JMP INST CODE
            STA     0028H ;LOAD IT IN ADDR 0028 HEX
            LXI     H,INTHDL
            SHLD    0029H
;************************************************************
;SET UP INTERRUPT CONTROL: (INT 5)
            MVI     A,012H
            OUT     0FDH
            MVI     A,0DFH; ENABLE INTERRUPT 5-ETHERNET BOARD
            OUT     0FCH
;************************************************************
;LOAD TRANSMIT DATA BLOCK-FIRST 3 BYTES ASSIGNED BY XEROX:
            MVI     A,02H
            STA     0700H
            MVI     A,07H
            STA     0701H
            MVI     A,01H
            STA     0702H
;LOAD INTERLAN ASSIGNED LAST 3 BYTES HERE:
DESTINP     CALL    CRLF
            LXI     D,DMSG0; ASK USER TO INPUT THIS ADDRESS
            MVI     C,PSTRING
```

```
                CALL    BDOS
                CALL    CRLF
                LXI     D,DMSG1
                MVI     C,PSTRING
                CALL    BDOS
                CALL    CRLF
                LXI     D,DMSG2
                MVI     C,PSTRING
                CALL    BDOS
                CALL    CRLF
                MVI     C,CONSIN;READ USER INPUT OF ADDRESS
                CALL    BDOS
                CPI     31H
                JZ      DADDR2
                CPI     32H
                JZ      DADDR1
                CALL    CRLF
                LXI     D,DMSG3
                MVI     C,PSTRING
                CALL    BDOS
                CALL    CRLF
                JMP     DESTINP
DADDR1          CALL    CRLF; ADDR 00-03-EA SELECTED BY USER:LOAD
                MVI     A,00H
                STA     0703H
                MVI     A,03H
                STA     0704H
                MVI     A,0EAH
                STA     0705H
                JMP     ADDIN
DADDR2          CALL    CRLF; ADDRESS 00-04-0A SELECTED:LOAD IT
                MVI     A,00H
                STA     0703H
                MVI     A,04H
                STA     0704H
                MVI     A,0AH
                STA     0705H
;LOAD TYPE FIELD- 2 BYTES:
ADDIN           MVI     A,00H
                STA     0606H
                MVI     A,00H
                STA     0607H
;NOTE:FOR THIS TEST THE ACTUAL DATA IS IN ADDRESSES
;0608-0632HEX FOR TRANSMISSION
;*****************************************************
;READ IN THE TEST DATA FOR MODULE INTERFACE LOOPBACK TEST:
                MVI     C,PSTRING
                LXI     D,FMSG
                CALL    BDOS
                CALL    CRLF
                CALL    CONIN
```

```
        CALL    CRLF
;GO ONLINE UPON POWER UP:
        EI
        MVI     A,09H;CMD TO GO ONLINE
        OUT     CREG
        CALL    READ
;************************************************************
;RUN ONBOARD DIAGNOSTICS TEST:
        MVI     A,0AH; CODE FOR SELF TEST COMMAND
        OUT     CREG
        CALL    READ
;************************************************************
;RUN MODULE INTERFACE LOOPBACK TEST:
        MVI     A,09H; GO BACK ONLINE
        OUT     CREG
        CALL    READ
;LOAD INTERRUPT ENABLE REGISTER=4. SET TO RECEIVE DATA.
        DI
        LXI     H,CEREG
        MVI     A,04H
        MOV     M,A
        OUT     IEREG
        EI
;COMMAND MODULE INTERFACE LOOPBACK MODE:
        MVI     A,02H
        OUT     CREG
        CALL    READ
;TRANSFER THE TEST DATA:
        CALL    TRMSG
        CALL    READ
;DISPLAY DATA TRANSFERRED BY MODULE INTERFACE LOOPBACK TEST:
        MVI     C,PSTRING
        LXI     D,LMSG
        CALL    BDOS
        CALL    CRLF
        CALL    CONOUT; TEXT OUTPUT TO THE CONSOLE
        CALL    CRLF
;************************************************************
;PERFORM INTERNAL LOOPBACK TEST:
;READ IN TEST DATA FOR EXTERNAL LOOPBACK TEST:
        MVI     C,PSTRING
        LXI     D,FEMSG
        CALL    BDOS
        CALL    CRLF
        CALL    CONIN
        CALL    CRLF
;EXIT INTERNAL LOOP TEST MODE:
        MVI     A,03H
        OUT     CREG
        CALL    READ
;GO BACK ONLINE:
```

```
                MVI     A,09H
                OUT     CREG
                CALL    READ
;TRANSMIT THE TEST DATA:
                CALL    TRMSG
                CALL    READ
;DISPLAY DATA TRANSFERRED VIA INTERNAL LOOPBACK TO CRT:
                MVI     C,PSTRING
                LXI     D,LEMSG
                CALL    BDOS
                CALL    CRLF
                CALL    CONOUT
                CALL    CRLF
                JMP     Ø       ;RETURN TO OPERATING SYSTEM
; END OF MAIN PROGRAM
;*************************************************************
;*************************************************************
; TRANSMIT SUBROUTINE:
TRMSG           DI
;LOOP UNTIL INTERRUPT ENABLE REGISTER =Ø OR 4:
LOOP            LXI     H,CEREG
                MOV     A,M
                CPI     ØØH
                JZ      CONT
                CPI     Ø4H
                JZ      CONT
                EI
                JMP     LOOP
CONT            DI
                LXI     H,CEREG
                MOV     A,M
                CPI     ØØH
                JZ      CONT1
                CPI     Ø4H
                JZ      CONT1
                EI
                JMP     LOOP
CONT1           MVI     A,ØØH
                LXI     H,CEREG
                MOV     M,A
                OUT     IEREG; SET INTERRUPT ENABLE REG = Ø
                EI
ADDR1           EQU     ØØH; LOCATION OF TRANSMIT BUFFER TOP
ADDR2           EQU     Ø7H
ADDR3           EQU     ØØH
                MVI     A,ADDR1; LOAD TRANSMIT MESSAGE 1ST ADDR.
                OUT     EBAR
                MVI     A,ADDR2
                OUT     HBAR
                MVI     A,ADDR3
                OUT     LBAR
```

```
          MVI     A,00H;LOAD BYTE COUNT
          OUT     HBREG
          MVI     A,032H
          OUT     LBREG
          DI
          MVI     A,06H; ENABLE TDD INTERRUPT
          LXI     H,CEREG
          MOV     M,A
          OUT     IEREG
          EI
DONE      LXI      H,CEREG
          MOV     A,M; READ THE COPY OF IEREG=CEREG
          CPI     06H
          JZ      DONE
TEST3     MVI     A,029H; LOAD TRANSMIT AND SEND COMMAND
          OUT     CREG
          RET
;END TRANSMIT SUBROUTINE
;*************************************************************
;READ STATUS SUBROUTINE:
READ      MVI      B,11111110B
          MVI      C,00H
RDLP      IN       ISREG
          ORA      B
          CPI      00FFH
          JNZ      RDLP;CONTINUE LOOP UNTIL STAT REG READY
          IN       SREG
          LXI      H,STATUS; KEEP COPY OF CMD STAT REG
          MOV      M,A
          CMP      C
          JNZ      ERMSG
          LXI      D,MSG
          MVI      C,PSTRING
          CALL     BDOS
          CALL     CRLF
          JMP      RDONE
ERMSG     LXI      D,NMSG
          MVI      C,PSTRING
          CALL     BDOS
          MVI      B,050H
          LXI      H,STATUS
          MOV      A,M
          ADD      B
          MVI      C,CONSOUT;ERROR CODE TO CONSOLE
          MOV      E,A
          CALL     BDOS
          CALL     CRLF
          LXI      D,NMSG1
          MVI      C,PSTRING
          CALL     BDOS
          CALL     CRLF
```

```
RDONE      RET
;END READ SUBROUTINE:
;*************************************************************
;INTERRUPT HANDLER:
;SAVE CPU STATE:
INTHDL     EI
           PUSH    PSW
           PUSH    B
           PUSH    D
           PUSH    H
           DI
           LXI      H,CEREG
           MOV      B,M; SAVE ENABLE REGISTER COPY VALUE
           MVI      A,00H; DISABLE NI3010 INTERRUPTS
           LXI      H,CEREG
           MOV      M,A
           OUT      IEREG
           MOV      A,B
           MVI      B,04H; WAS RBA INTERRUPT ENABLED?
           CMP      B
           JZ       RBA
           MVI      B,07H; WAS RDD INTERRUPT ENABLED?
           CMP      B
           JZ       RDD
           MVI      A,04H; IF NEITHER OF THE ABOVE THEN
           LXI      H,CEREG; WAS TDD- NOW ENABLE RBA AGAIN
           MOV      M,A
           OUT      IEREG
           JMP      FINI
RADD1      EQU      00H; LOCATION OF WHERE TO WRITE RECVD
RADD2      EQU      09H; FRAME DATA IN HOST MEMORY
RADD3      EQU      00H
RBA        MVI      A,RADD1; NOW LOAD ADDR INTO ADDR REGS.
           OUT      EBAR
           MVI      A,RADD2
           OUT      HBAR
           MVI      A,RADD3
           OUT      LBAR
           MVI      A,00H; LOAD BYTE COUNT REGISTERS
           OUT      HBREG
           MVI      A,040H
           OUT      LBREG
           LXI      H,CEREG
           MVI      A,07H; ENABLE RDD INTERRUPT
           MOV      M,A
           OUT      IEREG
           JMP      FINI
RDD        LXI      H,CEREG
           MVI      A,04H
;RECEIVE PROCESS WAKE UP IN HERE
           MOV      M,A
```

```
             OUT       IEREG
FINI         EI
;RESTORE CPU STATE:
             POP       H
             POP       D
             POP       B
             DI
             MVI       A,020H; RESTORE INTERRUPT STATUS
             OUT       0FDH
             POP       PSW
             EI
             RET
;END INTERRUPT HANDLER
;*************************************************************
CRLF         MVI       C,CONSOUT; GENERATES CARRIAGE RTN +LFEED
             MVI       E,0DH
             CALL      BDOS
             MVI       C,CONSOUT
             MVI       E,0AH
             CALL      BDOS
             RET
;*************************************************************
CONIN        LXI       H,0708H; READ TEST DATA INPUT FROM CONS.
INLP         MVI       C,CONSIN
             PUSH      H
             CALL      BDOS
             POP       H
             MOV       M,A
             CPI       60H;IF GRAVE ACCENT THEN RETURN
             RZ
             INX       H
             JMP       INLP
;*************************************************************
CONOUT       LXI       H,0912H; OUTPUT TEST DATA TO THE CONSOLE
OTLP         MVI       C,CONSOUT
             MOV       E,M
             MOV       A,E
             CPI       60H;TEST FOR END CHAR-GRAVE ACCENT
             RZ
             PUSH      H
             CALL      BDOS
             POP       H
             INX       H
             JMP       OTLP
;*************************************************************
BMSG         DB        'ETHERNET SECOND LEVEL TEST PROGRAM:'
             DB        ' VERSION 2.04: 04/30/83-MDS$'
DMSG0        DB        'ENTER ADDRESS OF INSTALLED NI3010 '
             DB        'BOARD: $'
DMSG1        DB        'BOARD 00-04-0A:ENTER " 1 "$'
DMSG2        DB        'BOARD 00-03-EA:ENTER " 2 "$'
```

```
DMSG3       DB      'INCORRECT SELECTION NUMBER-TRY AGAIN:$'
MSG         DB      'EXECUTING BOARD COMMAND....$'
NMSG        DB      'COMMAND FAILED-ERROR CODE:$'
NMSG1       DB      'FOR INTERPRETATION OF ERROR CODES-SEE'
            DB      'ASM LISTING FILE$'
FMSG        DB      'ENTER TEXT(42 CHAR MAX) FOR MODULE'
            DB      ' INTERFACE LOOPBACK TEST:                 '
            DB      '                         '
            DB      '(END STRING WITH A GRAVE ACCENT=> `)$'
FEMSG       DB      'ENTER TEXT(42 CHAR MAX) FOR INTERNAL'
            DB      ' LOOPBACK TEST:                             '
            DB      '                          '
            DB      '(END STRING WITH A GRAVE ACCENT=> `)$'
LMSG        DB      'THE DATA TRANSFERRED BY MODULE'
            DB      ' INTERFACE LOOPBACK IS:$'
LEMSG       DB      'THE DATA TRANSFERRED BY INTERNAL'
            DB      ' LOOPBACK IS:$'
;*************************************************************
;ERROR CODES:(IN RESPONSE TO TRANSMISSION COMMAND FAILURES):
;
;             LETTER      |    NATURE OF FAILURE
;-------------------------------------------------------------
;
;               S            YOU ISSUED AN INAPPROPRIATE COM
;                            MODE THE BOARD IS IN.
;
;               T            BOARD TIMER TIMED OUT-POSSIBLE
;                            PROBLEM.
;
;               U            TRANSMIT BUFFER SIZE EXCEEDED:(
;
;               V            FRAME SENT TO BOARD TOO SMALL:(
;
;               X            EXCESSIVE COLLISIONS
;
;*************************************************************
;*************************************************************
            END;ETHERNET SECOND LEVEL TEST PROGRAM-VERSION 2.
```

APPENDIX H

SOURCE CODE OF MAIN MODULE ETHERNET.PLI

```
ETHERNET:/*MAIN MODULE-APPLICATION LAYER-ISO LEVEL 7*/

PROCEDURE OPTIONS (MAIN);

DECLARE
        /* LOCAL VARIABLES */
        COUNT7    FIXED BINARY(7),/*LOOP CONTROL VARIABLE*/
        COUNT7A   FIXED BINARY(7),/*LOOP CONTROL*/
        COUNT7B   FIXED BINARY(7),/*LOOP CONTROL*/
        COUNT7C   FIXED BINARY(7),/*LOOP CONTROL*/
        DSKNO     CHARACTER(1),/*USER INPUT DISK NUMBER*/
        FRAMD     CHARACTER(1),/*USER INPUT FRAME SIZE*/
        SELECT    CHARACTER(1),/*USER INPUT MODE SELECTION*/
        /* GLOBAL VARIABLES */
        RECFIL    FIXED BINARY(7) EXTERNAL,/*RECVD FILE NO.*/
        FRSIZE    FIXED BINARY(15) EXTERNAL,/*FRAME SIZE*/
        VTERM     FIXED BINARY(7) EXTERNAL,/*TERMINAL FLAG*/
        TRMODE    FIXED BINARY(7) EXTERNAL,/*CMD MODE FLAG*/
        /* GLOBAL DATA STRUCTURES */
        TXBUFF(1508) FIXED BINARY(7) EXTERNAL,/*TRANS BUFF*/
        RXBUFF(1522) FIXED BINARY(7) EXTERNAL,/*RECV BUFF*/
        TXTBUF (128) FIXED BINARY(7) EXTERNAL,/*TEXT BUFF*/
        1 RXFCB EXTERNAL,/*RECEIVE FILE CONTROL BLOCK*/
          2 DISK FIXED BINARY(7),
          2 FNAME CHARACTER(8),
          2 FTYPE CHARACTER(3),
          2 RFCB(24) FIXED BINARY(7),
        1 TXFCB EXTERNAL,/*TRANSMIT FILE CONTROL BLOCK*/
          2 DISK FIXED BINARY(7),
          2 FNAME CHARACTER(8),
          2 FTYPE CHARACTER(3),
          2 TFCB(24) FIXED BINARY(7),
        /* EXTERNAL MODULES */
        INIT      ENTRY,/* INITIALIZES INTERRUPTS & NI3010*/
        SENDATA   ENTRY,/* TRANSMIT ISO LEVEL 6 MODULE */
        RECEIVE   ENTRY;/* RECEIVE MODULE */

 /*LAST REVISION: 09/15/83-0900 ORIGINAL PROGRAM:07/29/83 */
 /*AUTHOR: CAPT. MARK D. STOTZER-USMC-AEGIS GROUP         */
 /*THESIS ADVISOR: PROFESSOR UNO R. KODRES-COMP. SCIENCE  */

PUT SKIP LIST('********************************************');
PUT SKIP LIST('ETHERNET COMMUNICATION PROGRAM-VERSION 5.0');
PUT SKIP LIST('ALLOWS THIS HOST TO CONNECT TO THE NET.');
PUT SKIP LIST('CNTL-H=BACKSPACE FOR TEXT ENTRIES:');
PUT SKIP LIST('******************************************');
PUT SKIP(2);
RECFIL=47;
COUNT7=1;
DO WHILE (COUNT7=1);
   COUNT7A=1;
   DO WHILE(COUNT7A=1);
      PUT SKIP(2);
      PUT SKIP LIST('************ MAIN MENU *************');
      PUT SKIP LIST('WRITE RECEIVED FILES TO DISK NO:');
      PUT SKIP LIST('DEFAULT DRIVE(A)    = 1');
      PUT SKIP LIST('DISK DRIVE A        = 2');
      PUT SKIP LIST('DISK DRIVE B        = 3');
      PUT SKIP LIST('************************************');
      PUT SKIP LIST('ENTER DRIVE NUMBER==>');
      GET LIST(DSKNO);
      PUT SKIP(2);
      IF DSKNO='1' THEN
         DO;
           RXFCB.DISK=0;/* LOAD DISK NUMBER IN FCB */
           COUNT7A=2;
         END;
      ELSE
      IF DSKNO='2' THEN
         DO;
           RXFCB.DISK=1;/* DISK NUMBER TO FCB */
           COUNT7A=2;
         END;
      ELSE
      IF DSKNO='3' THEN
         DO;
           RXFCB.DISK=2;/* DISK NUMBER TO FCB */
           COUNT7A=2;
         END;
      ELSE
         PUT SKIP LIST('INVALID DRIVE NUMBER-REENTER:');
   END;/*DO LOOP*/
   COUNT7B=1;
   DO WHILE (COUNT7B=1);
      PUT SKIP LIST('ETHERNET FRAME DATA BLOCK SIZE:');
      PUT SKIP LIST('SELECT 128 FOR ALL FILE OPERATIONS');
      PUT SKIP LIST('AND VAX COMMUNICATIONS.');
      PUT SKIP LIST('    128 BYTES     = 1');
      PUT SKIP LIST('    256 BYTES     = 2');
      PUT SKIP LIST('    512 BYTES     = 3');
      PUT SKIP LIST('   1024 BYTES     = 4');
      PUT SKIP LIST('   1500 BYTES     = 5');
      PUT SKIP LIST('*******************************');
      PUT SKIP LIST('ENTER SELECTION==>');
      GET LIST(FRAMD);
      PUT SKIP(2);
      IF FRAMD='1' THEN
         DO;
           FRSIZE=128;/* SET THE FRAME SIZE */
           COUNT7B=2;
         END;
      ELSE
      IF FRAMD='2' THEN
         DO;
           FRSIZE=256;/* SET  FRAME SIZE */
           COUNT7B=2;
         END;
      ELSE
      IF FRAMD='3' THEN
         DO;
           FRSIZE=512;/* SET FRAME SIZE */
           COUNT7B=2;
         END;
      ELSE
      IF FRAMD='4' THEN
         DO;
           FRSIZE=1024;/* SET THE FRAME SIZE */
           COUNT7B=2;
         END;
      ELSE
      IF FRAMD='5' THEN
         DO;
           FRSIZE=1500;/* SET FRAME SIZE */
           COUNT7B=2;
         END;
      ELSE
         PUT SKIP LIST('INCORRECT CHOICE-REENTER:');
   END;/* DO LOOP */
   VTERM=0;/* RESET TERMINAL FLAG TO FALSE */
   TPMODE=0;/* RESET COMMAND MODE FLAG TO FALSE */
   CALL INIT;
   PUT SKIP LIST('OPERATING MODES:');
   PUT SKIP LIST('****************************');
   PUT SKIP LIST('RECEIVE WAIT LOOP        = 1');
   PUT SKIP LIST('TRANSMIT FILE OR MESSAGE= 2');
   PUT SKIP LIST('VIRTUAL TERMINAL OF VAX = 3');
   PUT SKIP LIST('VAX COMMAND MODE        = 4');
   PUT SKIP LIST('DISCONNECT FROM NET     = 5');
   PUT SKIP LIST('****************************************');
   PUT SKIP LIST('ENTER SELECTION ==>');
   GET LIST(SELECT);
   PUT SKIP(2);
   IF SELECT='1' THEN /* RECEIVE MODE */
      DO;
        TXBUFF(1)=2;/* LOAD FIRST THREE DEST ADDR BYTES */
      TXBUFF(2)=7;/* FOR ACK REPLY IN RECEIVE MODE */
      TXBUFF(3)=1;
      PUT SKIP LIST('IN RECEIVE WAIT LOOP-TO RETURN TO');
      PUT SKIP LIST('MAIN MENU: ENTER <CR> ==>');
      PUT SKIP LIST('*********************************');
      PUT SKIP(2);
      CALL RECEIVE;
    END;
ELSE
IF SELECT='2' THEN /* NORMAL TRANSMIT */
   CALL TRANS2  ;
ELSE
IF SELECT='3' THEN /* VAX TERMINAL MODE */
   DO;
      VTERM=1;/* SET THE TERMINAL FLAG TO TRUE */
      FRSIZE=1500;
      PUT SKIP LIST('******* VAX TERMINAL MODE *******');
      PUT SKIP(1);
      PUT SKIP LIST('VAX TERMINAL SERVICE:');
      PUT SKIP LIST('DATA BLOCK SIZE PER FRAME=');
      PUT LIST(FRSIZE);
      PUT SKIP LIST('-----------------------------------');
      PUT SKIP LIST('TERMINAL ENTRY BY LINE OF TEXT');
      PUT SKIP LIST('BEGIN AFTER INITIAL V PROMPT: "V>"');
      PUT SKIP LIST('ENTER: TEXT LINE<CR>');
      PUT SKIP LIST('PROMPT WILL AUTOMATICALLY REAPPEAR');
      PUT SKIP LIST('UPON ENTRY OF THE FIRST CHARACTER');
      PUT SKIP LIST('OF THE NEXT LINE YOU BEGIN.');
      PUT SKIP LIST('-----------------------------------');
      PUT SKIP LIST('TO END TERMINAL SESSION:');
      PUT SKIP LIST('ENTER: "."<CR> AFTER "V>"');
      PUT SKIP LIST('-----------------------------------');
      PUT SKIP(1);
      TXBUFF(1)=2; /* LOAD THE VAX NET ADDR INTO THE SIX*/
      TXBUFF(2)=7; /* ADDRESS BYTES */
      TXBUFF(3)=1;
      TXBUFF(4)=0;
      TXBUFF(5)=7;
      TXBUFF(6)=127;
      TXBUFF(7)=0;/* LOAD THE TYPE TWO TYPE FIELD BYTES */
      TXBUFF(8)=0;
      COUNT7C=1;
      PUT SKIP LIST('V>');
      DO WHILE (COUNT7C=1);
         CALL SENDATA;
         PUT SKIP LIST('V>');
         IF VTERM=0 THEN /*END TERMINAL SESSION*/
            DO;
               PUT SKIP LIST('**** END TERMINAL SESSION ****');
               COUNT7C=2;
            END;
```

```
           ELSE
              DO;
                CALL INIT;
                CALL RECEIVE;
                PUT LIST('^H^H^HV>');
              END;
        END; /* DO LOOP */
      END;
   ELSE
   IF SELECT='4' THEN /* VAX COMMAND MODE */
      DO;
        PUT SKIP LIST('*** VAX COMMAND INSTRUCTIONS ***');
        PUT SKIP LIST('-----------------------------------');
        PUT SKIP LIST('TO DOWNLOAD A FILE FROM THE VAX:');
        PUT SKIP LIST('ENTER THE MESSAGE:');
        PUT SKIP LIST('" !FNAME(VAX).FTYPE(VAX)/XXX` "');
        PUT SKIP LIST('WHERE "XXX"="EXE" FOR NON-TEXT FILES');
        PUT SKIP LIST('AND   "XXX"="TXT" FOR TEXT FILES');
        PUT SKIP LIST('FILE WILL THEN BE IMMEDIATELY SENT');
        PUT SKIP LIST('TO THIS HOST.');
        PUT SKIP LIST('-----------------------------------');
        PUT SKIP LIST('TO UPLOAD A FILE TO THE VAX:');
        PUT SKIP LIST('1.) ENTER THE MESSAGE:');
        PUT SKIP LIST('" @FNAME(VAX).FTYPE(VAX)/XXX` "');
        PUT SKIP LIST('TO OPEN A VAX FILE BY THE ABOVE NAME');
        PUT SKIP LIST('2.) THEN:');
        PUT SKIP LIST('SEND THE FILE TO THE VAX ADDRESS USING');
        PUT SKIP LIST('THE NORMAL FILE SENDING SELECTIONS.');
        PUT SKIP LIST('-----------------------------------');
        PUT SKIP(1);
        TRMODE=1; /*SET VAX CMD MODE FLAG TO TRUE*/
        FRSIZE=128;
        TXBUFF(1)=2; /*LOAD THE VAX NET ADDR INTO THE SIX */
        TXBUFF(2)=7; /*ADDRESS BYTES */
        TXBUFF(3)=1;
        TXBUFF(4)=0;
        TXBUFF(5)=7;
        TXBUFF(6)=127;
        TXBUFF(7)=0;/* LOAD THE TWO TYPE FIELD BYTES */
        TXBUFF(8)=0;
        CALL SENDATA;
        CALL INIT;
        RXBUFF(17)=255;
        CALL RECEIVE;
      END;
   ELSE
   IF SELECT='5' THEN /* DISCONNECT BY EXITING TO CP/M */
      COUNT7=2;
   ELSE
   PUT SKIP LIST('INCORRECT OPMODE SELECTION-REENTER:');
END; /* DO LOOP */
```

```
PUT SKIP LIST('DISCONNECTING FROM NET-RETURNING TO CP/M.');

TRANS2: /* GETS USER INPUT OF FILE DATA */

PROCEDURE;

DECLARE
        /* LOCAL VARIABLES */
        COUNT6   FIXED BINARY(7),/* LOOP CONTROL*/
        COUNT6A  FIXED BINARY(7),/* LOOP CONTROL*/
        COUNT6B  FIXED BINARY(7),/*LOOP CONTROL*/
        COUNT6C  FIXED BINARY(7),/*LOOP CONTROL*/
        SENDTYPE CHARACTER(1),/*USER INPUT TRANSMIT TYPE*/
        FTYP     CHARACTER(1),/*USER INPUT FILETYPE*/
        DRNO     CHARACTER(1),/*USER INPUT DRIVE NO.*/
        /* FILE DATA ENTRY DCLS */
        I FIXED,
        FN CHARACTER(20),
        LOWER CHARACTER(26) STATIC INITIAL
        ('abcdefghijklmnopqrstuvwxyz'),
        UPPER CHARACTER(26) STATIC INITIAL
        ('ABCDEFGHIJKLMNOPQRSTUVWXYZ'),
        /* GLOBAL VARIABLES */
        FILTYP   FIXED BINARY (7) EXTERNAL,/* FILE NATURE*/
        FNOP FIXED BINARY (7) EXTERNAL,/*FILE NOT OPEN FLG*/
        /* GLOBAL DATA STRUCTURES */
        TXBUFF(1508) FIXED BINARY(7) EXTERNAL,/*TRANS BUFF*/
        1 TXFCB EXTERNAL,/*TRANSMIT FILE CONTROL BLOCK*/
          2 DISK FIXED BINARY(7),
          2 FNAME CHARACTER(8),
          2 FTYPE CHARACTER(3),
          2 TFCB(24) FIXED BINARY(7),
        /* EXTERNAL MODULES */
        SENDATA   ENTRY;/* ISO LEVEL 3 FRAME SENDER*/

COUNT6 =1;
DO WHILE(COUNT6=1);
   PUT SKIP LIST('TRANSMISSION OPTIONS:');
   PUT SKIP LIST('SEND A MESSAGE   = 1');
   PUT SKIP LIST('SEND A DISK FILE = 2');
   PUT SKIP LIST('****************************************');
   PUT SKIP LIST('ENTER SELECTION ==>');
   GET LIST(SENDTYPE);
   PUT SKIP(2);
   TXBUFF(8)=0;/* TYPE FIELD BYTE 2=NORMAL MSG OR FILE*/
   IF SENDTYPE='1' THEN /*SEND A MESSAGE */
      DO;
        TXBUFF(7)=0;/*TYPE FIELD BYTE 1=MESSAGE*/
        CALL SENDATA;
        COUNT6=2;
      END;
```

```
ELSE
IF SENDTYPE='2' THEN /*SEND A DISK FILE*/
   DO;
     TXBUFF(7)=15;/* TYPE FIELD BYTE 1= FILE*/
     COUNT6A=1;
     DO WHILE(COUNT6A=1);
        PUT SKIP LIST('NATURE OF FILE TO SEND:');
        PUT SKIP LIST('TEXT (ASCII) FILE        = 1');
        PUT SKIP LIST('MACHINE CODE (COM) FILE = 2');
        PUT SKIP LIST('*******************************');
        PUT SKIP LIST('ENTER TYPE OF FILE CHOICE ==>');
        GET LIST(FTYP);
        PUT SKIP(2);
        IF FTYP='1' THEN
           DO;
             FILTYP=1;/* SET THE FILETYP=TEXT FILE */
             COUNT6A=2;
           END;
        ELSE
        IF FTYP='2'  THEN
           DO;
             FILTYP=2;/* FILE TYPE=MACHINE FILE */
             COUNT6A=2;
           END;
        ELSE
        PUT SKIP LIST('INCORRECT CHOICE-REENTER:');
     END;/* DO LOOP */
     COUNT6B=1;
     DO WHILE(COUNT6B=1);
        COUNT6C=1;
        DO WHILE(COUNT6C=1);
            PUT SKIP LIST('SPECIFY FILE TO SEND:');
            PUT SKIP LIST('FILE LOCATED ON:');
            PUT SKIP LIST('  DRIVE A = 1');
            PUT SKIP LIST('  DRIVE B = 2');
            PUT SKIP LIST('*********************');
            PUT SKIP LIST('ENTER DRIVE NUMBER==>');
            GET LIST(DRNO);
            PUT SKIP(2);
            IF DRNO='1' THEN
               DO;
                 TXFCB.DISK=1;
                 COUNT6C=2;
               END;
            ELSE
            IF DRNO='2' THEN
               DO;
                 TXFCB.DISK=2;
                 COUNT6C=2;
               END;
            ELSE
```

```
                    PUT SKIP LIST('INVALID DRIVE-REENTER:');
               END;/* DO LOOP */
               PUT SKIP LIST('ENTER:"FILENAME.FILETYPE"==>');
               GET LIST(FN);
               PUT SKIP(2);
               FN=TRANSLATE(FN,UPPER,LOWER);
               I=INDEX(FN,'.');
               IF I=Ø THEN
                  DO;
                    TXFCB.FNAME=FN;
                    TXFCB.FTYPE='   ';
                  END;
               ELSE
                  DO;
                    TXFCB.FNAME=SUBSTR(FN,1,I-1);
                    TXFCB.FTYPE=SUBSTR(FN,I+1);
                  END;
               TXFCB.TFCB(1)=Ø;/* SET FCB FIELDS THAT COUNT=Ø*/
               TXFCB.TFCB(4)=Ø;/CURRENT EXTENT,RECORD ETC. */
               TXFCB.TFCB(21)=Ø;
               CALL SENDATA;
               IF FNOP~=1 THEN
                  COUNT6B=2;
            END;/* DO LOOP */
            COUNT6=2;
          END;
       ELSE
          PUT SKIP LIST('INCORRECT TRANSMIT MODE-REENTER:');
    END; /* DO LOOP */
    END TRANS2;

    END ETHERNET;/* ISO LAYER 7 MODULE */
```

APPENDIX I

SOURCE CODE FOR MODULE SENDATA.PLI

```
SENDATA: /* PRESENTATION LAYER MODULE-ISO LEVEL 6 */

PROCEDURE;

DECLARE
        /* LOCAL VARIABLES */
        COUNT5A  FIXED BINARY(7),/*LOOP CONTROL*/
        DESTADDR CHARACTER(1),/* DEST ADDRESS-USER INPUT*/
        /* GLOBAL VARIABLES */
        TRMODE   FIXED BINARY(7) EXTERNAL,/*VAX CMD FLAG*/
        VTERM    FIXED BINARY(7) EXTERNAL,/*TERMINAL FLAG*/
        FRSIZE   FIXED BINARY(15) EXTERNAL,/*FRAME SIZE*/
        /* GLOBAL DATA STRUCTURES */
        TXBUFF(1508) FIXED BINARY(7) EXTERNAL;/*TRANS BUFF*/

 /*LAST REVISION: 09/15/83-0900 ORIGINAL PROGRAM:07/29/83*/
 /*AUTHOR: CAPT. MARK D. STOTZER-USMC-AEGIS GROUP        */
 /*THESIS ADVISOR: PROF. UNO R. KODRES-COMPUTER SCIENCE  */

IF VTERM= 1 THEN /* TERMINAL MODE */
   DO;
     CALL SENDMSG;
     RETURN;
   END;
IF TRMODE= 1 THEN /* VAX COMMAND MODE */
   DO;
     CALL SENDMSG;
     RETURN;
   END;
COUNT5A=1;
DO WHILE(COUNT5A=1);
   PUT SKIP LIST('ADDRESSES ON THIS NETWORK:');
   PUT SKIP LIST('00-03-EA: MDS SYSTEM  = 1');
   PUT SKIP LIST('00-04-0A: MDS SYSTEM  = 2');
   PUT SKIP LIST('00-07-7F: VAX 11/780  = 3');
   PUT SKIP LIST('******************************');
   PUT SKIP LIST('ENTER SELECTION ==>');
   GET LIST(DESTADDR);
   PUT SKIP(2);
   TXBUFF(1)=2; /*LOAD THE FIRST FOUR DEST ADDR BYTES*/
   TXBUFF(2)=7;
   TXBUFF(3)=1;
   TXBUFF(4)=0;
```

```
      IF DESTADDR='1' THEN
         DO;
           TXBUFF(5)=3;/*LOAD LAST TWO DEST ADDR BYTES*/
           TXBUFF(6)=234;
           IF TXBUFF(7)=0 THEN/* SEND THE MSG*/
              CALL SENDMSG;
           ELSE
              CALL SENDFILE;/*SEND THE FILE*/
           COUNT5A=2;
         END;
      ELSE
      IF DESTADDR='2' THEN
         DO;
           TXBUFF(5)=4;/*LOAD LAST TWO DESTINATON ADDR BYTES*/
           TXBUFF(6)=10;
           IF TXBUFF(7)=0 THEN
              CALL SENDMSG;
           ELSE
              CALL SENDFILE;
           COUNT5A=2;
         END;
      ELSE
      IF DESTADDR='3' THEN
         DO;
           TXBUFF(5)=7;/LOAD LAST TWO DEST ADDR BYTES*/
           TXBUFF(6)=127;
           TRMODE=0;
           IF TXBUFF(7)=0 THEN
              CALL SENDMSG;
           ELSE
              CALL SENDFILE;
           COUNT5A=2;
         END;
      ELSE
      PUT SKIP LIST('INVALID NET ADDRESS SELECTED-REENTER:');
   END; /* DO LOOP */

   SENDMSG: /* MESSAGE SENDING MODULE */

   PROCEDURE;

   DECLARE  /* LOCAL VARIABLES */
            /* GLOBAL VARIABLES */
            FRSIZE  FIXED BINARY(15) EXTERNAL,/*FRAME SIZE*/
            TRMODE  FIXED BINARY(7)  EXTERNAL,/*VAX CMD FLAG*/
            VTERM   FIXED BINARY(7)  EXTERNAL,/*TERMINAL FLAG*/
            /* GLOBAL DATA STRUCTURES */
            TXBUFF(1508) FIXED BINARY(7) EXTERNAL,/*TRANS BUF*/
            RXBUFF(1522) FIXED BINARY(7) EXTERNAL,/*RECV BUFF*/
            /* EXTERNAL MODULES */
            FILBUF   ENTRY,/* LOADS TRANS.BUFFER FROM CONSOLE*/
```

```
          SENDFRAM ENTRY;/* ISO LEVEL 3 FRAME SENDER*/

IF VTERM=1 THEN /* VIRTUAL TERMINAL MODE */
   DO;
     CALL FILBUF;
     IF TXBUFF(9)=96 THEN
        RETURN;
     IF TXBUFF(9)=46 & TXBUFF(10)=96 THEN /*END SESSION*/
        VTERM=0; /*END TERMINAL SESSION*/
     ELSE
        CALL SENDFRAM;
   END;
ELSE
   DO;
     PUT SKIP LIST('MESSAGE SENDER:');
     PUT SKIP LIST('MAXIMUM NUMBER OF CHARACTERS= ');
     PUT LIST(FRSIZE);
     PUT SKIP LIST('ENTER MESSAGE AFTER PROMPT: >');
     PUT SKIP LIST('END MESSAGE WITH ACCENT: ` ');
     PUT SKIP LIST('>');
     CALL FILBUF; /*FILL TRANSMIT BUFFER FROM CONSOLE*/
     CALL SENDFRAM; /* SEND THE MESSAGE */
   END;
END SENDMSG;

SENDFILE: /* FILE SENDING MODULE*/

PROCEDURE;
DECLARE    /* LOCAL VARIABLES */
           COUNT4  FIXED BINARY(7),/*LOOP CONTROL*/
           /* GLOBAL VARIABLES */
           FILTYP FIXED BINARY(7) EXTERNAL,/*FILE NATURE*/
           FNOP   FIXED BINARY(7) EXTERNAL,/*NOT OPEN FLAG*/
           LFRM   FIXED BINARY(7) EXTERNAL,/*LAST DATA FLAG*/
           /* GLOBAL DATA STRUCTURES */
           TXBUFF(1508) FIXED BINARY(7) EXTERNAL,
           /* EXTERNAL MODULES */
           VAXTXT ENTRY,/* CP/M TO VAX FORMAT CONVERTER*/
           TRNDMA ENTRY,/*TRANSMIT SET DMA ADDRESS*/
           OPENDF ENTRY,/*OPEN DISK FILE*/
           RDISK  ENTRY,/*READ DISK FILE RECORD*/
           SENDFRAM ENTRY;/*ISO LEVEL 3 FRAME SENDER*/

 /*LAST REVISION: 08/25/83-1530 ORIGINAL PROGRAM:08/16/83 */
 /*AUTHOR: CAPT. MARK D. STOTZER-USMC-AEGIS GROUP          */
 /*THESIS ADVISOR: PROF. UNO R. KODRES-COMPUTER SCIENCE    */

TXBUFF(7)=15;/* LOAD TYPE FIELD BYTES*/
TXBUFF(8)=0;
CALL OPENDF;
IF FNOP=1 THEN /*FILE NOT ON DISK*/
```

```
    DO;
      PUT SKIP LIST('FILE NOT ON DISK-REENTER DATA:');
      PUT SKIP(2);
      RETURN;
    END;
IF TXBUFF(6)=127 & FILTYP=1 THEN
       CALL VAXTXT;  /*VAX TEXT FILE FORMAT CONVERTER*/
ELSE
    DO;
      CALL TRNDMA; /* SET DISK DMA ADDRESS*/
      PUT SKIP LIST('******* FILE TRANSFER BEGINS ******');
      PUT SKIP(2);
      COUNT4=1;
      DO WHILE(COUNT4=1);
         CALL RDISK; /*READ A DISK FILE RECORD*/
         IF LFRM~=1 THEN
            DO;
              CALL SENDFRAM;
              TXBUFF(8)=1;/*ENCODE TYPE FLD=INTERMED FRAME*/
            END;
         ELSE
            COUNT4=2;
      END;/* DO LOOP */
      TXBUFF(8)=255;/*ENCODE TYPE FIELD=LAST FRAME*/
      CALL SENDFRAM;
      PUT SKIP LIST('***** FILE TRANSFER ENDS *****');
      PUT SKIP(2);
      RETURN;
    END;
END SENDFILE;

END SENDATA; /* ISO LAYER 6 TRANSMIT MODULE */
```

APPENDIX J

SOURCE CODE FOR MODULE RECDATA.PLI

```
RECDATA: /* ISO LAYER 6 RECEIVE MODULE */

PROCEDURE;

DECLARE  /* GLOBAL DATA STRUCTURES */
         RXBUFF(1522) FIXED BINARY(7) EXTERNAL;/*RCV BUFF*/

 /*LAST REVISION: 09/15/83-1215 ORIGINAL PROGRAM:08/17/83 */
 /*AUTHOR: CAPT MARK D. STOTZER-USMC-AEGIS GROUP          */
 /*THESIS ADVISOR: PROF. UNO R. KODRES-COMPUTER SCIENCE   */

IF RXBUFF(17)= 0 THEN /* MESSAGE FRAME */
   CALL CONMSG;
ELSE
IF RXBUFF(17)= 15 THEN /* FILE FRAME */
   CALL FILER;
ELSE
   PUT SKIP LIST('RECEIVED IMPROPERLY ENCODED FRAME');


CONMSG: /* MESSAGE RECEIPT MODULE */

PROCEDURE;

DECLARE    /* GLOBAL VARIABLES */
           TRMODE  FIXED BINARY(7) EXTERNAL,/*VAX CMD FLAG*/
           FRSIZE  FIXED BINARY(15) EXTERNAL,/*FRAME SIZE*/
           VTERM   FIXED BINARY(7) EXTERNAL,/*TERMINAL FLAG*/
           /* GLOBAL DATA STRUCTURES */
           RXBUFF(1522) FIXED BINARY(7) EXTERNAL,/*RECV BUF*/
           /* EXTERNAL MODULES */
           TRMSG ENTRY,/* ACKNOWLEDGE SENDER*/
           EMTBUF ENTRY;/*DUMPS RECEIVE BUFFER TO CONSOLE*/


     IF VTERM~=1 THEN /* NOT IN VIRTUAL TERMINAL MODE*/
        DO;
          PUT SKIP LIST('***** RECEIVED MESSAGE IS:');
          PUT SKIP(2);
        END;
     CALL EMTBUF; /* DUMP THE RECVD FRAME DATA TO CONSOLE */
     CALL TRMSG;  /* SEND THE ACK FRAME */
     IF VTERM~=1 THEN /*NOT IN TERMINAL MODE*/
```

```
          DO;
            PUT SKIP(2);
            PUT SKIP LIST('***** END OF MESSAGE TEXT.');
            PUT SKIP(2);
            PUT SKIP LIST('BACK IN WAIT LOOP-ENTER<CR> TO EXIT=>');
            PUT SKIP LIST('*************************************');
            PUT SKIP(2);
          END;
        ELSE
        IF RXBUFF(18)= 15 THEN /*LAST FRAME OF TERMINAL REPLY*/
           PUT SKIP LIST('V>');
END CONMSG;


FILER: /* FILE FRAME RECEIPT MODULE*/

PROCEDURE;

DECLARE     /*  GLOBAL VARIABLES */
            TRMODE     FIXED BINARY(7) EXTERNAL,/*CMD FLAG*/
            RECFIL     FIXED BINARY(7) EXTERNAL,/*RFILE NO.*/
            VTERM      FIXED BINARY(7) EXTERNAL,/*TERM FLAG*/
            /* GLOBAL DATA STRUCTURES */
            1 RXFCB EXTERNAL,/*RECEIVE FILE CONTROL BLOCK*/
              2 DISK FIXED BINARY(7),
              2 FNAME CHARACTER(8),
              2 FTYPE CHARACTER(3),
              2 TFCB(24) FIXED BINARY(7),
            RXBUFF(1522) FIXED BINARY(7) EXTERNAL,/*RX BUF*/
            /* EXTERNAL MODULES */
            RCVDMA ENTRY,/*SETS RECEIVE DISK DMA ADDR*/
            DELEDF ENTRY,/*DELETES FILES*/
            MAKEDF ENTRY,/*MAKES NEW DISK FILES*/
            WRDISK ENTRY,/*WRITES A DISK RECORD*/
            TRMSG  ENTRY,/*SENDS ACK FRAMES*/
            CLOSDF ENTRY;/*CLOSES DISK FILES*/

CALL RCVDMA;
IF RXBUFF(18)=0 THEN /* FIRST FILE FRAME */
   DO;
     PUT SKIP LIST('******* FILE RECEIPT BEGINS *******');
     PUT SKIP LIST('  OPENING FILE- RECFROM_.NET:');
     PUT SKIP(2);
     RXFCB.FNAME='RECFROM '; /*NAME THE RECEIVED FILE*/
     RXFCB.FTYPE='NET';
     RXFCB.TFCB(1)=0; /*ZERO THREE FIELDS OF FCB*/
     RXFCB.TFCB(4)=0;
     RXFCB.TFCB(21)=0;
     CALL DELEDF; /*DELETE OLD FILE OF THIS FN.FT*/
     CALL MAKEDF; /*CREATE A NEW ONE*/
     CALL WRDISK; /*WRITE FIRST RECORD(128 BYTES) TO DISK*/
```

```
          CALL TRMSG;   /* SEND THE FIRST ACK FRAME */
       END;
    ELSE
    IF RXBUFF(18)=1 THEN /*INTERMEDIATE FILE FRAME*/
       DO;
          CALL WRDISK; /*WRITE NEXT RECORD TO DISK*/
          CALL TRMSG;   /* SEND THE ACK FRAME */
       END;
    ELSE
    IF RXBUFF(18)=255 THEN /*LAST(DUMMY) FILE FRAME*/
       DO;
          CALL CLOSDF; /*CLOSE THE DISK FILE*/
          PUT SKIP LIST('******* END FILE RECEIPT *******');
          PUT SKIP LIST('    SEE FILE(S):RECFROM_.NET');
          PUT SKIP(2);
          CALL TRMSG;   /*SEND THE LAST ACK */
          PUT SKIP LIST('            NOTE:');
          PUT SKIP LIST('-----------------------------------');
          PUT SKIP LIST('IF RECEIVED FILE IS A TEXT FILE FROM');
          PUT SKIP LIST('THE VAX THEN REFORMAT USING:');
          PUT SKIP LIST(' 'PIP FNAME.FTYPE=RECFROM_.NET[D80]'');
          PUT SKIP LIST('WHERE FNAME.FTYPE IS YOUR CHOICE');
          PUT SKIP LIST('-----------------------------------');
          PUT SKIP(2);
          IF VTERM=1 THEN
             DO;
                PUT SKIP LIST('STILL IN VAX TERMINAL MODE:');
                PUT SKIP LIST('V>');
             END;
          ELSE
             DO;
                PUT SKIP LIST('IN WAIT LOOP-ENTER<CR> TO EXIT');
                PUT SKIP LIST('******************************');
                PUT SKIP(2);
             END;
       END;
    ELSE
       PUT SKIP LIST(' FRAME TYPE FIELD BYTE 2 INVALID CODE');
    END FILER;

    END RECDATA; /* ISO LAYER 6 RECEIVE MODULE */
```

APPENDIX K

SOURCE CODE FOR MODULE ETHER2.ASM

```
;*************************************************************
;*************************************************************
;*************************************************************
;
; PROGRAM NAME:ETHER2.ASM
;
; THIS MODULE PERFORMS THE ISO LAYER 2 AND 3 FUNCTIONS IN
; TRANSMIT AND RECEIVE AND PROVIDES THE ISO LAYER 7
; RECEIVE MODULE
;
;        APPLICATION LAYER(LAYER 7):IN RECEIVE ONLY- WAIT LOOP
;        FOR FRAME ARRIVAL.
;
;        NETWORK LAYER(LAYER 3):TRANSMIT OR RECEIVE FRAMES
;
;        DATA LINK LAYER(LAYER 2):PROCESSES ACKNOWLEDGE FRAMES
;        IN ADDITION TO THE LAYER 2 FUNCTIONS PERFORMED BY THE
;        NI3010 CONTROLLER BOARD.
;
;        THIS MODULE ALSO ALLOWS ALL OTHER MODULES TO ACCESS
;        THE CP/M-80 OPERATING SYSTEM FUNCTIONS SHOWN BELOW
;
; LAST REVISION: 09/16/83-1000   ORIGINAL PROGRAM: 08/14/83
; AUTHOR: CAPT MARK D. STOTZER-USMC-AEGIS MODELING GROUP
; THESIS ADVISOR: PROFESSOR UNO R. KODRES-COMPUTER SCIENCE
;
;*************************************************************
PUBLIC   INIT; SUBROUTINES AVAILABLE TO EXTERNAL MODULES:
PUBLIC   RECEIVE
PUBLIC   FILBUF
PUBLIC   EMTBUF
PUBLIC   NULBUF
PUBLIC   AWAIT
PUBLIC   TRMSG
PUBLIC   WRDISK
PUBLIC   VAXTXT
PUBLIC   SENDFRAM
PUBLIC   RDISK
PUBLIC   OPENDF
PUBLIC   DELEDF
PUBLIC   MAKEDF
PUBLIC   CLOSDF
PUBLIC   RCVDMA; MODULES CALLED BY THIS MODULE
PUBLIC   TRNDMA
EXTRN    RECDATA
; NI3010 BOARD REGISTER PORT ADDRESSES:
CREG     EQU        00B0H; COMMAND REGISTER
SREG     EQU        00B1H; COMMAND STATUS REGISTER
ISREG    EQU        02B5H; INTERRUPT STATUS REGISTER
IEREG    EQU        00B8H; INTERRUPT ENABLE REGISTER
EBAR     EQU        00B9H; EXTENDED BASE ADDRESS REGISTER
HBAR     EQU        00BAH; HIGH BASE ADDRESS REGISTER
LBAR     EQU        00BBH; LOW BASE ADDRESS REGISTER
HBREG    EQU        00BCH; HIGH BYTE COUNT REGISTER
LBREG    EQU        00BDH; LOW BYTE CCUNT REGISTER
;CP/M WARM BOOT ENTRY POINT:
EXIT     EQU        0000H; WARM BOOT-TERMINAL ERROR ESCAPE
;BDOS EQUATES:
BDOS     EQU        0005H; BDOS ENTRY POINT
;BDOS FUNCTION CODES:
CONSIN   EQU        01H; CONSOLE CHARACTER INPUT
CONSOUT  EQU        02H; CONSOLE CHARACTER OUTPUT
PSTRING  EQU        09H; PRINT STRING
CONSTAT  EQU        0BH; CHECK CONSOLE STATUS
OPENFIL  EQU        0FH; OPEN A DISK FILE
CLOSEF   EQU        10H; CLOSE A DISK FILE
DELETE   EQU        13H; DELETE A DISK FILE
READF    EQU        14H; READ A DISK FILE RECORD-128 BYTES
WRITEF   EQU        15H; WRITE A DISK FILE RECORD-128 BYTES
MAKEF    EQU        16H; CREATE A NEW DISK FILE
SDMA     EQU        1AH; SET DISK DMA ADDRESS
;*********************************************************
;*********************************************************
; INIT- INITIALIZES INTERRUPT VECTOR AND NI3010 REGISTERS:
;
INIT     DI
         IN         SREG; READ STATUS REGISTER TO CLEAR
         MVI        A,03FH; CLEAR NI3010 RECEIVE BUFFER
         OUT        CREG
         CALL       READ
         MVI        A,12H; SET UP INTERRUPT CONTROL
         OUT        0FDH
         MVI        A,00H
         OUT        0FCH
         MVI        A,0DFH; ENABLE INT5 ONLY
         OUT        0FCH
         MVI        A,0C3H
         STA        0028H
         LXI        H,RECFRAM
         SHLD       0029H
         LXI        H,ACK
         MVI        A,0FFH; PRELOAD ACKNOWLEDGE BUFFER
         MOV        M,A
         LXI        H,CEREG; ENABLE RECEIVE(RBA) INTERRUPT
```

```
        MVI     A,04H
        MOV     M,A
        OUT     IEREG
        MVI     A,09H; NI3010 ONLINE COMMAND
        OUT     CREG
        CALL    READ
        EI
        RET
;**********************************************************
;**********************************************************
; RECEIVE:ISO LAYER 7-WAIT LOOP FOR INCOMING FRAMES:
;
RECEIVE EI
WAITLP  NOP
        NOP
        NOP
        NOP
        NOP
        DI
        LXI     H,FRAMIN
        MOV     A,M
        CPI     01H; HAS A FRAME ARRIVED?
        JNZ     NOTYET
        CALL    RECDATA
        MVI     A,00H; RESET FRAME ARRIVAL FLAG
        STA     FRAMIN
NOTYET  MVI     C,CONSTAT
        CALL    BDOS
        CPI     00H
        RNZ
        EI
        JMP     WAITLP
;**********************************************************
;**********************************************************
; RECFRAM-PERFORMS ISO LEVEL 3 FUNCTION IN THE RECEIVE
;       MODE:RECEIVES FRAMES AND TRANSFERS THEM TO MEMORY.
;       HANDLES ALL NI3010 INTERRUPTS AND ENABLES.
;
RECFRAM DI
        PUSH    PSW
        PUSH    B
        PUSH    D
        PUSH    H
        LXI     H,CEREG
        MOV     B,M
        MVI     A,00H
        LXI     H,CEREG; DISABLE NI3010 INTERRUPTS
        MOV     M,A
        OUT     IEREG
        MOV     A,B
        MVI     B,04H
        CMP     B
        JZ      RBA; RECEIVE FRAME INT WAS ENABLED
        MVI     B,07H
        CMP     B
        JZ      RDD; RECEIVE DMA INT WAS ENABLED
        JMP     RDD2; IF TRANSMIT DMA INT WAS ENABLED
RBA     MVI     A,00H
        OUT     EBAR
        LXI     H,RBUFFT; TOP OF RECEIVE BUFFER
        MOV     A,H
        OUT     HBAR
        MOV     A,L
        OUT     LBAR
        LHLD    FRSIZE
        LXI     D,0016H; ADD 22 TO IT
        DAD     D
        MOV     A,H
        OUT     HBREG
        MOV     A,L
        OUT     LBREG
        LXI     H,CEREG
        MVI     A,07H; SET INT ENABLE TO RDD
        MOV     M,A
        OUT     IEREG
        JMP     FINI
RDD     LXI     H,RBUFFT; TOP OF RECEIVE BUFFER
        MOV     A,M
        CPI     00H; TESTS FOR GOOD FRAME
        JNZ     FRERR; BAD RECVD FRAME
        MVI     A,01H; SET FRAME ARRIVED FLAG
        STA     FRAMIN
        LXI     H,RTYPE1; TEST FOR RECVD ACK FRAME
        MOV     A,M
        CPI     00H
        JNZ     RDD2
        LXI     H,RTYPE2
        MOV     A,M
        CPI     0FFH
        JNZ     RDD2
        MVI     A,01H
        STA     ACK; ACK FRAME RECVD
        JMP     RDD2
FRERR   DI
        LXI     H,CEREG
        MVI     A,00H
        MOV     M,A; DISABLE BOARD INTERRUPTS
        OUT     IEREG
        LXI     D,FERMSG0
        CALL    TXTOUT
        LXI     D,TERRMSG
        CALL    TXTOUT
        JMP     EXIT; ESCAPE TO CPM
RDD2    LXI     H,CEREG
        MVI     A,04H
        MOV     M,A; RESET INT ENABLE TO RBA
        OUT     IEREG
FINI    POP     H
        POP     D
        POP     B
        MVI     A,020H; RESTORE INT PRIORITY
        OUT     0FDH
        POP     PSW
        EI
        RET
;**********************************************************
;**********************************************************
; FILBUF-PLACES CONSOLE INPUT MESSAGES INTO TRANSMIT BUFFER
;
FILBUF  LHLD    FRSIZE; LOAD COUNT=FRAME SIZE
        XCHG
        PUSH    D
        LXI     H,TFDATA; LOAD ADDR =TRANSMIT DATA TOP
        PUSH    H
MSGLP   MVI     C,CONSIN; INPUT CONSOLE CHAR.
        CALL    BDOS
        POP     H
        POP     D
        CPI     0DH; WAS CARRIAGE RETURN INPUT?
        JNZ     RDCP
        PUSH    H  ; YES
        LXI     H,VTERM; IN TERMINAL MODE?
        MOV     A,M
        CPI     01H
        JZ      VTEND; THEN THIS IS END OF MSG.
        POP     H
        MOV     M,A; STORE THE CHAR.
        INX     H
        MVI     A,0AH; ADD A LINE FEED
        MOV     M,A; STORE THE LINEFEED TOO
        PUSH    D
        PUSH    H
        MVI     C,CONSOUT; OUTPUT IT TO CONSOLE
        MOV     E,A
        CALL    BDOS
        POP     H
        POP     D
        JMP     RDCON; CONTINUE TO READ THE BUFFER
RDCP    CPI     08H; BACKSPACE=8=CNTL-H
        JZ      BACKSP
        CPI     60H; GRAVE ACCENT=`=END OF MESSAGE
        JZ      SENT
        MOV     M,A; STORE THE CHAR.
        DCX     D; DECREMENT THE COUNTER
        MOV     A,D
        ORA     E
        JNZ     RDCON; IF CTR NOT ZERO THEN CONTINUE READ
        PUSH    H
        LXI     D,LONGMSG;ERROR MSG:TOO MANY INPUT CHAR.
        CALL    TXTOUT
VTEND   POP     H; TERMINAL MSG IN BUFFER-DONE
        MVI     A,60H
        JMP     SENT
RDCON   PUSH    D; CONTINUE BRANCH
        INX     H
        PUSH    H
        JMP     MSGLP; GET ANOTHER CHAR
BACKSP  INX     D
        PUSH    D
        DCX     H
        PUSH    H
        JMP     MSGLP; GET ANOTHER CHAR
SENT    MOV     M,A; STORE THE CHAR
        PUSH    H
        LXI     D,DADDF; LAST ADDR BYTE
        MOV     A,M
        CPI     07FH; IS VAX =DESTINATION?
        JZ      SENFIN
        POP     H
        MVI     A,00H
        MOV     M,A; SOTRE A NULL IN PLACE OF ACCENT
        CALL    EOLN
        RET
SENFIN  POP     H
        CALL    EOLN
        RET
;*****************************************************************
;*****************************************************************
; EMTBUF-DUMPS RECEIVE BUFFER TO CONSOLE:
;
EMTBUF  LHLD     FRSIZE
        XCHG
        PUSH     D
        LXI     H,RDATAT; TOP OF RECEIVE BUFFER
CONLP   MVI     C,CONSOUT; CHAR TO CONSOLE
        MOV     E,M
        PUSH    H
        CALL    BDOS
        POP     H
        POP     D
        DCX     D
        MOV     A,D
        ORA     E
        JZ      MSGDONE; IF COUNT=FRAME SIZE-DONE
        PUSH    D
        INX     H
        JMP     CONLP
MSGDONE CALL    EOLN
        CALL    EOLN
        RET
;****************************************************************
;****************************************************************
; VAXTXT-CONVERTS CPM FORMAT TEXT FILES TO VAX FORMAT:
;
VAXTXT  CALL    EOLN
        MVI     C,OPENFIL; OPEN THE DISK FILE
        LXI     D,FCBIN
        CALL    BDOS
        CPI     ØFFH; TEST IF OPEN SUCCESSFUL
        JZ      FERR1
        MVI     C,SDMA; SET THE DISK DMA ADDRESS
        LXI     D,TXTTOP
        CALL    BDOS
        LXI     D,TRMSG1
        CALL    TXTOUT
        CALL    EOLN
        LXI     H,TXTTOP; TOP OF TEXT BUFFER
        PUSH    H
        LXI     D,TFDATA; TRANSMIT BUFFER 1ST DATA BYTE
        PUSH    D
        MVI     B,ØØH; BYTE CTR=Ø
        PUSH    B
        CALL    NULBUF; FILL TRANSMIT BUFFER WITH ØØ HEX
READREC MVI     C,READF; READ A DISK FILE RECORD=128 BYTES
        LXI     D,FCBIN
        CALL    BDOS
        CPI     ØØH; IS THIS LAST RECORD?
        JNZ     ENDRD
RDLPA   POP     B
        POP     D
        POP     H
        INR     B; INCREMENT COUNTER
        MOV     A,B
        CPI     Ø81H;=129 LAST BYTE THIS RECORD
        JZ      READ2; GET ANOTHER RECORD
        MOV     A,M
        CPI     ØDH; CRET?
        JZ      SKIP2
        CPI     ØAH; LFEED?
        JZ      SKIP3
        XCHG
        MOV     M,A
        XCHG
        INX     H
        INX     D
```

```
          PUSH      H
          PUSH      D
          PUSH      B
          JMP       RDLPA
SKIP2     INX       H; IF BYTE=CRET THEN SEND THE FRAME
          PUSH      H
          LXI       D,TFDATA
          PUSH      D
          PUSH      B
          CALL      SENDFRAM; SEND IT
          CALL      NULBUF; NULL THE BUFFER AGAIN
          MVI       A,01H; SET TYPE FIELD=INTERMED FRAME
          STA       TTYP2
          JMP       RDLPA; READ NEXT BYTE AFTER SKIP CRET
SKIP3     INX       H; IF LINEFEED THEN SKIP AND READ MORE
          PUSH      H
          PUSH      D
          PUSH      B
          JMP       RDLPA
READ2     LXI       H,TXTTOP; IF CTR >128 THEN GET RECORD
          PUSH      H
          INX       D
          PUSH      D
          MVI       B,00H; RESET BYTE CTR
          PUSH      B
          JMP       READREC GET THE NEXT RECORD
ENDRD     MVI       A,0FFH
          STA       TTYP2
          POP       B
          POP       D
          POP       H
          CALL      SENDFRAM
          LXI       D,DMSG
          CALL      TXTOUT
          RET               ; DONE
FERR1     LXI       D,ERMSG; ERROR MSG-FILE NOT OPEN
          CALL      TXTOUT
          RET
;*************************************************************
;*************************************************************
; ISO LEVEL 3 TRANSMIT FUNCTION-SENDFRAM:
;
; SENDFRAM-SENDS FRAMES ON THE ETHERNET:
;
SENDFRAM DI
LOOP1     LXI        H,CEREG; LOOP UNTIL ENABLE REG= 0 OR 4
          MOV        A,M
          CPI        00H
          JZ         GO
          CPI        04H
          JZ         GO
```

```
        EI
        JMP     LOOP1; KEEP CHECKING
GO      DI
        LXI     H,CEREG
        MOV     A,M
        CPI     00H
        JZ      GO1
        CPI     04H
        JZ      GO1
        EI
        JMP     LOOP1; IF CHANGED GO BACK TO LOOP
GO1     MVI     A,00H
        LXI     H,CEREG; DISABLE NI3010 INTERRUPTS
        MOV     M,A
        OUT     IEREG
        EI
        MVI     A,00H; LOAD TRANSMIT ADDR/BYTE COUNT
        OUT     EBAR
        LXI     H,TBUFFT; TOP OF TRANSMIT BUFFER
        MOV     A,H
        OUT     HBAR
        MOV     A,L
        OUT     LBAR
        LHLD    FRSIZE; SET TRANSMIT FRAME SIZE
        LXI     D,0008H; ADD 8 TO IT
        DAD     D
        MOV     A,H
        OUT     HBREG
        MOV     A,L
        OUT     LBREG
        DI
        MVI     A,06H
        LXI     H,CEREG; ENABLE TRANSMIT(TDD) INTERRUPT
        MOV     M,A
        OUT     IEREG
        EI
        HLT             ; WAIT FOR THE INTERRUPT
COMP    LXI     H,CEREG
        MOV     A,M
        CPI     06H; HAS TDD INTERRUPT ARRIVED?
        JZ      COMP
        DI
        LXI     H,VTERM
        MOV     A,M
        CPI     01H; VIRTUAL TERMINAL MODE?
        JZ      VTCON
        LXI     D,MSG1
        CALL    TXTOUT
VTCON   EI
        MVI     A,029H; NI3010 LOAD TRANSMIT AND SEND CMD.
        DI
```

```
         OUT       CREG
         CALL      TRREAD
         LXI       H,ACK; SET ACK TO SENT
         MVI       A,00H
         MOV       M,A
         EI
         CALL      AWAIT; WAIT FOR ACKNOWLEDGE FRAME
         RET
;*************************************************************
;*************************************************************
; ISO LEVEL 2 ROUTINES: AWAIT(TRANSMIT) AND TRMSG(RECEIVE):
;
;*************************************************************
; AWAIT-WAITS FOR RETURN OF ACKNOWLEDGE FRAMES:
;
AWAIT    LXI       D,0000FH; FIRST TIMER LOOP COUNTER
TRNLP    LXI       B,0FFFFH; INNER LOOP
TRNLP1   LXI       H,ACK
         MOV       A,M
         CPI       01H; RECEIVED ACK YET?
         JZ        BACK
         DCX       B
         MOV       A,C
         ORA       B
         JNZ       TRNLP1
         DCX       D
         MOV       A,E
         ORA       D
         JNZ       TRNLP
         LXI       D,TIMMSG; TIMED OUT-ABORT
         CALL      TXTOUT
         LXI       D,TERRMSG
         CALL      TXTOUT
         JMP       EXIT; ESCAPE TO CPM
BACK     MVI       A,0FFH; RESET ACK FLAG
         STA       ACK
         MVI       A,00H; RESET FRAME ARRIVAL FLAG
         STA       FRAMIN
         RET
;*************************************************************
; TRMSG-SENDS ACKNOWLEDGE FRAMES IN RECEIVE MODE:
;
TRMSG    MVI       C,03H; CTR=3
         LXI       H,SRCADDD
         LXI       D,DADDD
LOOP2    MOV       A,M
         XCHG
         MOV       M,A
         XCHG
         DCR       C
         JZ        LDCONT
         INX      H
         INX      D
         JMP      LOOP2
LDCONT   MVI      A,020H; RESET INTERRUPT PRIORITY
         OUT      0FDH
         MVI      A,00H
         OUT      EBAR
         LXI      H,TBUFFT
         MOV      A,H
         OUT      HBAR
         MOV      A,L
         OUT      LBAR
         LHLD     FRSIZE
         LXI      D,0008H
         DAD      D
         MOV      A,H
         OUT      HBREG
         MOV      A,L
         OUT      LBREG
         MVI      A,00H; LOAD TYPE FIELD=ACK FRAME
         STA      TTYP1
         MVI      A,0FFH; ACK FRAME
         STA      TTYP2
         MVI      A,06H; ENABLE TDD INTERRUPT
         LXI      H,CEREG
         MOV      M,A
         OUT      IEREG
         EI
         HLT               ; WAIT FOR THE INTERRUPT
DONE     LXI      H,CEREG
         MOV      A,M
         CPI      06H; TRANSMIT DMA DONE?
         JZ       DONE
         DI
         MVI      A,029H; LOAD TRANSMIT AND SEND COMMAND
         OUT      CREG
         CALL     TRREAD
         RET
;*************************************************************
;*************************************************************
; OPERATING SYSTEM SUBROUTINES:
;
RDISK    MVI      A,00H; READS A DISK FILE RECORD=128 BYTES
         STA      LFRM ; PRELOAD LAST FRAME FLAG
         LXI      D,FCBIN
         MVI      C,READF
         CALL     BDOS
         CPI      00H; =NOT LAST FRAME
         RZ
         MVI      A,01H;=LAST FRAME
         STA      LFRM
         RET
;*************************************************************
WRDISK   MVI        C,WRITEF;WRITES DISK FILE RECORD-128BYTES
         LXI        D,FCBOUT
         CALL       BDOS
         CPI        00H
         JNZ        DWERR
         LXI        D,WRMSG
         CALL       TXTOUT
         RET
DWERR    LXI        H,CEREG
         MVI        A,00H; DISABLE BOARD INTERRUPTS
         OUT        IEREG
         LXI        D,DWMSG
         CALL       TXTOUT
         JMP        EXIT; ESCAPE TO CPM
;*************************************************************
OPENDF   MVI        A,00H; OPENS DISK FILES
         STA        FNOP
         LXI        D,FCBIN
         MVI        C,OPENFIL
         CALL       BDOS
         CPI        0FFH; OPENING ERROR
         RNZ
         MVI        A,01H
         STA        FNOP
         RET
;*************************************************************
DELEDF   LXI        H,RECFIL; DELETES EXISTING DISK FILES
         MOV        A,M
         INR        A; INCREMENT RECEIVED FILE NUMBER
         STA        RECFIL
         STA        FCBOUT+8
         LXI        D,FCBOUT
         MVI        C,DELETE
         CALL       BDOS
         RET
;*************************************************************
MAKEDF   LXI        D,FCBOUT; MAKES A NEW DISK FILE
         MVI        C,MAKEF
         CALL       BDOS
         RET
;*************************************************************
CLOSDF   LXI        D,FCBOUT; CLOSES A DISK FILE
         MVI        C,CLOSEF
         CALL       BDOS
         RET
;*************************************************************
RCVDMA   LXI        D,RDATAT; SETS DISK DMA FOR RECEIVE MODE
         MVI        C,SDMA
         CALL       BDOS
```

```
        RET
;**************************************************************
TRNDMA  LXI     D,TFDATA; SETS DISK DMA ADDR FOR TRANSMIT
        MVI     C,SDMA
        CALL    BDOS
        RET
;**************************************************************
;**************************************************************
; UTILITY SUBROUTINES:
; READ-READS THE COMMAND STATUS REGISTER AFTER EACH COMMAND:
;
READ    MVI     B,11111110B
        MVI     C,00H
STLP    IN      ISREG
        ORA     B
        CPI     0FFH; STATUS READY TO BE READ?
        JNZ     STLP
        IN      SREG
        CMP     C
        JZ      STDONE
        JMP     ERROR
TRREAD  MVI     B,11111110B
STLP1   IN      ISREG
        ORA     B
        CPI     0FFH
        JNZ     STLP1
        IN      SREG
        CPI     00H
        JZ      STDONE
        CPI     01H
        JZ      STDONE
ERROR   LXI     D,EMSG
        CALL    TXTOUT
STDONE  RET
;**************************************************************
; TXTOUT-OUTPUTS TEXT STRINGS TO THE CONSOLE:
;
TXTOUT  MVI     C,PSTRING
        CALL    BDOS
        CALL    EOLN
        RET
;**************************************************************
; EOLN-GENERATES CARRIAGE RETURN + LINE FEED:
;
EOLN    MVI     C,CONSOUT
        MVI     E,0DH
        CALL    BDOS
        MVI     C,CONSOUT
        MVI     E,0AH
        CALL    BDOS
        RET
```

```
;**************************************************************
; NULBUF-FILLS THE TRANSMIT BUFFER WITH NULLS(00 HEX):
;
NULBUF   MVI       C,0080H; CTR=128
         LXI       H,TFDATA
NULLOOP  MVI       A,00H
         MOV       M,A
         DCR       C
         RZ
         INX       H
         JMP       NULLOOP
;**************************************************************
;**************************************************************
; STORAGE ALLOCATION:
;
FRAMIN   DS        1 ; FRAME ARRIVAL FLAG
CEREG    DS        1 ; COPY OF INTERRUPT ENABLE REG VALUE
; NEEDED MESSAGES:
TRMSG1   DB       '****** FILE TRANSFER BEGINS *****$'
DMSG     DB       '****** FILE TRANSFER COMPLETE *****$'
ERMSG    DB       'FILE NOT ON DISK$'
NORESMSG DB       'ON RESPONSE FROM VAX-EXITING TO CPM$'
LONGMSG  DB       'MAX CHARACTER LENGTH REACHED-MSG SENT$'
TERRMSG  DB       'UNRECOVERABLE ERROR-EXITING TO CP/M$'
TIMMSG   DB       'TIMED OUT-ABORTING TRANSMISSION$'
EMSG     DB       'NI3010 COMMAND FAILED$'
MSG1     DB       'TX$'
FERMSG0  DB       'RECEIVED BAD FRAME$'
WRMSG    DB       'RX$'
DWMSG    DB       'DISK WRITE ERROR-DISK FULL$'
COMMON/TXFCB/
FCBIN    DS        36; TRANSMIT FILE CONTROL BLOCK
COMMON/RXFCB/
FCBOUT   DS        36; RECEIVE FILE CONTROL BLOCK
COMMON/TXBUFF/
TBUFFT   DS        1 ; TRANSMIT BUFFER TOP-1ST DEST ADDBYTE
DADDB    DS        1 ; SECOND DEST ADDR BYTE
DADDC    DS        1 ; THIRD DEST ADDR BYTE
DADDD    DS        1 ; FOURTH DEST ADDR BYTE
DADDE    DS        1 ; FIFTH DEST ADDR BYTE
DADDF    DS        1 ; SIXTH DEST ADDR BYTE
TTYP1    DS        1 ; FIRST TYPE FIELD BYTE
TTYP2    DS        1 ; SECOND TYPE FIELD BYTE
TFDATA   DS      1500; DATA FIELD MAX SIZE
COMMON/RXBUFF/
RBUFFT   DS        13; RECEIVE BUFFER TOP-FRAME CHECK BYTE
SRCADDD  DS        1 ; FOURTH SRCE ADDR BYTE
SRCADDE  DS        1 ; FIFTH SRCE ADDR BYTE
SRCADDF  DS        1 ; LAST SRCE ADDR BYTE
RTYPE1   DS        1 ; FIRST RECVD FRAME TYPE FLD BYTE
RTYPE2   DS        1 ; SECOND RECVD TYPE FLD BYTE
```

```
RDATAT    DS       1500; RECVD DATA FIELD MAX SIZE
CRCBYT    DS          4 ; CRC FIELD
COMMON/TXTBUF/
TXTTOP    DS        128; VAX TEXT TEMP BUFFER
COMMON/FRSIZE/
FRSIZE    DS          2 ; ACTUAL FRAME DATA BLOCK SIZE
COMMON/ACK/
ACK       DS          1 ; ACKNOWLEDGE FLAG LOCATION
COMMON/FNOP/
FNOP      DS          1 ; FILE NOT OPEN FLAG
COMMON/LFRM/
LFRM      DS          1 ; LAST FRAME FLAG
COMMON/TRMODE/
TRMODE    DS          1 ; VAX TRANSMIT FLAG
COMMON/FILTYP/
FILTYP    DS          1 ; TYPE OF FILE TO SEND
COMMON/RECFIL/
RECFIL    DS          1 ; RECEIVED FILE NUMBER
COMMON/VTERM/
VTERM     DS          1 ; VIRTUAL TERMINAL SERVICE FLAG
          END; ASSEMBLY LANGUAGE MODULE ETHER2.ASM
;************************************************************
;************************************************************
;************************************************************
```

APPENDIX L

TEST PROGRAM USER INSTRUCTIONS

The Ethernet hardware test programs, ETHTESTA and ETHTESTB, are used in the manner below:

1. Invoke either program using normal CP/M-8Ø procedures.
2. Both programs first command the NI3Ø1Ø to run it´s built-in diagnostic tests and report failures to the user via the console. The codes that ETHTESTB will display as ASCII letters are encoded as noted at the end of the ETHTESTB.ASM source listing.
3. Next, both programs ask the user to input a short line of text that the programs use in testing the integrity of the essential data paths of the NI3Ø1Ø. Program ETHTESTB will ask the user for a second text line input because it performs one more test than ETHTESTA. The maximum number of characters per line is 42 and the line must be ended with a grave accent: "`".
4. The tests are successful if no error indications are displayed on the console and the text typed in is shown on the console exactly as it was entered after each data path input.

APPENDIX M

COMMUNICATION PROGRAM USER INSTRUCTIONS

The instructions for use of the communication program ETHERNET.COM are as listed below:

1. Invoke the program ETHERNET using normal CP/M-80 procedures.

2. The program will then ask for the selection of:
   A. The disk drive number to write any received files to.
   B. The desired number of data bytes per Ethernet frame.
   C. The network service desired. The choices are:
      1. Send messages or files.
      2. Receive messages or files.
      3. Virtual terminal service with the VAX.
      4. Command file transfers to or from the VAX.
      5. Disconnect from the network.

Depending on which of the above services is requested by the user, the program will do the following:

1. Send a file or message: The program will ask the user to specify which one and, depending on the response. will do the following:
   A. If message sending is selected, the program will:
      1. Ask the user to choose the network address of the destination.
      2. Then ask the user to input the message itself. The maximum message size is determined by the previously selected data block size. The last character entered in order to transmit must be a grave accent character: " ` ".
      3. The message is then sent and upon successful receipt by the destination host the program restarts.
   B. If file sending is selected, the program will:
      1. Ask the user if the file is a text or machine code file.
      2. Ask the user to specify which disk the file is located on.
      3. Ask the user the filename and filetype of the

file.
4. Ask the user to specify the network address of the destination.
5. Upon successful transmission of the entire file the program will restart.

2. Receive a file or message: The program will, upon selection of this mode, wait in a loop for any transmissions addressed to it to arrive. After the receipt of any file or message, the program will return to the wait loop. This feature allows the user to leave the system unattended and then send multiple files and/or messages to it from another network host. The program numbers files in the order they are received beginning with RECFROM0.NET, etc. Text files received from the VAX must be run through the CP/M PIP utility as follows: "PIP newfilname.filetype=RECFROM_.NET[D80]" which will chop off unneeded characters. The user can exit the wait loop to return to the above menus by entering a carriage return.

3. Terminal service with the VAX 11/780: The program will display a set of instructions to the user concerning the operation of the program in this mode. The user can input text after each V-prompt (V>) appearance. To exit this mode, the user must enter a period (.) followed by a carriage return immediately following any V-prompt (V>). Upon exiting this mode, the program returns to the beginning user menus.

4. Command VAX file transfers: This mode allows the INTELLEC system to command the VAX to either send or receive files by sending it specially coded messages. The procedure is as follows:
   A. Downloading VAX files:
      1. The user must enter the message: "!VAX filename.VAXfiletype/TXT or EXE`"
      2. The specified VAX file will then be sent to the requesting unit.
      3. In the above message, TXT refers to text and EXE refers to machine code files.
      4. After the file receipt is completed, the puser can exit the wait loop by entering a carraige return.
   B. Uploading VAX files:
      1. The user must enter the message: "@VAX filename.VAX filetype/TXT or EXE`"
      2. The above message opens a file by the above filename and filetype on the VAX. The VAX will reply: "Ready for sendfile FN.FT" and the

    program will be in the receive wait loop.
    3. The user must then enter a carriage return to the beginning of the program and then follow the normal file sending procedures as noted above.

5. Disconnect from the network: Selection of this mode causes the program to return control to the CP/M-80 operating system.

The other features of this program are as follows:

1. Error handling: The below listed transmission or reception errors will cause the program to display error messages and return to CP/M-80:
   A. Receipt of a bad frame.
   B. Receipt of a frame that has an improperly encoded type field.
   C. Acknowledge frame not received by the sending host in a given time frame (Source timed out).
   D. Receipt of a file larger than the disk space remaining (Disk full).

2. Special instructions for IAPX 432 files that must be transferred from the VAX to an INTELLEC system running the Intel ISIS-II operating system:
   A. These special files can only be transferred using the VAX command mode. The VAX/VMS program ETHERNET.EXE must be invoked on the VAX in order for this transfer to be successful.
   B. The procedure is as follows:
      1. After downloading the file to the INTELLEC double density system using ETHERNET.COM and CP/M-80, the user must rename it from the name assigned to it by the receive program to it´s original name.
      2. The user must put the CP/M-80 disk in drive A which must have stored on it both the renamed file and the program TOISIS.COM.
      3. The user must then insert an ISIS-II disk into drive B.
      4. The user then, while logged on drive A, must invoke TOISIS filename.filetype. This will convert the program on disk A to the ISIS-II format and store it on disk B.
      5. The user must then remove the CP/M-80 disk in drive A and replace it with the disk from drive B.
      6. The last step is to reboot the INTELLEC system under the ISIS-II operating system and proceed with the IAPX 432 procedures.

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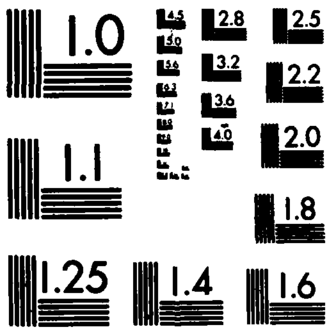

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