THIS BOOK CONTAINS NUMEROUS PAGES WITH DIAGRAMS THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.

THIS IS AS RECEIVED FROM CUSTOMER.

STERLING: A PEDAGOGICAL IMPLEMENTATION OF THE ISO MODEL FOR OPEN SYSTEM INTERCONNECTION

by

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ACKNOWLEDGEMENTS

This report is dedicated to my father, in fulfillment of a birthday pledge I made to him over twenty years ago. I would like to thank my wife Suzette and my son Sterling for their support during this project, my brother Randy for being such a good role model, and my advisor Dr. Wallentine for refusing to let me do anything less than my best.

PREFACE

In the spring of 1982 I completed course CS-725, Computer Networks, with the assigned text 'COMPUTER NETWORKS' by Andrew Tanenbaum. I found the text to be clear and easily understood, but suffering from several problems.

The Tanenbaum text is built around a discussion of the ISO (International Standards Organization) Reference Model for computer networks. While I agree with the idea of using a central reference when discussing the design of the various networks currently in use, a problem arises because there are no networks that truly follow the ISO model. The author does give segments of Pascal code to illustrate portions of the model, but no comprehensive overview is given.

Another problem is the order in which the layers of the ISO model are presented. It is now generaly considered good style to aproach problem analysis and program design in a 'top down' manner. Tanenbaum chose, however, to start with the bottom layers of the model and work his way to the top. This results in students having to cope with such problems as error correcting protocols before they even have an understanding of the essential aspects of a computer network and the functions it is to provide.

I believe that Per Brinch Hansen has shown us an excellent way to teach a complex computer system with his SOLO operating system [solo]. He wrote a simplified but operational version of a single user operating system in a concurrent superset of Pascal.

He used a highly structured design to separate the various functions of the operating system and provided sufficient docmentation to allow the students to modify the various components of the program.

I intend to correct those problems mentioned above by following Brinch Hansen's example and implementing a simple pedagogical network (STERLING) based on the ISO model. I will discuss the functions of the top four layers, design processes that perform simple subsets of those functions, and implement the designs in a language available at KSU. The report will not be an in-depth study of the ISO model, networking in general, or the language chosen for the implementation. Rather it should simply be viewed as a general workbook and source of assignments for a course in computer networks.

The goals of this project are as follows, to:

1. Provide a reference for teaching the ISO network reference model by implementing a simple version in a language available at KSU;
2. Provide a minimal subset of functions for the top four layers of the ISO model;
3. Design the layers for easy expansion and modification by students;
4. Allow for the function of each layer to be examined separately from other layers; and
5. Design for simplicity and clarity rather than efficiency and robustness.

CHAPTER 0

0.0: Motivations For Networks

Computers were originally expensive, monolithic machines of limited capabilities. They were the nucleus of a small cluster of terminals, printers, and other peripheral devices. Because of the expense of the equipment, it was practical to devise methods for remote facilities to communicate with a central computer rather than purchasing additional equipment. This trend continued with the linking together of large facilities, making it easier to share both hardware and software resources. If one location's facilities became overloaded, part of the burden could be shifted to a remote site. Users could also access proprietary software developed at another location.

As the cost of equipment decreased it became cost effective to install small computers at those remote sites that had none. Data could be partially processed, and its volume greatly reduced, before transmission to a central location for final disposition. As computers became more specialized, small computers were introduced which served as 'front end machines', freeing the large machines from trivial duties and allowing them to concentrate their resources on those problems that they could best solve. Some modern applications of computer networks follow [1].

* Systems for corporate operations of many different types, e.g., order entry systems, centralized purchasing, distributed inventory control, insurance underwriting.

* Corporate information networks, marketing information, customer information, product information.

* Airline reservations, car rental, hotel booking,

* Electronic mail and message sending, two-way interchange of messages.

* Electronic transfer of financial transactions between banks and via checking clearing houses.

* Consumer check and credit verification in stores and restaurants, and in some cases consumer electronic fund transfer; bank cash dispensers and customer terminals.

* Intercorporate networks. For example, a computer in one firm transmits orders or invoices to another. Insurance agents have insurance company terminals, possibly via a shared network. Travel agents have terminals from airlines, shipping lines, hotel chains, etc.

* Stock market information systems which permit searches for stocks that meet a certain criteria, performance comparisons, moving averages, and various forecasting techniques, all using dialogues which employ graphics.

* Terminal systems for investment advice and management, tax preparation, tax minimization [sic].

* Home information services (Such as Prestel [British Post Office], or any which use the home TV set)

0.1: An Approach To The Study Of Networks

Modern software engineering techniques stress the Top Down approach to understanding and solving problems. This paper's method of understanding computer networks will follow this approach of decomposing the problem into smaller modules, or layers. Starting with an application program, it will be determined what services are necessary for the layer to communicate with processes on other machines. A module will be added providing these services, then this module itself will be decomposed. This process will continue until we have reached the

underlying network itself. Each layer will be formalized and tested before continuing, in order to insure the robustness of the solution.

A basic principle of layering is to ensure independence of each layer by defining the services provided by the layer, regardless of how these services are performed. This layering permits changes to be made in the way a layer or a set of layers operates, provided that they still offer the same service to the next higher layer [2].

This is the approach used by the International Standards Organization (ISO) Subcommittee 97/16 in formulating the ISO Reference Model of Open Systems Interconnection [2] [3] [15]. The members of this organization approached the layering of the model using the following guidelines [3] :

P1: do not create so many layers as to make difficult the system engineering task describing and integrating these layers,

P2: create a boundary at a point where the services description can be small and the number of interactions across the boundary are minimized [sic],

P3: create separate layers to handle functions which are manifestly different in the process performed or the technology involved,

P4: collect similar functions into the same layer,

P5: select boundaries at a point which past experience has demonstrated to be sucessful,

P6: Create a layer of easily localized functions so that the layer could be totaly redesigned and its protocols changed in a major way to take advantage of new advances in architectural, hardware or software technology without changing the services and interfaces with adjacent layers,

P7: create a boundary where it may be useful at some point in time to have the corresponding interface standardized,

P8: create a layer when there is a need for a different level of abstraction in the handling of data, e.g. morphology, syntax, semantics,

P9: Enable changes of functions or protocols within a layer without affecting the other layers,

P10: create for each layer interfaces with its upper and lower layer only,

P11: create further subgrouping and organization of functions to form sublayers within a layer in cases where distinct communication services need it [sic],

P12: create, where needed, two or more sublayers with a common, and therefore minimum, functionally [sic] to allow interface operation with adjacent layers,

P13: Allow by-passing of sublayers,

Figure-1 depicts the ISO model with its seven layers. This model provides the framework for this study. Layers one, two, and three comprise a network over which data can be routed to another computer. Standards for the lower three layers are the most clearly defined because CCITT and the ISO and ANSI Data Communication Technical Committees have been working on these standards for many years [11]. Layers four, five, and six are the means by which a host machine can access the network, and are the primary emphases of this work.

STERLING is a series of five programs that demonstrates the functions of the top layers of the ISO model. A minimal subset of the layer under study is implemented at each stage of the top-down decomposition. The programs are strictly pedagogical, with the emphasis on underlying principles rather than clever code. They are fully documented, and their modular design lends

itself to easy modification by students. Network services can be added, deleted, and modified with a minimum of difficulty.

I.S.O. NETWORK MODEL

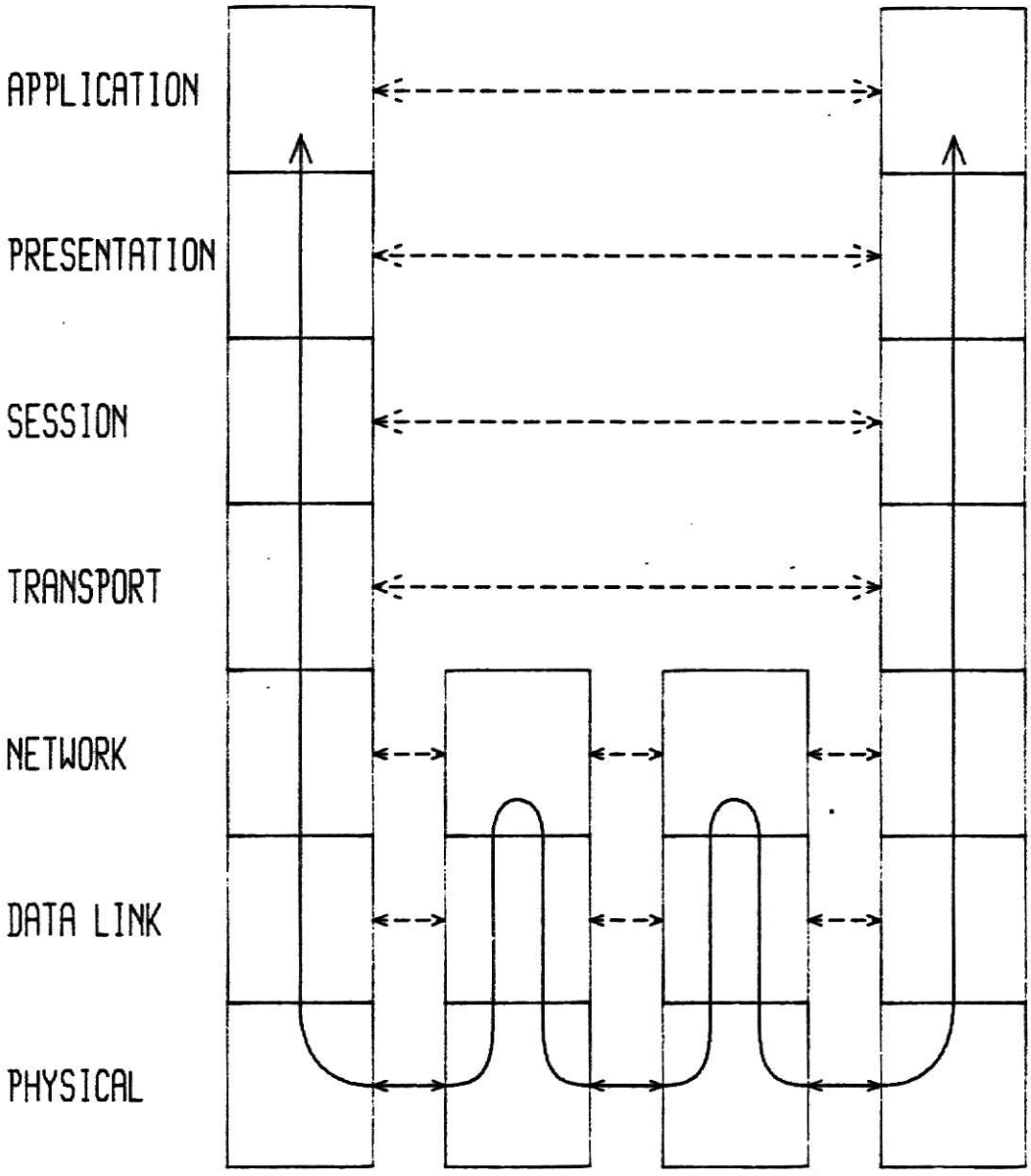


Figure 1

CHAPTER 1

1.0: Concurrent Pascal

Sterling is implemented in Concurrent Pascal (C-Pascal), a superset of standard Pascal developed by Per Brinch Hansen at the California Institute of Technology. C-Pascal is a highly structured language designed to allow the user to specify exactly what concurrent processes can do to shared variables, and to depend on the compiler to check that the programs satisfy these assumptions [5].

C-Pascal has several additional advantages which led to its choice as the implementation language. The original compiler, written in 1974 by Al Hartman, has been fully documented and published [16]. Also, C-Pascal is widely available in academia and is implemented at KSU on the Interdata 8/32 computer. It is a simple extension to standard Pascal, and can be understood easily by anyone with a working knowledge of structured programming languages. Additionally, it has proved successful in other pedagogical implementations of operating systems [5] and networks [4].

A major benefit of Concurrent Pascal is the ability of the programmer to divide the shared data structures of an operating system into small parts and define allowable operations on each of them. Processes perform concurrent operations using monitors to synchronize themselves and exchange data, and access private data structures by means of classes [5].

A Class is a privately owned procedure. It is initialized

once by its parent (a process or monitor), and after initialization its private data structures exist until the termination of its parent. Access rights to the class are owned by its parent. These rights can be passed to other classes owned by the same parent, but not to other processes or monitors.

Monitors, independently introduced by Hoare [6] and Brinch Hansen [7], refer to a shared procedure and its permanent data structures within a zone of mutual exclusion. Mutual exclusion is the mechanism which allows processes to acquire exclusive control of a resource for a finite period of time. Processes competing for the monitors thus gain access to, or control of, them in some sequential order [9]. Synchronization through monitors is enhanced by the two primitives DELAY and CONTINUE.

A process can be delayed in a monitor for any length of time by the process executing a DELAY. When a calling process is delayed in a monitor it loses its exclusive access to the monitor's variables until another process calls the same monitor and executes a CONTINUE. The process issuing the CONTINUE is then removed from the monitor, and the delayed process regains its exclusive access and resumes execution.

1.1: Mailboxes

In STERLING the C-Pascal primitives are uses to implement another method of interprocess communication and synchronization: the Mailbox or Message Buffer. A mailbox can be viewed as a restricted monitor, where the only operations allowed on the shared data structure are the storage and retrival of messages.

Mailboxes were chosen for several reasons. The primitives for the creation, use, and deletion of mailboxes already exist on many operating systems (Data General AOS, Digital VMS, Unix, etc). By strictly limiting the monitor's capabilities to communicate and synchronize, the entire function of a network layer can be viewed within a single process. The two entry points to a mailbox are analgous to performing 'reads' and 'writes' , thus making them easy to understand. Finally the user processes are only loosely coupled to each other and therefore need not share common memory, making this method easily adaptable to distributed systems. (see figure 2)

Communication through a mailbox is subject to two resource constraints [7]:

1) the sender cannot exceed the finite capacity of the storage buffer; and
2) the receiver cannot consume messages faster than they are produced.

The messages should also be delivered in the same order that they are sent, without loss or modification of their content.

STERLING satisfies these constraints. If a sender tries to deposit a message in a full buffer, it is delayed until the receiver removes a message from the buffer. If a receiver tries to take a message from an empty buffer, the receiver is delayed until a sender has deposited a message into the buffer. Finally, the buffer is controlled on a strictly First-In-First-Out basis, with no operations performed on it but depositing and removing messages.

MAILBOX COMMUNICATION

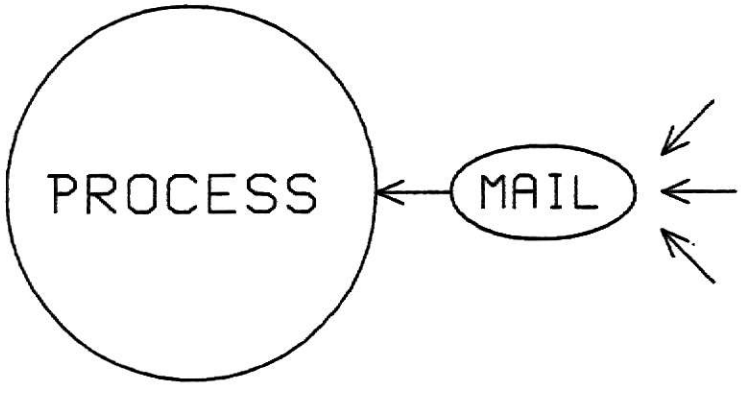


Figure 2

1.2: Design Of STERLING

Each of STERLING's five programs is designed as a group of independent processes communicating through mailboxes. Each process has a private mailbox through which it receives messages from one or more other processes. The processes may receive mail only through their private mailbox. As each layer of the ISO model is introduced a new process is added to each site of the simulated network representing the function of that layer. Figure 3 contains an illustration of how the communication paths for one node of the network would look with all seven layers of the model implemented.

A node of a network may have several application processes residing on it which access the network at the same time. While the code necessary to multi-thread STERLING's nodes would not be very complicated, the network was implemented with single-user nodes, with multi-threading left as a programming activity for the student.

As the messages are passed through the various layers on the way to the network, new information is added to allow the peer layers to communicate. It is also typical for some layers to break long messages into smaller packets before transmission. This breaking into packets conflicts somewhat with C-Pascal's rigid enforcement of compile-time strong typing. Experiments with variant records made the mailbox mechanism clumsy, and were abandoned in favor of a single fixed-length record (with some fields ignored) for all communication.

C-Pascal, as implemented at KSU, has extremely limited I/O

7 LAYER ACCESS DIAGRAM

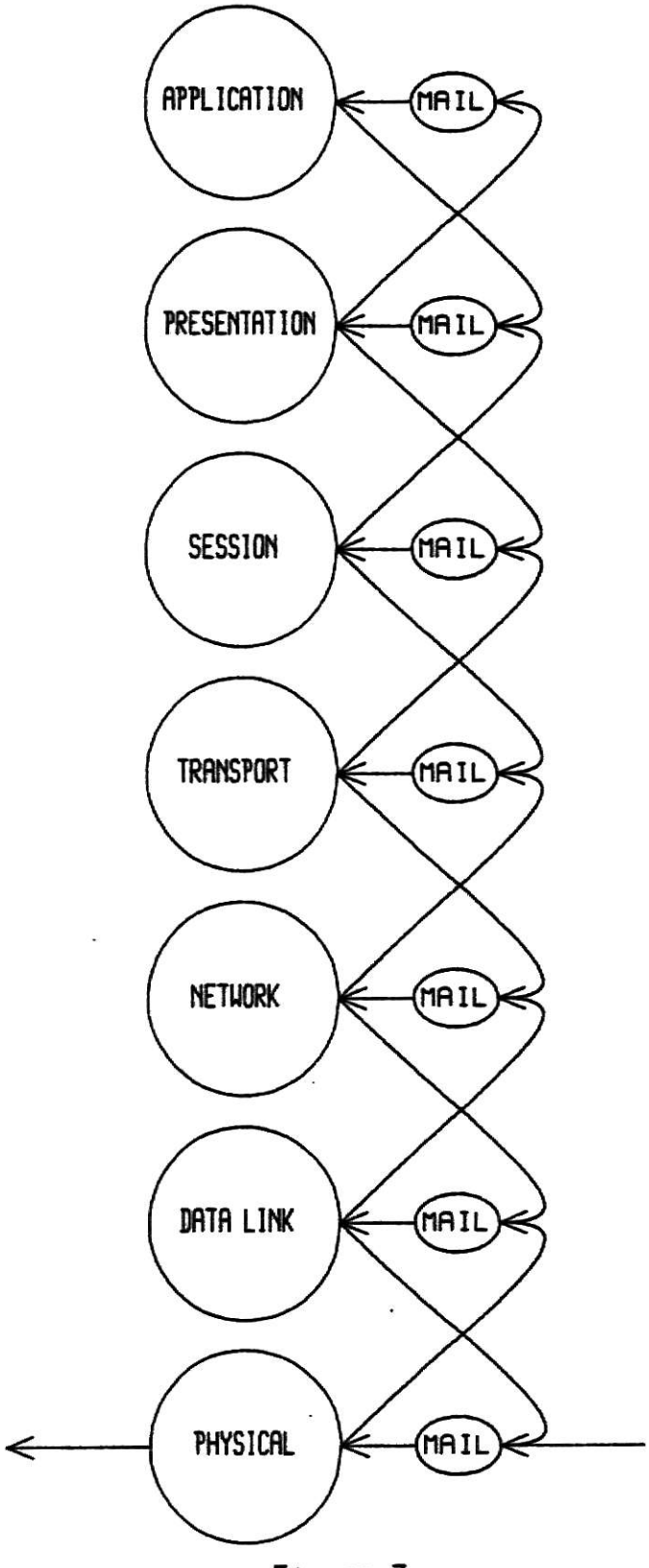


Figure 3

capabilities. In order to provide STERLING with the file access it required, it was necessary to perform all input and output via supervisory calls to the operating system. Because of the limited capabilities of the programs, very little was required of these calls, and they were implemented in an easily understood Class procedure. The flag setting necessary for supervisory calls closely parallels the flag setting STERLING uses in communicating with the network, and should help the student to understand the principle of the hiding of low level interfaces within a high level language.

It becomes necessary at the Transport layer of this model for a process to be able to 'time out' if it receives no messages. This facility is not provided by the language, and had to be simulated by adding an additional process and monitor at each node of the network. A minor modification had to be made to the C-Pascal Kernel [10] to allow a process to call the 'Wait' primitive even if all other processes are in a delayed state.

Another problem that became most apparent during the implementation of the Transport layer was the inability of C-Pascal to allocate buffer space dynamically at run-time. Several solutions were examined and rejected because their complexity distracted from the general goals of the layer. The final implementation uses a simplified Transport protocol that does not require buffer management.

CHAPTER 2

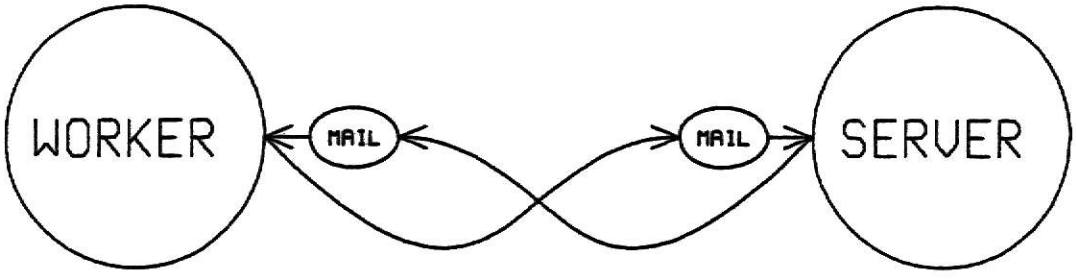
2.0: NET0

In the simplest view, a network can be thought of as just the means for two or more processes to communicate. The processes must be sure that any messages sent are delivered to the correct destination in a timely manner, in the correct order, and with no loss of data integrity. These constraints hold no matter if the processes are on the same host computer or are on opposite sides of the earth. It is appropriate, therefore, that the study of networks begins by looking at a simple example of two processes exchanging messages without the use of any formal network structures.

A typical situation calling for interprocess communication is the management of a data base. In this situation it is the duty of one process to control all access to the information stored in the data base. This 'Server' process is the only process with access rights to the information. Any query from a 'Worker' process must be made by sending a request message to the Server. The Server can respond either by accessing the data base and transfering the requested information to the Worker, or by sending back a rejection message.

NET0 (see listing 0) is a simple demonstration of this type of interprocess communication. The Server process controls access to four files (FILE_A to FILE_D). The Worker process receives a request for a file from the terminal, then sends the request to the Server. If the Server is able to fill the request, it

transfers the file to the worker, which displays it on the terminal. If the request cannot be filled (i.e. the file does not exist), the server sends a rejection message to the worker. This sequence cycles until the program is terminated by issuing a break at the terminal.



NETO ACCESS DIAGRAM

Figure 4

```
(* *Cpascal Prefix*)
INCLUDE NETPFX

  (*************************************************************
   *                                                           *
   *  PROGRAM NET0                                             *
   *     Interprocess communication.                           *
   *                                                           *
   *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
   *  Programmer: Ronald C. Albury                             *
   *  Date Written: June 1982                                  *
   *  Computer: Interdata 8/32                                 *
   *  Copyright 1982 by Ronald C. Albury                       *
   *************************************************************)

(* **Packet description*)
   TYPE
      PACKET_TYPE = RECORD
                       TEXT: MESSAGE_TYPE
                    END;

(* **Constants for Mail_box_monitor*)
   CONST
      MAX_MAIL = 4;
      MAX_SENDERS = 1;

(* **Constants for Resource*)
   CONST
      MAX_RESOURCE_USERS = 1;

(* **Types and constants for Message_io_class*)
INCLUDE SVC1PFX

(* *Class to provide fixed record I/O*)
INCLUDE MSGIO

(* *Modified Brinch Hansen FIFO*)
INCLUDE FIFO

(* *Standard Brinch Hansen Resource*)
INCLUDE RESOURCE

(* *Interprocess communication mailbox*)
INCLUDE MAILBOX

(* *Worker application process*)
INCLUDE WORKER0

(* *Server application process*)
INCLUDE SERVER0
```

```
VAR
   CONSOLE: RESOURCE_MONITOR;
   WORKER_EVT, SERVER_EVT: MAIL_BOX_MONITOR;
   WORKER: WORKER_PROCESS;
   SERVER: SERVER_PROCESS;

BEGIN
   INIT
      CONSOLE,
      WORKER_EVT, SERVER_EVT,
      WORKER(CONSOLE, WORKER_EVT, SERVER_EVT),
      SERVER(SERVER_EVT, WORKER_EVT)
END.
```

2.1: NET1

A number of considerations must be introduced to the demonstration of interprocess communication if the Worker and Server processes are allowed to reside on different computers. Both machines must agree on certain protocols to insure the integrety of their communication. These protocols are analogous to the hierarchy of people necessary for executives of two companies to communicate.

The Application layer is the executive himself. It is the ultimate source and sink for all data transmitted across the network, and it is also the entry point for the application programs to interface with the rest of the network. In STERLING, these interfaces are provided through access rights which are doled out by the initial process. The following come under the domain of the application layer:

1) Identification of intended communication partners
2) Transfer of information
3) Synchronization of cooperating application processes.

The Presentation layer assumes the role of the assistant to the executive, who makes sure that all messages are in a form that the boss can understand. The following problems must be considered:

1) The machines may use different formats to store files (e.g. 80 byte fixed length records vs. 512 byte blocked variable length records).

2) The machines may use different character codes (e.g. ASCII vs. EBCDIC).
3) They may be exchanging secret information which should be encrypted before it is transmitted over a non-secure medium.
4) If large amounts of data are being transfered, it may be cost effective to use a compression algorithm to reduce the transmission costs.

The Session layer assumes the role of the executive's secretary, who makes the appointments, places the outgoing phone calls, screens the incoming calls, and takes messages. The following problems must be considered:

1) A process may need to 'log on' to a remote machine before it can communicate with any processes on that machine.
2) A process may have restricted access and require a password or some other form of authorization before it will agree to exchange messages.
3) The two processes must agree on such options as who can terminate the session and whether the communication will be half-duplex or full-duplex.
4) A process may be running, but not expecting messages, or already busy, and unable to receive new messages.
5) If a break in the network connection during mid-transaction would prove to be disasterous, it may be necessary to 'bracket' or 'chain' together several messages into a single large message at the destination. This is

also known as "quarantining messages" [3].

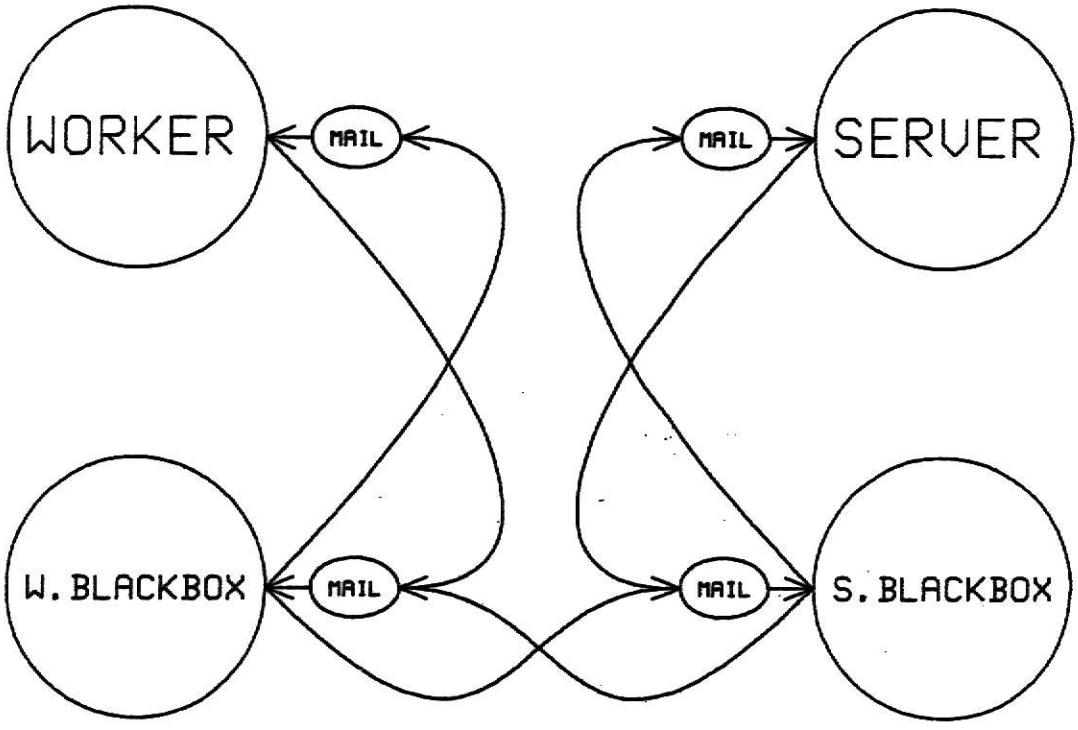
The Transport layer assumes the role of the company switchboard operator, who manages all telephone connections comming into the business. The following problems must be considered:

1) The host must be able to establish and keep track of all of its connections across the network.
2) The host must be sure that the destination has sufficient buffer space to hold the messages that will be sent.
3) The host must be sure that all of the messages sent were received by the destination in the correct order.

Local Area Network: To complete the analogy there must be a telephone company to handle the actual transmission of the messages from one company to the other. The problems encountered in implementing a local area network [12] [13] [14], however, are beyond the scope of this report.

NET1 (see listing 1) assumes that the Worker and Server processes (the Application layers) are on separate hosts. A new process, the 'Black Box', is added to each host to simulate the protocols being in place to satisfy all of the previously mentioned problems.

The Worker and Server continue to act as if they are communicating directly with each other, while in fact there is another layer of processes that handles the details of the communication. In future chapters the Black Box will be subdivided into further layers, each addressing a specific type of protocol. Currently, the Black Box's only duty is to determine if a message is going into the host or coming out of it.



NET1 ACCESS DIAGRAM

Figure 5

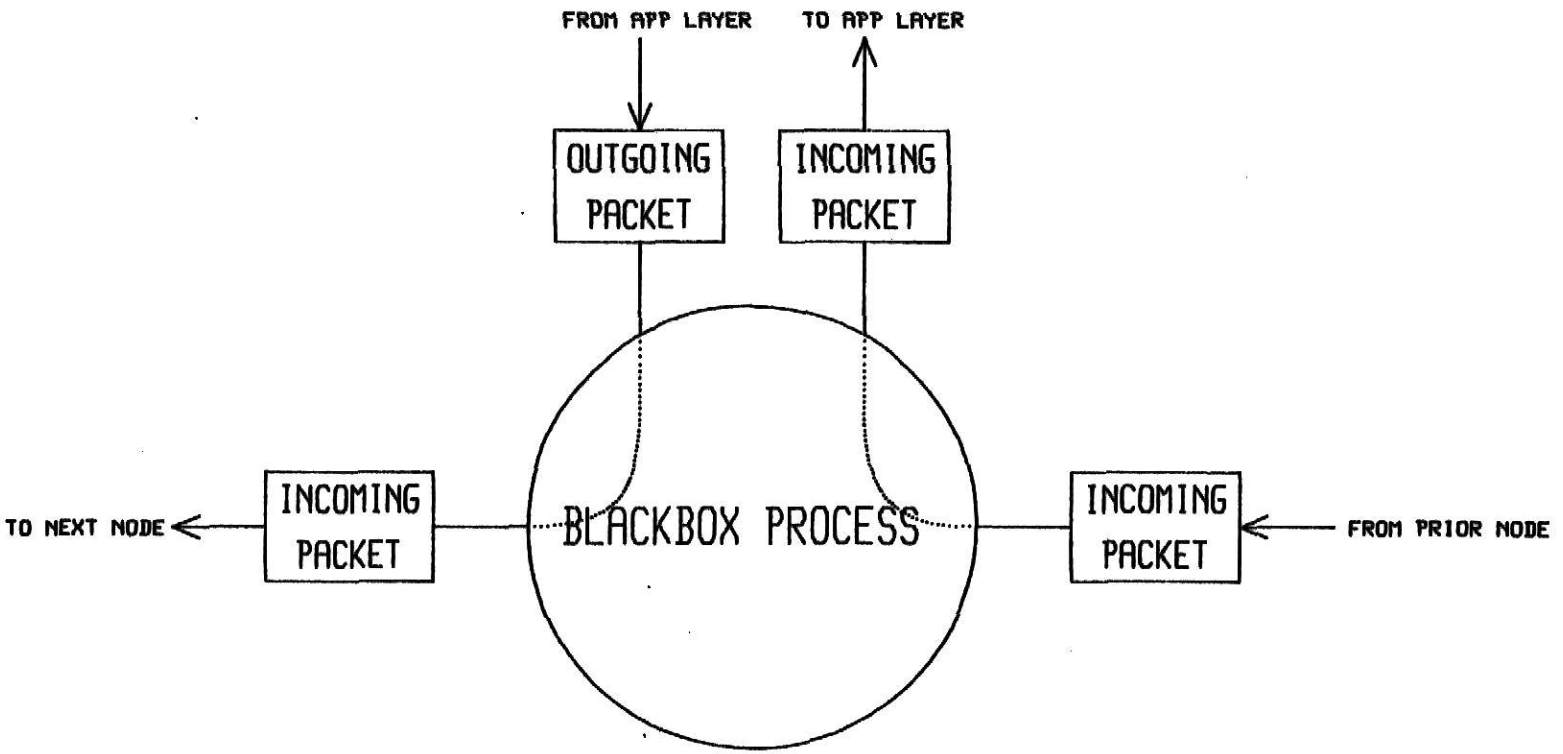


Figure 6

LOGICAL VIEW OF BLACKBOX

```
(* *Cpascal prefix*)
INCLUDE NETPFX

  (*****************************************************************
   *                                                               *
   *  PROGRAM NET1                                                 *
   *     Interprocess communication between remote sites.          *
   *                                                               *
   *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
   *  Programmer: Ronald C. Albury                                 *
   *  Date Written: July 1982                                      *
   *  Computer: Interdata 8/32                                     *
   *  Copyright 1982 by Ronald C. Albury                           *
   *****************************************************************)

(*NOTE:  modifications to previous program are indicated    *)
(*       by  (****)                                         *)

(* **Packet description*)
   TYPE
      DIRECTION_TYPE = (INCOMING, OUTGOING);  (****)
      PACKET_TYPE = RECORD
                       DIRECTION: DIRECTION_TYPE;  (****)
                       TEXT: MESSAGE_TYPE
                    END;

(* **Constants for Mail_box_monitor*)
   CONST
      MAX_MAIL = 4;
      MAX_SENDERS = 2;  (****)

(* **Constants for Resource*)
   CONST
      MAX_RESOURCE_USERS = 1;

(* **Types and constants for Message_io_class*)
INCLUDE SVC1PFX

(* *Class to provide fixed record I/O*)
INCLUDE MSGIO

(* *Modified Brinch Hansen FIFO*)
INCLUDE FIFO

(* *Standard Brinch Hansen RESOURCE*)
INCLUDE RESOURCE

(* *Interprocess communication mailbox*)
INCLUDE MAILBOX

(* *Undefined layers of the network*)  (****)
INCLUDE BLACKBOX
```

```
(* *Worker application process*)  (****)
INCLUDE WORKER1

(* *Server application process*)  (****)
INCLUDE SERVER1

   TYPE
      NODE_W = RECORD  (****)
                  APP: WORKER_PROCESS;
                  APP_EVT: MAIL_BOX_MONITOR;
                  BLACKBOX: BLACKBOX_PROCESS;
                  BB_EVT: MAIL_BOX_MONITOR
               END;

      NODE_S = RECORD  (****)
                  APP: SERVER_PROCESS;
                  APP_EVT: MAIL_BOX_MONITOR;
                  BLACKBOX: BLACKBOX_PROCESS;
                  BB_EVT: MAIL_BOX_MONITOR
               END;

   VAR
      CONSOLE: RESOURCE_MONITOR;
      WORKER: NODE_W;
      SERVER: NODE_S;

   BEGIN
      INIT
         CONSOLE,
         SERVER.BB_EVT, WORKER.BB_EVT,
         SERVER.APP_EVT, WORKER.APP_EVT,
         SERVER.BLACKBOX(SERVER.APP_EVT, SERVER.BB_EVT,
          WORKER.BB_EVT),
         WORKER.BLACKBOX(WORKER.APP_EVT, WORKER.BB_EVT,
          SERVER.BB_EVT),
         SERVER.APP(SERVER.APP_EVT, SERVER.BB_EVT),
         WORKER.APP(CONSOLE, WORKER.APP_EVT,
          WORKER.BB_EVT)
   END.
```

2.2: NET2

The first category of protocol addressed is the Presentation Protocol. The presentation layer performs functions that are requested sufficiently often to warrant finding a general solution for them, rather than letting each user solve them [15]. These functions could be explicitly invoked by the user in the form of language enhancements or library routines called by the user, or be transparently invoked by the operating system/network interface.

When computers communicate over a network, they are vulnerable to unauthorized use of their transmissions. Sensitive information may be copied or altered on the way to its destination. In many applications (e.g. electronic funds transfer) it is imperative that this be prevented. Data encryption is the means used to assure the security of messages.

Another service which may be provided in the Presentation layer is text compression. Processing costs are currently decreasing much more rapidly than transmission costs. It will become increasingly economical to edit or compress the data so that a smaller number of bits is transmitted over the network. In addition to saving money, compression can reduce response times when the data components are long enough to take many seconds to transmit.

When incompatible machines are connected on a network, problems are introduced which must be corrected before those machines can communicate. The machines may use different character sets,

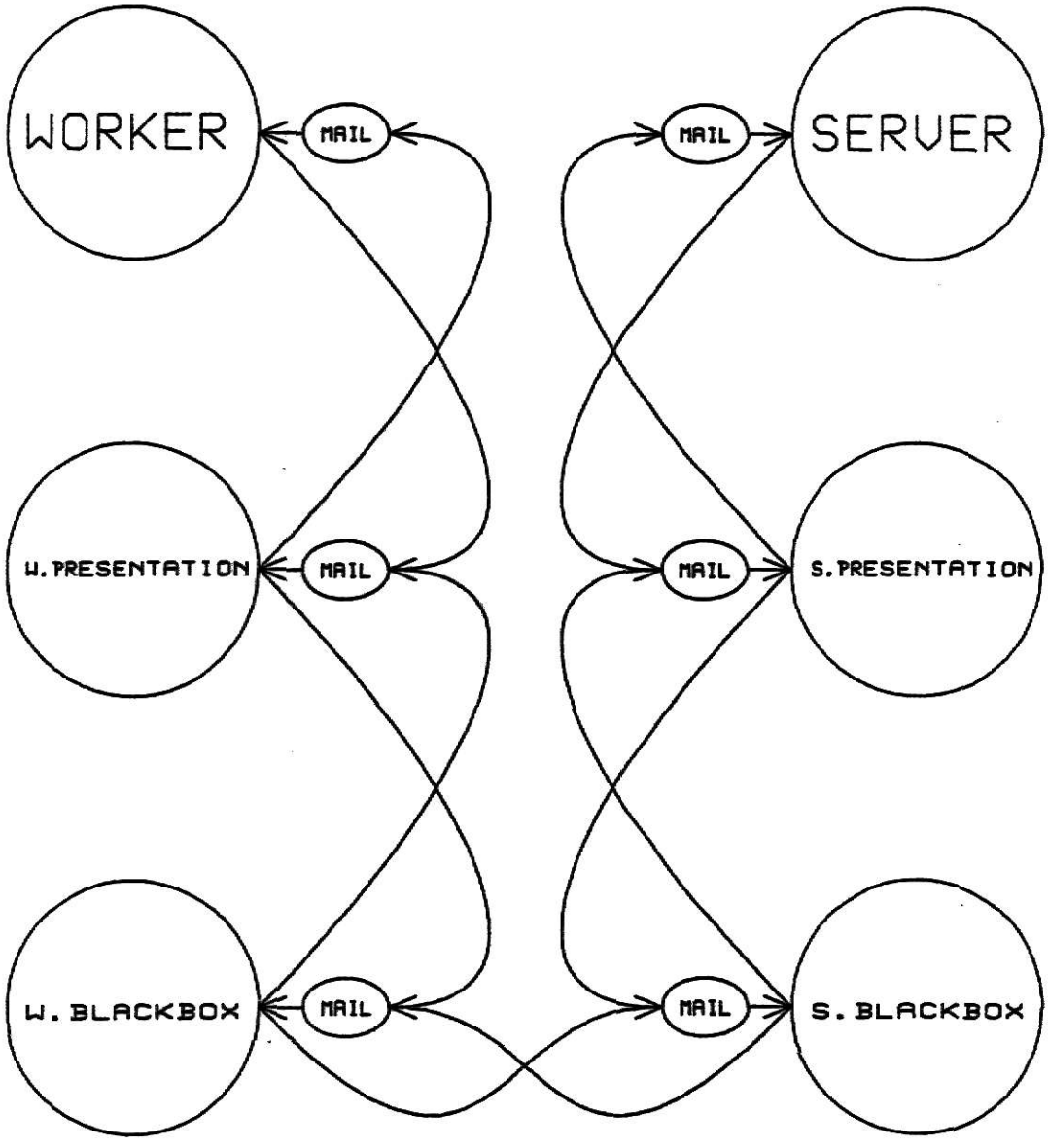
requiring only simple translation. When a program moves between machines with different instruction sets, the program will have to be recompiled. Some machines store their files as fixed length records and some as variable length records terminated by some combination of control characters.

Even on identical machines there may be incompatible terminals. The computer which a person wishes to access may not know the appropriate control codes to use with his terminal. The Presentation layer may serve as a hidden translator, allowing all application programs on the network to assume that they are communicating with a standard virtual terminal.

NET2 (see listing 2) provides only two presentation services: data encryption and the modification of record delimiters. The data encryption is accomplished through the Vignere cipher, a simple substitution cipher [15]. The encoded message is created by using the original text and the key as the row and column coordinates of a two dimensional array of characters. All nodes on the simulated network are currently initialized with the same key, with no provisions for modifying the key at run-time. The encryption routine is not transparent to the user and must be invoked by the Application Layer setting a flag in the network packet.

The record delimiter routine, on the other hand, is transparent to the user. On this simulated network there are only two kinds of machines: those whose record delimiter is a Carriage Return, and those who use a New Line. All packets automaticaly have a flag set before transmission indicating the delimiter used. The

destination presentation layer automaticaly converts any incompatible message to the format required by its host.



NET2 ACCESS DIAGRAM

Figure 7

		KEY								
		A	B	C	D	E	F	G	-	-
	A	a	b	c	d	e	f	g	-	-
	B	b	c	d	e	f	g	h	-	-
	C	c	d	e	f	g	h	i	-	-
T	D	d	e	f	g	h	i	j	-	-
E	E	e	f	g	h	i	j	k	-	-
X	F	f	g	h	i	j	k	l	-	-
T	G	g	h	i	j	k	l	m	-	-
	H	h	i	j	k	l	m	n	-	-
	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-

TEXT: DEAD
KEY: FEED
CODE: iieg

Vigenere Cipher

Figure 8

```
(* *Cpascal prefix*)
IN NETPFX

  (*************************************************************
   *                                                           *
   *  PROGRAM NET2                                             *
   *     Application, Presentation, and Blackbox.              *
   *                                                           *
   *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
   *  Programmer: Ronald C. Albury                             *
   *  Date Written: July 1982                                  *
   *  Computer: Interdata 8/32                                 *
   *  Copyright 1982 by Ronald C. Albury                       *
   *************************************************************)

(*NOTE:  modifications to previous program are indicated    *)
(*       by  (****)                                         *)

(* **Packet description*)
   TYPE
      DIRECTION_TYPE = (INCOMING, OUTGOING);
      SECURITY_TYPE = (SECRET, PUBLIC);  (****)
      FILE_FORMAT_TYPE = (CR_DELIM, NL_DELIM);  (****)
      PACKET_TYPE = RECORD
                       SECURITY: SECURITY_TYPE;  (****)
                       FILE_FORMAT: FILE_FORMAT_TYPE;  (****)
                       DIRECTION: DIRECTION_TYPE;
                       TEXT: MESSAGE_TYPE
                    END;

(* **Constants for Mail_box_monitor*)
   CONST
      MAX_MAIL = 4;
      MAX_SENDERS = 2;

(* **Constants for Resource*)
   CONST
      MAX_RESOURCE_USERS = 1;

(* **Types and constants for Message_io_class*)
INCLUDE SVC1PFX

(* *Class to provide fixed record I/O*)
INCLUDE MSGIO

(* *Modified Brinch Hansen FIFO*)
INCLUDE FIFO

(* *Standard Brinch Hansen RESOURCE*)
INCLUDE RESOURCE

(* *Interprocess communication mailbox*)
INCLUDE MAILBOX
```

```
(* *Presentation layer record delimiter conversion*)  (****)
INCLUDE CR2NL

(* *Presentation layer data encryption*)  (****)
INCLUDE CRIPTV

(* *Process to simulate the Presentation layer*)  (****)
INCLUDE PRESENT

(* *Undefined layers of the network*)
INCLUDE BLACKBOX

(* Worker application process*)  (****)
INCLUDE WORKER2

(* *Server application process*)  (****)
INCLUDE SERVER2

   TYPE
      NODE_W = RECORD
                  APP: WORKER_PROCESS;
                  APP_EVT: MAIL_BOX_MONITOR;
                  PRES: PRESENT_PROCESS;  (****)
                  PRES_EVT: MAIL_BOX_MONITOR;  (****)
                  BLACKBOX: BLACKBOX_PROCESS;
                  BB_EVT: MAIL_BOX_MONITOR
               END;

      NODE_S = RECORD
                  APP: SERVER_PROCESS;
                  APP_EVT: MAIL_BOX_MONITOR;
                  PRES: PRESENT_PROCESS;  (****)
                  PRES_EVT: MAIL_BOX_MONITOR;  (****)
                  BLACKBOX: BLACKBOX_PROCESS;
                  BB_EVT: MAIL_BOX_MONITOR
               END;

   VAR
      CONSOLE: RESOURCE_MONITOR;
      SERVER: NODE_S;
      WORKER: NODE_W;

   BEGIN
      INIT
         CONSOLE,
         SERVER.BB_EVT, WORKER.BB_EVT,
         SERVER.PRES_EVT, WORKER.PRES_EVT,
         SERVER.APP_EVT, WORKER.APP_EVT,
         SERVER.BLACKBOX(SERVER.PRES_EVT, SERVER.BB_EVT,
          WORKER.BB_EVT),
         WORKER.BLACKBOX(WORKER.PRES_EVT, WORKER.BB_EVT,
          SERVER.BB_EVT),
         SERVER.PRES(SERVER.APP_EVT,SERVER.PRES_EVT,
```

```
        SERVER.BB_EVT, CR_DELIM),
      WORKER.PRES(WORKER.APP_EVT,WORKER.PRES_EVT,
        WORKER.BB_EVT, CR_DELIM),
      SERVER.APP(SERVER.APP_EVT, SERVER.PRES_EVT),
      WORKER.APP(CONSOLE, WORKER.APP_EVT,
        WORKER.PRES_EVT)
END.
```

2.3: NET3

The session protocols of the ISO model are scattered throughout adjacent layers in most currently implemented networks. The purpose of the Session layer is to assist the higher layers in two ways. First, it controls the establishment of a communication session by having the two processes decide on "ground rules" for the session. This session administration service is also known as "binding the processes". Second, it controls the delimiting and synchronization of data operations through a session dialogue service.

A list of session functions could include the following:

1. Establish communications with the node which owns or controls the requested function or data.
2. Check that the communicating nodes have the software necessary for communication.
3. Exchange information about the protocols to be used in the communication.
4. Convert the high-level statements or requests of the user programs into the protocols of the lower layers.
5. Interpret end-of-record and end-of-file indicators in messages.
6. Perform end-to-end acknowledgement and sequence-number checking, if it is felt necessary to have additional checks on the lower layers.
7. Recover from a temporary break in the network without breaking the session.

8. Divide long messages into segments and use an acknowledgement protocol so that if a crash occurs, at most one segment has to be retransmitted.
9. Screen incoming calls, permitting only those from authorized users.
10. Issue or check passwords.

NET3 (see listing 3) has a Session layer which provides orderly creation and termination of sessions without data loss, full duplex communication paths, access control, and message chaining.

There are three notable additions to NET3. The Mailbox communication mechanism has been altered to allow the network packets to be assigned a priority. One possible priority scheme would segregate the packets into [1]:

1 = Control messages

2 = Real-time or fast interactive

3 = Slow interactive

4 = Batch-processing traffic

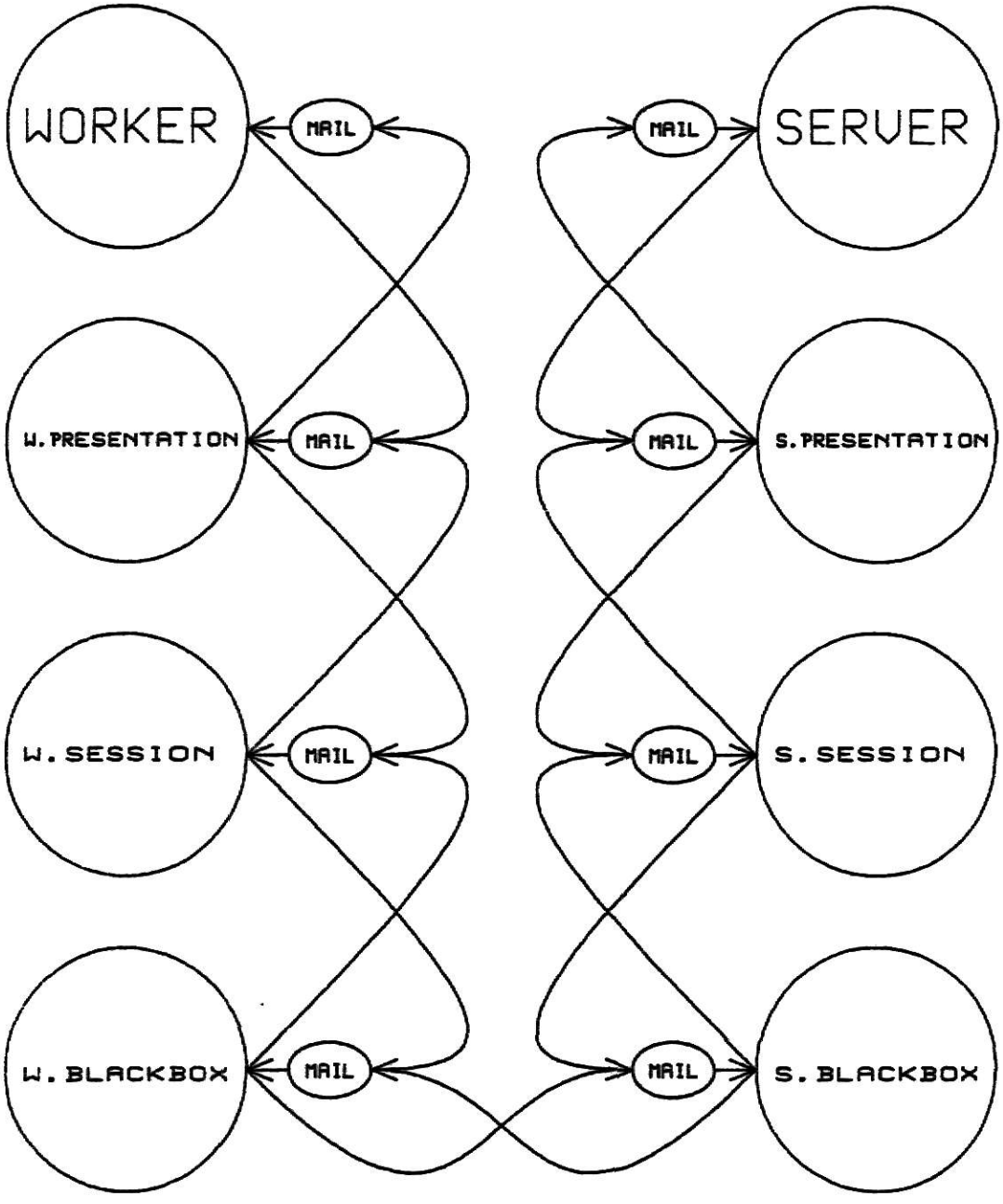
5 = Traffic which can be deferred

A new class has been added to provide standard entry points to the network. NETIO allows the application program to access the network just as MSGIO provides it with I/O to the disk and terminal.

A new class has been added to interpret any error messages sent to the application layer from the network and display them on the terminal.

Every host on the simulated network is initialized with a password. Anyone attempting to establish a session must include the appropriate password with the request or the request will be refused.

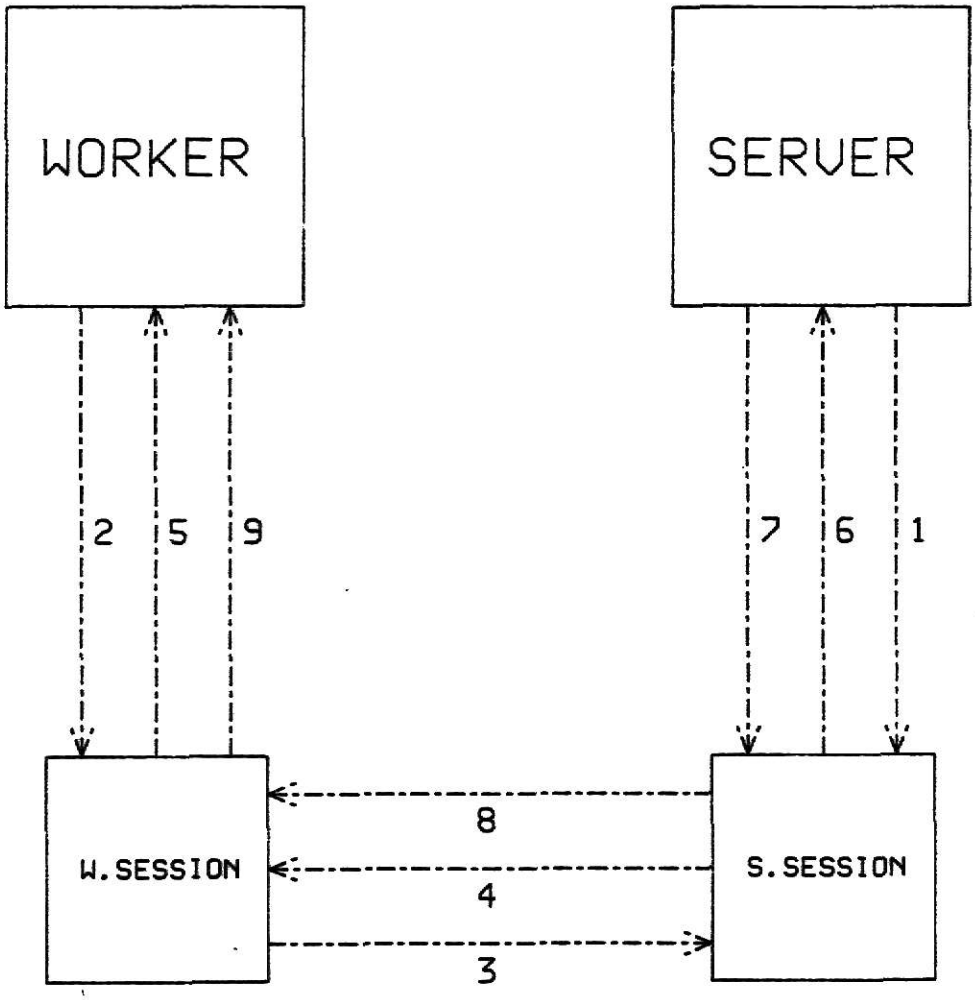
The message-chaining facility allows a source process to send multiple messages to a destination and have the messages assembled into a single large message at the destination. This chaining continues until the source process either explicitly releases the message or sends a request that all data currently quarantined be discarded. The destination process receives no information that the data being received has been quarantined or if some data has been discarded.



NET3 ACCESS DIAGRAM

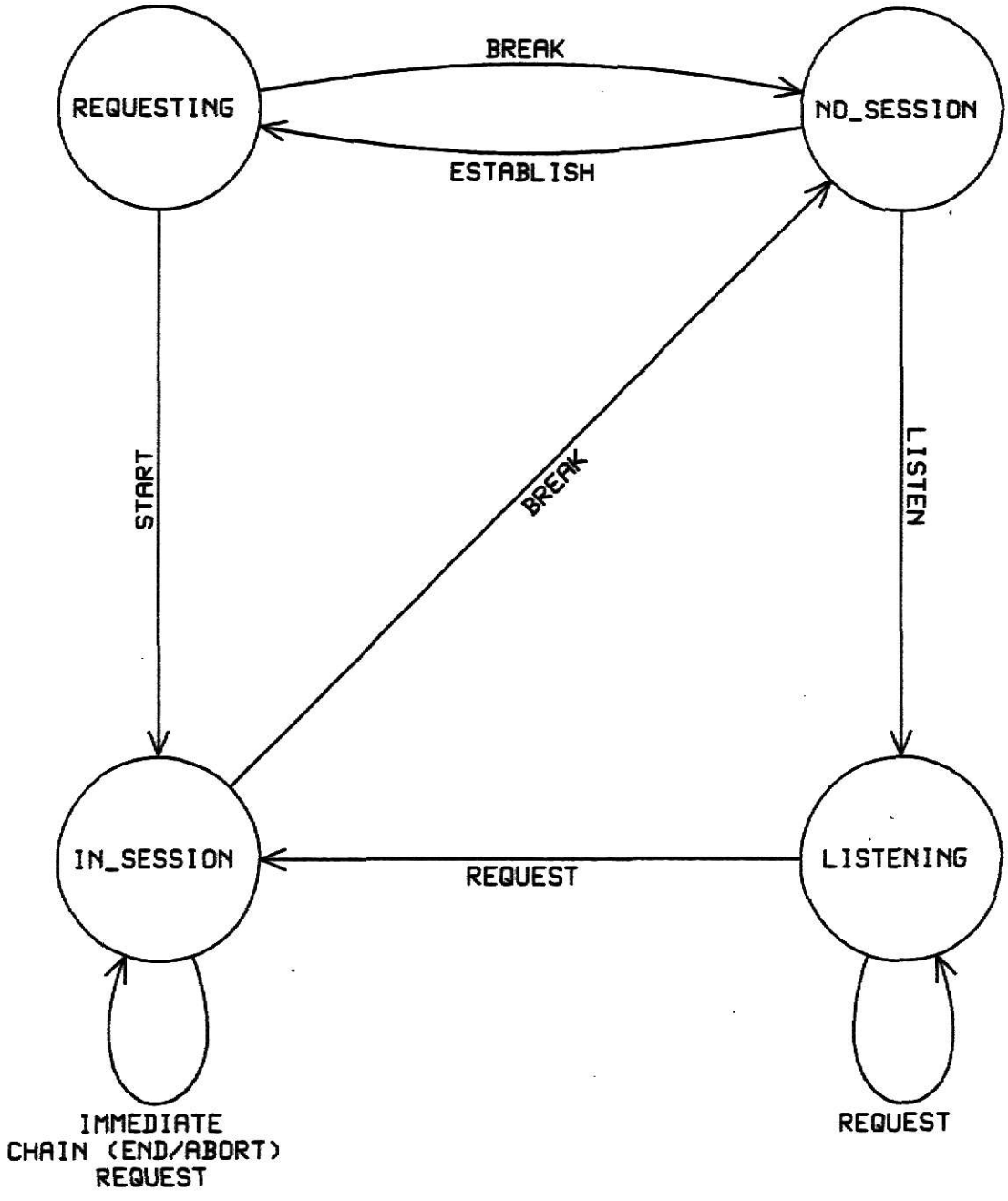
Figure 9

NET3 SESSION PROTOCOL



1) LISTEN
2) ESTABLISH
3) REQUEST
4) START/BREAK
5) START/BREAK
6) START
7) BREAK
8) BREAK
9) BREAK

Figure 10



SESSION LAYER

FINITE STATE AUTOMATON

Figure 11

```
(* *Cpascal Prefix*)
INCLUDE NETPFX

  (*************************************************************
   *                                                           *
   *  PROGRAM NET3                                             *
   *     Application, Presentation, Session, and Blackbox.     *
   *                                                           *
   *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
   *  Programmer: Ronald C. Albury                             *
   *  Date Written: July 1982                                  *
   *  Computer: Interdata 8/32                                 *
   *  Copyright 1982 by Ronald C. Albury                       *
   *************************************************************)

(*NOTE:  modifications to previous program are indicated     *)
(*       by  (****)                                          *)

(* **Packet description*)
   TYPE
      PRIORITY_TYPE = (LOW_PRI, MED_PRI, HIGH_PRI);  (****)
      SESSION_COMMANDS = (LISTEN, ESTABLISH, REQUEST, (****)
       START, IMMEDIATE, CHAIN, END_CHAIN, ABORT_CHAIN,
       BREAK);
      CHAIN_TYPE = IMMEDIATE..ABORT_CHAIN;  (****)
      STATUS_TYPE = (NO_LOCAL_SESSION, (****)
       NO_REMOTE_SESSION, LOCAL_IN_SESSION, REMOTE_IN_SESSION,
       BAD_PASSWORD, SESSION_ENDING, BUSY);
      PKT_STATUS_TYPE = SET OF STATUS_TYPE;  (****)
      DIRECTION_TYPE = (INCOMING, OUTGOING);
      SECURITY_TYPE = (SECRET, PUBLIC);
      FILE_FORMAT_TYPE = (CR_DELIM, NL_DELIM);
      PACKET_TYPE = RECORD
                       PRIORITY: PRIORITY_TYPE;
                       SESSION_CMD: SESSION_COMMANDS;
                       STATUS: PKT_STATUS_TYPE;
                       SECURITY: SECURITY_TYPE;
                       FILE_FORMAT: FILE_FORMAT_TYPE;
                       DIRECTION: DIRECTION_TYPE;
                       TEXT: MESSAGE_TYPE
                    END;

(* **Constants for packet status messages*)  (****)
   CONST
      FIRST_ERROR = NO_LOCAL_SESSION;
      LAST_ERROR = BUSY;
      ERROR_MSG = ('NO LOCAL SESSION    ',
                   'NO REMOTE SESSION   ',
                   'LOCAL IN SESSION    ',
                   'REMOTE IN SESSION   ',
                   'BAD PASSWORD        ',
                   'SESSION ENDING      ',
                   'REMOTE SESSION BUSY ');
```

```
      ARRAY [STATUS_TYPE] OF MESSAGE_TYPE;

(* **Constants for password check*)  (****)
   TYPE
      HOST_ID_TYPE = (HOST_S, HOST_W);
   CONST
      PASSWORD = ('HOST S   PASSWORD   ',
                  'HOST W   PASSWORD   '):
       ARRAY [HOST_ID_TYPE] OF MESSAGE_TYPE;

(* **Constants for Mail_box_monitor*)
   CONST
      MAX_MAIL = 6;
      MAX_SENDERS = 2;

(* **Constants for Resource*)
   CONST
      MAX_RESOURCE_USERS = 1;

(* **Constants for Session layer*)
   CONST
      MAX_SESSION_WAIT = 2;
      MAX_CHAIN = 7;

(* *Types and constants for Message_io_class*)
INCLUDE SVC1PFX

(* *Class to provide fixed record I/O*)
INCLUDE MSGIO

(* *Modified Brinch Hansen FIFO*)
IN FIFO

(* *Standard Brinch Hansen Resource*)
INCLUDE RESOURCE

(* *Prioritized communication mailbox*)  (****)
INCLUDE MAILBOX3

(* *Standard entries to the network*)  (****)
INCLUDE NETIO

(* *Class for reporting network errors*)  (****)
INCLUDE ERROR

(* *Undefined layers of the network*)
INCLUDE BLACKBOX

(* *Presentation layer record delimiter conversion*)
INCLUDE CR2NL

(* *Presentation layer data encryption*)
INCLUDE CRIpTV
```

```
(* *Process to simulate Presentation layer*)
INCLUDE PRESENT

(* *Process to simulate Session layer*)  (****)
INCLUDE SESSION

(* *Worker application process*)  (****)
INCLUDE WORKER3

(* *Server application process*)  (****)
INCLUDE SERVER3

   TYPE
      NODE_W = RECORD
                  APP: WORKER_PROCESS;
                  APP_EVT: MAIL_BOX_MONITOR;
                  PRES: PRESENT_PROCESS;
                  PRES_EVT: MAIL_BOX_MONITOR;
                  SESS: SESSION_PROCESS;
                  SESS_EVT: MAIL_BOX_MONITOR;
                  BLACKBOX: BLACKBOX_PROCESS;
                  BB_EVT: MAIL_BOX_MONITOR
               END;

      NODE_S = RECORD
                  APP: SERVER_PROCESS;
                  APP_EVT: MAIL_BOX_MONITOR;
                  PRES: PRESENT_PROCESS;
                  PRES_EVT: MAIL_BOX_MONITOR;
                  SESS: SESSION_PROCESS;
                  SESS_EVT: MAIL_BOX_MONITOR;
                  BLACKBOX: BLACKBOX_PROCESS;
                  BB_EVT: MAIL_BOX_MONITOR
               END;

   VAR
      CONSOLE: RESOURCE_MONITOR;
      SERVER: NODE_S;
      WORKER: NODE_W;

   BEGIN
      INIT
         CONSOLE,
         SERVER.BB_EVT, WORKER.BB_EVT,
         SERVER.SESS_EVT, WORKER.SESS_EVT,
         SERVER.PRES_EVT, WORKER.PRES_EVT,
         SERVER.APP_EVT, WORKER.APP_EVT,
         SERVER.BLACKBOX(SERVER.SESS_EVT, SERVER.BB_EVT,
          WORKER.BB_EVT),
         WORKER.BLACKBOX(WORKER.SESS_EVT, WORKER.BB_EVT,
          SERVER.BB_EVT),
         SERVER.SESS(SERVER.PRES_EVT, SERVER.SESS_EVT,
          SERVER.BB_EVT, HOST_S),
```

```
        WORKER.SESS(WORKER.PRES_EVT, WORKER.SESS_EVT,
         WORKER.BB_EVT, HOST_W),
        SERVER.PRES(SERVER.APP_EVT,SERVER.PRES_EVT,
         SERVER.SESS_EVT, CR_DELIM),
        WORKER.PRES(WORKER.APP_EVT,WORKER.PRES_EVT,
         WORKER.SESS_EVT, CR_DELIM),
        SERVER.APP(CONSOLE, SERVER.APP_EVT,
         SERVER.PRES_EVT),
        WORKER.APP(CONSOLE, WORKER.APP_EVT,
         WORKER.PRES_EVT)
END.
```

2.4: NET4

The transport layer is potentialy the most complex protocol of the model. It is the bridge between the services offered to the user and what the network actualy offers. It insulates the upper layers from changes in the network. It provides the upper layers with a transparent connection to the network no matter to what kind of network the host is connected.

If the host is connected to a perfect network that guarantees correct delivery of the messages, then the transport layer is primarily concerned with the efficient use of the network. If, however, the network occasionally loses or scrambles a message, the Transport layer must also provide an end-to-end error correcting protocol to ensure that all messages sent were correctly received at the proper destination.

The ISO Model [3] defines the role of the Transport layer as follows:

1) Mapping transport address onto network address
2) End-to-end multiplexing of transport connections onto network connections
3) Establishing and terminating transport connections
4) Controling the end-to-end sequencing of individual connections
5) Detecting end-to-end errors, and monitoring the quality of the service
6) Recovering from end-to-end errors

7) End-to-end segmenting and blocking of messages

8) Controling the end-to-end flow on individual connections

9) Providing supervisory functions.

10) Transfering expedited transport-service-data-units

One way that the Transport layer assures efficient use of the network is by multiplexing several sessions onto a single network connection. The average transmission rate during an interactive session is usually less than 20 bits per second for both directions of transmission combined [1]. This grossly underutilizes even a voice grade transmission line. Yet low bandwidth lines cannot be used because of the potential need for delivering large quantities of data quickly. An economical solution to the underutilization of transmission lines is to allow several sessions on one host to use the same high speed transmission facility. The transport protocol rotates between the sessions, sending messages in successive high speed bursts.

The Transport layer must also be sure that its peer has enough buffer space to receive all of the messages it is being sent. One solution to the buffer allocation problem is to send only an agreed-upon quantity of data, then wait for the destination to send a request for more. This solution can be expanded to the general principle of using tokens to indicate the buffer space available at the destination. The sender decrements its number of tokens for each message sent, and the destination replenishes them as its buffers become available. A continuous two-way dialogue can be supported in this way, with messages going in one

direction and tokens simultaneously returning in the other.

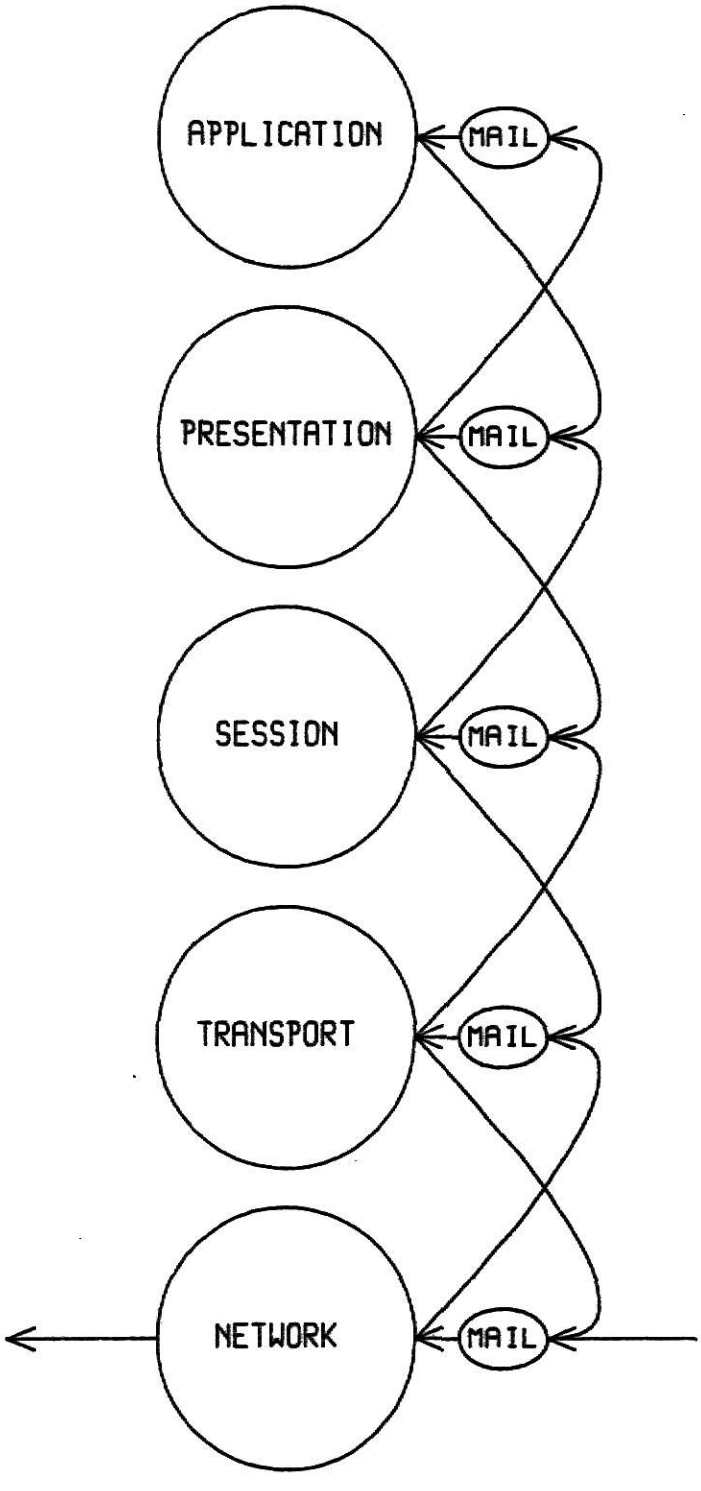
A two-way dialogue is also necessary to provide the sessions with an error-free data transfer over an imperfect network. The sender does not assume that the messages reached their destination in good condition unles it receives an acknowlegment, and keeps a copy of all outstanding messages in case they must be re-transmitted. If an acknowlegment is not received in a reasonable period of time, the Transport layer sends the lost message again. This protocol is complicated by the fact that an acknowlegment may itself be lost in transmission, and because messages/acknowlegments may actually only be delayed rather than lost.

Finally, the Transport layer provides connection management for the sessions on the host. It allows a transport user to be identified by a transport address without regard to its location in the network. It controls the connections to the network. And it allows either session-entity to terminate the connection and have its peer session-entity informed of the termination.

NET4 (see listing 4) is the final program of STERLING. Three new nodes have been added to the network, and a Transport layer has been added to the Worker and Server nodes. The Blackbox has been slightly modified and is now assumed to be a Local Area Network. The Worker now has two Servers from which it can request files. One Server oversees files A and B; the other oversees files C and D. A new node is added to the network to simulate transmission loss; this new node fails to forward packets at pre-set intervals. Also, a new process and monitor

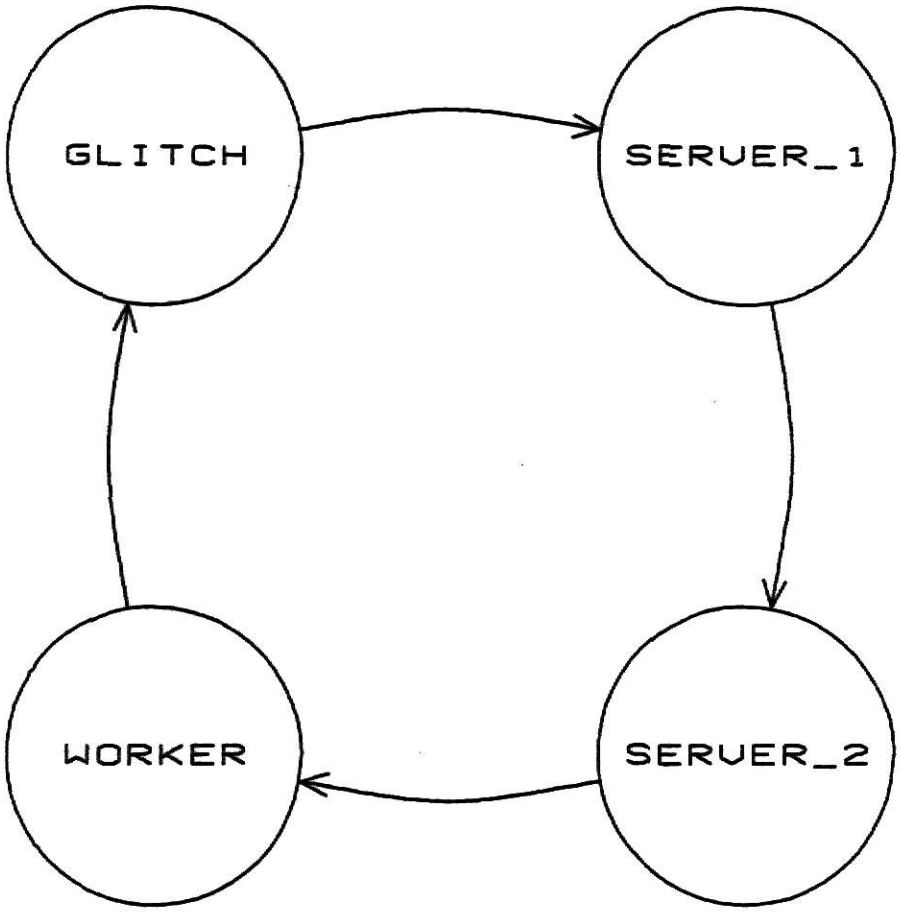
have been added to the worker and server nodes to detect lost messages and notify the Transport layer when it should re-transmit a lost packet.

The Transport layer was patterned very loosely on the National Bureau of Standards' Draft Report on Transport Protocols [8]. It uses a simple alternating-bit protocol to insure that all messages sent were received in the correct order. Its primary concerns are with connection management and end-to-end error correction.



NET4 ACCESS DIAGRAM

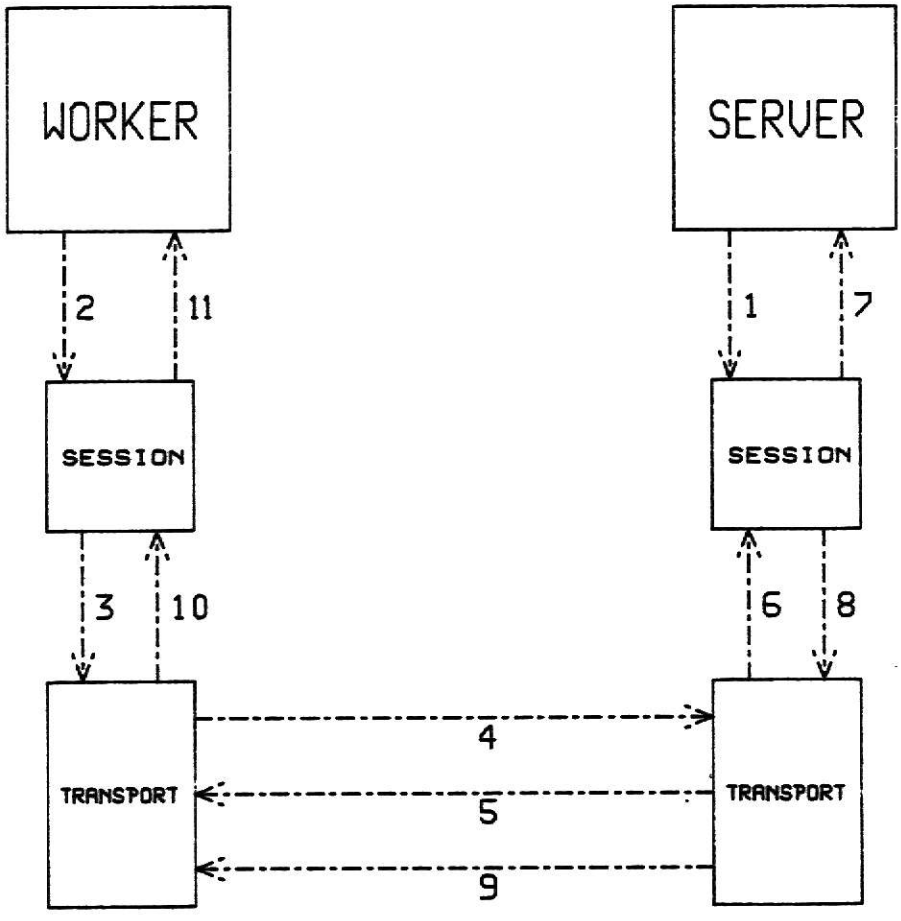
Figure 12



NET4 TOPOLOGY

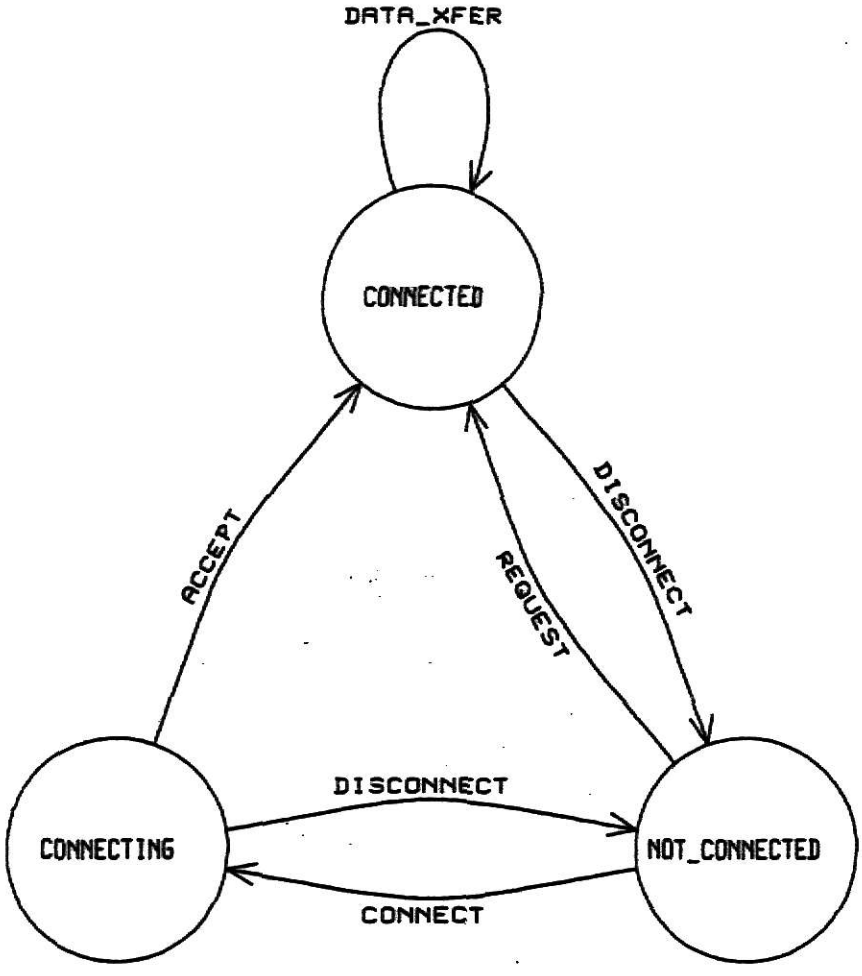
Figure 13

NET4 CONNECTION PROTOCOL



1) LISTEN
2) ESTABLISH
3) REQUEST - CONNECT
4) REQUEST - INQUIRE
5) ACCEPT
6) REQUEST
7) START
8) START - DATA_XFER
9) START - DATA_XFER
10) START
11) START

Figure 14



TRANSPORT LAYER

FINITE STATE AUTOMATON

Figure 15

```
(*C-pascal Prefix*)
INCLUDE NETPFX

  (*************************************************************
   *                                                           *
   *  PROGRAM NET4                                             *
   *     Application, Presentation, Session, Transport,        *
   *      and Network layers.                                  *
   *                                                           *
   *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
   *  Programmer: Ronald C. Albury                             *
   *  Date Written: 10/11/82                                   *
   *  Computer: Interdata 8/32                                 *
   *  Copyright 1982 by Ronald C. Albury                       *
   *************************************************************)

(*NOTE:  modifications to previous program are indicated     *)
(*       by  (****)                                          *)

(* **Packet description*)
   TYPE
      TRANSPORT_COMMANDS = (CONNECT, DISCONNECT, INQUIRE,  (****)
       T_O_ACCEPT, T_O_DATA_ACK, ACCEPT, DATA_XFER, DATA_ACK);
      DATA_WINDOW_TYPE = 0..1;  (****)
      HOST_ID_TYPE = (HOST_W, HOST_S_1, HOST_S_2); (****)
      PRIORITY_TYPE = (LOW_PRI, MED_PRI, HIGH_PRI);
      SESSION_COMMANDS = (LISTEN, ESTABLISH, REQUEST,
       START, IMMEDIATE, CHAIN, END_CHAIN, ABORT_CHAIN,
       BREAK);
      CHAIN_TYPE = IMMEDIATE..ABORT_CHAIN;
      STATUS_TYPE = (NO_LOCAL_SESSION,
       NO_REMOTE_SESSION, LOCAL_IN_SESSION, REMOTE_IN_SESSION,
       BAD_PASSWORD, SESSION_ENDING, BUSY, NO_LOCAL_CONNECTION,
       NO_REMOTE_CONNECTION, NO_SUCH_HOST, DESTINATION_NODE_DOWN,
        CONNECTION_BROKEN);                    (****)
      PKT_STATUS_TYPE = SET OF STATUS_TYPE;
      DIRECTION_TYPE = (INCOMING, OUTGOING);
      SECURITY_TYPE = (SECRET, PUBLIC);
      FILE_FORMAT_TYPE = (CR_DELIM, NL_DELIM);
      PACKET_TYPE = RECORD
                       TRANS_CMD: TRANSPORT_COMMANDS;
                       NAME: MESSAGE_TYPE;
                       DESTINATION: HOST_ID_TYPE;
                       SOURCE: HOST_ID_TYPE;
                       S_CONNUM: INTEGER;
                       D_CONNUM: INTEGER;
                       DATA_SEQ: DATA_WINDOW_TYPE;
                       PRIORITY: PRIORITY_TYPE;
                       SESSION_CMD: SESSION_COMMANDS;
                       STATUS: PKT_STATUS_TYPE;
                       SECURITY: SECURITY_TYPE;
                       FILE_FORMAT: FILE_FORMAT_TYPE;
                       DIRECTION: DIRECTION_TYPE;
```

```
                    TEXT: MESSAGE_TYPE
                  END;

(* **Constants for packet status messages*)
   CONST
      FIRST_ERROR = NO_LOCAL_SESSION;
      LAST_ERROR = CONNECTION_BROKEN;
      ERROR_MSG = ('NO LOCAL SESSION    ',
                   'NO REMOTE SESSION   ',
                   'LOCAL IN SESSION    ',
                   'REMOTE IN SESSION   ',
                   'BAD PASSWORD        ',
                   'SESSION ENDING      ',
                   'REMOTE SESSION BUSY ',
                   'NO LOCAL CONNECTION ',  (****)
                   'NO REMOTE CONNECTION',
                   'NO SUCH SERVER      ',
                   'DEST. NODE OFF LINE ',
                   'CONNECTION BROKEN   '):
       ARRAY [STATUS_TYPE] OF MESSAGE_TYPE;

(* **Constants for password check*)
   CONST
      PASSWORD = ('HOST W   PASSWORD   ',
                  'HOST S 1 PASSWORD   ',  (****)
                  'HOST S 2 PASSWORD   '):
       ARRAY [HOST_ID_TYPE] OF MESSAGE_TYPE;

(* **Constants for transport address look-up*)
   CONST                                    (****)
      DIRECTORY = ('HOST_W              ',
                   'HOST_S_1            ',
                   'HOST_S_2            '):
      ARRAY [HOST_ID_TYPE] OF MESSAGE_TYPE;

(* **Constants for Mail_box_monitor*)
   CONST
      MAX_MAIL = 6;
      MAX_SENDERS = 3;  (****)

(* **Constants for Resource*)
   CONST
      MAX_RESOURCE_USERS = 1;

(* **Constants for Session layer*)
   CONST
      MAX_SESSION_WAIT = 2;
      MAX_CHAIN = 7;

(* *Types and constants for Message_io_class*)
INCLUDE SVC1PFX

(* *Class to provide fixed record I/O*)
```

```
INCLUDE MSGIO

(* *Modified Brinch Hansen FIFO*)
INCLUDE FIFO

(* *Standard Brinch Hansen RESOURCE*)
INCLUDE RESOURCE

(* *Prioritized communication mailbox*)
INCLUDE MAILBOX3

(* *Revised network entries*)   (****)
INCLUDE NETIO4

(* *Class for reporting network errors*)
INCLUDE ERROR

(* *Process to simulate a local area network*)  (****)
INCLUDE LOCNET4

(* *Presentation layer record delimiter conversion*)
INCLUDE CR2NL

(* *Presentation layer data encryption*)
INCLUDE CRIPTV

(* *Process to simulate Presentation layer*)
INCLUDE PRESENT

(* *Process to simulate Session layer*)  (****)
INCLUDE SESSION4

(* *Monitor for controlling time-outs*)  (****)
INCLUDE CLOCK

(* *Time-out simulator*)  (****)
INCLUDE TIMER

(* *Process to simulate Transport layer*)  (****)
INCLUDE TRANS

(* *Process to simulate data loss in the network*)  (****)
INCLUDE BADNODE

(* *Worker application process*) (****)
INCLUDE WORKER4

(* *Server application process*)  (****)
INCLUDE SERVER4
```

```
TYPE
   NODE_W = RECORD
               APP: WORKER_PROCESS;
               APP_EVT: MAIL_BOX_MONITOR;
               PRES: PRESENT_PROCESS;
               PRES_EVT: MAIL_BOX_MONITOR;
               SESS: SESSION_PROCESS;
               SESS_EVT: MAIL_BOX_MONITOR;
               TRANS: TRANSPORT_PROCESS;
               TRANS_EVT: MAIL_BOX_MONITOR;
               CLOCK: CLOCK_MONITOR;
               TIMER: TIMEOUT_PROCESS;
               NET: NETWORK_PROCESS;
               NET_EVT: MAIL_BOX_MONITOR
            END;

   NODE_S = RECORD
               APP: SERVER_PROCESS;
               APP_EVT: MAIL_BOX_MONITOR;
               PRES: PRESENT_PROCESS;
               PRES_EVT: MAIL_BOX_MONITOR;
               SESS: SESSION_PROCESS;
               SESS_EVT: MAIL_BOX_MONITOR;
               TRANS: TRANSPORT_PROCESS;
               TRANS_EVT: MAIL_BOX_MONITOR;
               CLOCK: CLOCK_MONITOR;
               TIMER: TIMEOUT_PROCESS;
               NET: NETWORK_PROCESS;
               NET_EVT: MAIL_BOX_MONITOR
            END;

   NODE_GLITCH = RECORD  (****)
                    NET: BAD_NODE_PROCESS;
                    NET_EVT: MAIL_BOX_MONITOR
                 END;

VAR
   CONSOLE: RESOURCE_MONITOR;
   SERVER1: NODE_S;  (****)
   SERVER2: NODE_S;  (****)
   WORKER: NODE_W;
   GLITCH: NODE_GLITCH;  (****)

BEGIN
   INIT
      CONSOLE,
      SERVER1.NET_EVT, SERVER2.NET_EVT,
      WORKER.NET_EVT, GLITCH.NET_EVT,
      SERVER1.TRANS_EVT, SERVER2.TRANS_EVT,
      WORKER.TRANS_EVT,
      SERVER1.CLOCK, SERVER2.CLOCK,
      WORKER.CLOCK,
      SERVER1.SESS_EVT, SERVER2.SESS_EVT,
```

```
        WORKER.SESS_EVT,
        SERVER1.PRES_EVT, SERVER2.PRES_EVT,
        WORKER.PRES_EVT,
        SERVER1.APP_EVT, SERVER2.APP_EVT,
        WORKER.APP_EVT,
        GLITCH.NET (GLITCH.NET_EVT, SERVER1.NET_EVT),
        SERVER1.NET(SERVER1.TRANS_EVT, SERVER1.NET_EVT,
         SERVER2.NET_EVT, HOST_S_1),
        SERVER2.NET(SERVER2.TRANS_EVT, SERVER2.NET_EVT,
         WORKER.NET_EVT, HOST_S_2),
        WORKER.NET(WORKER.TRANS_EVT, WORKER.NET_EVT,
         GLITCH.NET_EVT, HOST_W),
        SERVER1.TIMER (SERVER1.CLOCK, SERVER1.TRANS_EVT),
        SERVER2.TIMER (SERVER2.CLOCK, SERVER2.TRANS_EVT),
        WORKER.TIMER (WORKER.CLOCK, WORKER.TRANS_EVT),
        SERVER1.TRANS (SERVER1.SESS_EVT, SERVER1.TRANS_EVT,
         SERVER1.NET_EVT, SERVER1.CLOCK, HOST_S_1),
        SERVER2.TRANS (SERVER2.SESS_EVT, SERVER2.TRANS_EVT,
         SERVER2.NET_EVT, SERVER2.CLOCK, HOST_S_2),
        WORKER.TRANS (WORKER.SESS_EVT, WORKER.TRANS_EVT,
         WORKER.NET_EVT, WORKER.CLOCK, HOST_W),
        SERVER1.SESS(SERVER1.PRES_EVT, SERVER1.SESS_EVT,
         SERVER1.TRANS_EVT, HOST_S_1),
        SERVER2.SESS(SERVER2.PRES_EVT, SERVER2.SESS_EVT,
         SERVER2.TRANS_EVT, HOST_S_2),
        WORKER.SESS(WORKER.PRES_EVT, WORKER.SESS_EVT,
         WORKER.TRANS_EVT, HOST_W),
        SERVER1.PRES(SERVER1.APP_EVT,SERVER1.PRES_EVT,
         SERVER1.SESS_EVT, CR_DELIM),
        SERVER2.PRES(SERVER2.APP_EVT, SERVER2.PRES_EVT,
         SERVER2.SESS_EVT, NL_DELIM),
        WORKER.PRES(WORKER.APP_EVT,WORKER.PRES_EVT,
         WORKER.SESS_EVT, CR_DELIM),
        SERVER1.APP(CONSOLE, SERVER1.APP_EVT,
         SERVER1.PRES_EVT, 'A', 'B'),
        SERVER2.APP(CONSOLE, SERVER2.APP_EVT,
         SERVER2.PRES_EVT, 'C', 'D'),
        WORKER.APP(CONSOLE, WORKER.APP_EVT,
         WORKER.PRES_EVT)
END.
```

FURTHER WORK

Sterling is indended as a source of assignments for a course in computer networks. It is designed to be easily understood and easily modified. Once the students have familiarized themselves with the programming style and the functions of the four layers introduced, they can be expected to make major revisions to the programs.

One type of assignment would be to add the bottom layers of the ISO Model to Sterling (see figure 3). The Physical Layer could either be left as a Blackbox, or modified to more closely resemble a bit-oriented data stream. Pascal-like algorithms for several Data Link protocols can be found in Tanenbaum's book [15]. The Network Layer could either be left as a simple ring network, or expanded to a point-to-point network concerned with routing and congestion control.

A second type of assignment would be to expand and modify the services provided by the existing layers. The layers' functions listed in this report are only a small subset of possible functions, and only a small subset of these are implemented. Students could also multi-thread the layers, allowing more than one application program to reside on a node.

A third type of assignment would be to attempt to make Sterling more flexible and robust. The Session and Transport protocols are currently unable to recover gracefully from erroneous commands and would be unusable in a production environmnet. Students could be refered to the National Bureau of

Standards' Draft Report on Transport Protocols [8] as an example of a "real-world" protocol and instructed to modify Sterling to withstand minor errors.

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Appendix A

I N C L U D E M O D U L E S

```
                (*$$$   NETPFX   $$$*)
          (*$$$ C-Pascal Kernel for 8-32 $$$*)

 (*************************************************************
  *                                                           *
  * MODIFIED KSU CPASCAL PREFIX                               *
  *             modified for STERLING                         *
  *                                                           *
  *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
  * PROGRAMMER: ROBERT YOUNG                                  *
  * MODIFIED BY: RON ALBURY                                   *
  * COMPUTER: P.E. 8/32                                       *
  *************************************************************)
  KERNEL
     TYPE KERN_SVC1_BLOCK = ARRAY [1..24] OF BYTE;
     TYPE ATTRINDEX = ( CALLER, HEAPTOP, PROGLINE, PROGRESULT,
      RUNTIME);
     FUNCTION ATTRIBUTE ( A: ATTRINDEX ): INTEGER;
     PROCEDURE SETHEAP ( A: INTEGER );
     PROCEDURE START ( A: INTEGER );
     PROCEDURE STOP ( A, B: INTEGER );
     PROCEDURE WAIT;
     FUNCTION REALTIME: INTEGER;
     PROCEDURE SVC1 ( VAR PARAM: UNIV KERN_SVC1_BLOCK );
     PROCEDURE SVC2;
     PROCEDURE SVC7;
     PROCEDURE GETMEM;
     PROCEDURE BREAKPNT ( LN: INTEGER );
  END (*KERNEL*);

(*@@Added for network*)
(*Disk file id's and logical units*)
  CONST
     TRACE_OUTPUT = 9;
     TERMINAL = 10;
     FILE_A_LU = 11;
     FILE_B_LU = 12;
     FILE_C_LU = 13;
     FILE_D_LU = 14;
     FIRST_FILE_ID = 'A';
     LAST_FILE_ID = 'D';
  TYPE
     FILE_RANGE = FIRST_FILE_ID .. LAST_FILE_ID;
  CONST
     FILE_LU = (11, 12, 13, 14): ARRAY [FILE_RANGE] OF INTEGER;

(*Constants and types for fixed length I/O*)
  CONST
     MESSAGE_LENGTH = 20;
  TYPE
     MESSAGE_TYPE = ARRAY [1.. MESSAGE_LENGTH] OF CHAR;
```

```
                    (*$$$  SVC1PFX   $$$*)
      (*$$$ Types and constants for Message_io_class $$$*)


(*@@@@SVC1 PREFIX@@@@*)
  (*Record structure of the SVC1 parameter*)
    TYPE
       ERROR_SVC1_TYPE = RECORD
                            DI: BYTE;
                            DD: BYTE
                         END;
       SVC1_BLOCK_TYPE =
          PACKED RECORD
             FUNC          : BYTE;
             LOG_UNIT      : BYTE;
             D_I_ERROR     : BYTE;
             D_D_ERROR     : BYTE;
             BUFFER_START  : INTEGER;
             BUFFER_END    : INTEGER;
             RANDOM_ADRS   : INTEGER;
             LENGTH_XFER   : INTEGER;
             RESERVED      : INTEGER
          END;

  (*Function flags for communicating with SVC1*)
    CONST
       FUN_READ_SVC1          = #40;
       FUN_WRITE_SVC1         = #20;
       FUN_BINARY_SVC1        = #10;
       FUN_ASCII_SVC1         = #00;
       FUN_WAIT_SVC1          = #08;
       FUN_RANDOM_SVC1        = #04;
       FUN_SEQUEN_SVC1        = #00;
       FUN_PROCED_SVC1        = #02;
       FUN_FORMAT_SVC1        = #00;
       FUN_IMAGE_SVC1         = #01;
       FUN_REWIND_SVC1        = #C0;
       FUN_BKSPAC_SVC1        = #A0;
       FUN_FSPAC_SVC1         = #90;
       FUN_WRITE_FM_SVC1      = #88;
       FUN_SKIP_TO_FM_SVC1    = #84;
       FUN_BKSPAC_TO_FM_SVC1  = #82;
   (****END SVC1 PREFIX****)
```

```
                    (*$$$   MSGIO   $$$*)
          (*$$$ Class to provide fixed record I/O $$$*)


TYPE MESSAGE_IO_CLASS= CLASS;
  (*************************************************************
   *   MESSAGE_IO_CLASS provides standard entry points for     *
   * interfacing with the SVC1 supervisory call.  Allows       *
   * fixed record I/O and rewind capabilities to specified     *
   * logical units.                                            *
   *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
   * Programmer:  Ronald C. Albury                             *
   * Date Written: 3/25/82                                     *
   * Computer: Interdata 8/32                                  *
   * Copyright 1982 by Ronald C. Albury                        *
   *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
   *  EXTERNAL                                                 *
   *     CONST                                                 *
   *        FUN_-:-_SVC1: Bit flags used to communicate with   *
   *         the supervisory call.                             *
   *     TYPE                                                  *
   *        SVC1_BLOCK_TYPE: Record structure used to pass     *
   *         parameters to the supevisory I/O calls.           *
   *        ERROR_SVC1_TYPE: Record structure of the status    *
   *         bytes from the supervisory call.                  *
   *        MESSAGE_TYPE: Array of characters.                 *
   *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
   *  INTERNAL                                                 *
   *     VAR                                                   *
   *        PARAM: The parameter block for the supervisory     *
   *         calls.                                            *
   *************************************************************)
   VAR
      PARAM: SVC1_BLOCK_TYPE;

   (***PROCEDURE ENTRY READ*************************************
   *  INTERNAL                                                 *
   *     VAR                                                   *
   *        PAD: Loop variable to pad the text buffer with     *
   *         blanks if less then Message_length bytes are      *
   *         read in.                                          *
   *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
   *  PARAMETERS                                               *
   *     IN                                                    *
   *        IO_DEVICE: Logical unit for the input request.     *
   *     OUT                                                   *
   *        TEXT: Buffer to store the input characters.        *
   *        ERROR: The status bytes of the I/O call.           *
   *************************************************************)
   PROCEDURE ENTRY READ ( IO_DEVICE: BYTE;
                          VAR TEXT: UNIV MESSAGE_TYPE;
                          VAR ERROR: ERROR_SVC1_TYPE );
   VAR
      PAD: 0..MESSAGE_LENGTH;
  (*Begin entry Read*)
   BEGIN
```

```
                    (*$$$   MSGIO   $$$*)
          (*$$$ Class to provide fixed record I/O $$$*)


   (*Set the SVC1 parameters for a sequential ASCII read*)
     PARAM.FUNC := FUN_ASCII_SVC1 + FUN_SEQUEN_SVC1
      + FUN_READ_SVC1;
   (*Set the logical unit to read from*)
     PARAM.LOG_UNIT := IO_DEVICE;
   (*Set the address to store the read data*)
     PARAM.BUFFER_START := ADDRESS (TEXT);
     PARAM.BUFFER_END := ADDRESS (TEXT) + SIZE(TEXT) -1;
   (*Execute an SVC1*)
     SVC1 ( PARAM );
   (*Pad out the buffer with blanks*)
     FOR PAD := PARAM.LENGTH_XFER TO MESSAGE_LENGTH DO
        TEXT [PAD] := ' ';
    {Endfor}
   (*Set the status bytes*)
     ERROR.DI := PARAM.D_I_ERROR;
     ERROR.DD := PARAM.D_D_ERROR
(*End entry Read*)
  END;

 (***PROCEDURE ENTRY WRITE*************************************
  *  INTERNAL                                                 *
  *     VAR                                                   *
  *        MESSAGE: A local variable, necessary to make       *
  *         ADDRESS function work correctly.                  *
  *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
  *  PARAMETERS                                               *
  *     IN                                                    *
  *        IO_DEVICE: Logical unit for the output request.    *
  *        TEXT: Buffer of characters to output.              *
  *     OUT                                                   *
  *        ERROR: The status bytes of the I/O call.           *
  ************************************************************)
  PROCEDURE ENTRY WRITE ( IO_DEVICE: BYTE;
                          TEXT: UNIV MESSAGE_TYPE;
                      VAR ERROR: ERROR_SVC1_TYPE );
  VAR
     MESSAGE: MESSAGE_TYPE;
(*Begin entry Write*)
  BEGIN
   (*Set the SVC1 parameters for a sequential ASCII write*)
     PARAM.FUNC := FUN_ASCII_SVC1 + FUN_SEQUEN_SVC1
      + FUN_WRITE_SVC1;
   (*Set the logical unit to write to*)
     PARAM.LOG_UNIT := IO_DEVICE;
   (*Set the address of the data to be transfered*)
     MESSAGE := TEXT;  (*must be local variable for ADDRESS*)
     PARAM.BUFFER_START := ADDRESS (MESSAGE);
     PARAM.BUFFER_END := ADDRESS (MESSAGE) + SIZE(MESSAGE) -1;
   (*Execute the SVC1*)
     SVC1 ( PARAM );
   (*Set the status bytes*)
```

```
    ERROR.DD := PARAM.D_I_ERROR;
    ERROR.DI := PARAM.D_D_ERROR
(*End entry Write*)
  END;

 (***PROCEDURE ENTRY REWIND*************************************
  *  PARAMETERS                                                 *
  *     IN                                                      *
  *        IO_DEVICE: Logical unit for the rewind request.      *
  *     OUT                                                     *
  *        ERROR: The status bytes of the rewind call.          *
  ************************************************************)
  PROCEDURE ENTRY REWIND ( IO_DEVICE: BYTE;
                           VAR ERROR: ERROR_SVC1_TYPE );
  VAR
     PARAM: SVC1_BLOCK_TYPE;
(*Begin entry Rewind*)
  BEGIN
   (*Set the SVC1 parameters for rewind*)
     PARAM.FUNC := FUN_REWIND_SVC1;
   (*Set the logical unit to be rewound*)
     PARAM.LOG_UNIT := IO_DEVICE;
   (*Execute the SVC1*)
     SVC1 ( PARAM );
   (*Set the status bytes*)
     ERROR.DI := PARAM.D_I_ERROR;
     ERROR.DD := PARAM.D_D_ERROR
(*End entry Rewind*)
  END;

  BEGIN
  END;
```

```
                    (*$$$   FIFO   $$$*)
              (*$$$ Modified Brinch Hansen FIFO $$$*)

 TYPE FIFO = CLASS ( LIMIT: INTEGER );
(*************************************************************
 *                                                           *
 * MODIFIED PBH FIFO CLASS                                   *
 *                                                           *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 * PROGRAMMER: PER BRINCH HANSEN                             *
 * MODIFIED BY: RONALD C. ALBURY                             *
 * DATE WRITTEN:                                             *
 * COMPUTER: P.E. 8/32                                       *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  INTERNAL                                                 *
 *     VAR                                                   *
 *        HEAD: Position of the oldest entry in the queue.   *
 *        TAIL: Position of the newest entry in the queue.   *
 *        LENGTH: Length of the queue.                       *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  PARAMETERS                                               *
 *     IN                                                    *
 *        LIMIT: Number of positions available in the queue  *
 *************************************************************)
 VAR
    HEAD, TAIL, LENGTH: INTEGER;

 FUNCTION ENTRY ARRIVAL: INTEGER;
 BEGIN
    ARRIVAL := TAIL;
    TAIL := TAIL MOD LIMIT + 1;
    LENGTH := LENGTH  + 1
 END;

 FUNCTION ENTRY DEPARTURE: INTEGER;
 BEGIN
    DEPARTURE := HEAD;
    HEAD := HEAD MOD LIMIT + 1;
    LENGTH := LENGTH - 1
 END;

(***New function entry EXAMINE***)
 FUNCTION ENTRY EXAMINE: INTEGER;
 BEGIN
  (*Set to FIFO head without changing the FIFO*)
    EXAMINE := HEAD
 END;

(***New function entry SIZE***)
 FUNCTION ENTRY SIZE: INTEGER;
 BEGIN
  (*Set to the number of entries in the FIFO*)
    SIZE := LENGTH
 END;
```

```
                    (*$$$   FIFO   $$$*)
            (*$$$ Modified Brinch Hansen FIFO $$$*)

 FUNCTION ENTRY EMPTY: BOOLEAN;
 BEGIN
    EMPTY := (LENGTH = 0)
 END;

(***New function entry OCCUPIED***)
 FUNCTION ENTRY OCCUPIED: BOOLEAN;
 BEGIN
  (*Set true if FIFO is occupied*)
    OCCUPIED := ( LENGTH <> 0 )
 END;

(***New function entry FULL***)
 FUNCTION ENTRY FULL: BOOLEAN;
 BEGIN
  (*Set true if FIFO is full*)
    FULL := ( LENGTH = LIMIT )
 END;

 BEGIN (*FIFO INITIALIZATION*)
    HEAD := 1;
    TAIL := 1;
    LENGTH := 0
 END;
```

```
                    (*$$$   RESOURCE   $$$*)
          (*$$$ Standard Brinch Hansen Resource $$$*)

(*************************************************************
 *                                                           *
 * Standard BRINCH HANSEN RESOURCE                           *
 *                                                           *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 * PROGRAMMER: PER BRINCH HANSEN                             *
 * DATE WRITTEN:                                             *
 * COMPUTER: P.E. 8/32                                       *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  EXTERNAL                                                 *
 *     CONST                                                 *
 *        MAX_RESOURCE_USERS = Maximum number of processes   *
 *         that will attempt to access the resource.         *
 *     TYPE                                                  *
 *        FIFO = A P.B.H. CLASS for managing a FIFO buffer   *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  INTERNAL                                                 *
 *     VAR                                                   *
 *        FREE: A boolean variable that indicates if the     *
 *         resource is available.                            *
 *        Q: An array of Queue variables used as a fifo      *
 *         buffer for delaying processes.                    *
 *        NEXT: An instance of a P.B.H. FIFO class           *
 *************************************************************)
TYPE RESOURCE_MONITOR = MONITOR;
VAR
   FREE: BOOLEAN;
   Q: ARRAY [1..MAX_RESOURCE_USERS] OF QUEUE;
   NEXT: FIFO;

PROCEDURE ENTRY REQUEST;
BEGIN
   IF ( FREE ) THEN
      FREE := FALSE
   ELSE
   (*@@@CAUTION@@@*)
   (*@IF MAX_RESOURCE_USERS IS TOO SMALL WE
     @LOOSE A PROCESS HERE OR GET A DELAY QUEUE ERROR*)
      DELAY ( Q [NEXT.ARRIVAL] );
  {ENDIF}
END;

PROCEDURE ENTRY RELEASE;
BEGIN
   IF ( NEXT.EMPTY ) THEN
      FREE := TRUE
   ELSE
      CONTINUE ( Q [NEXT.DEPARTURE] )
  {ENDIF}
END;

BEGIN (*MAIN BODY OF MONITOR*)
```

```
                (*$$$   RESOURCE   $$$*)
          (*$$$ Standard Brinch Hansen Resource $$$*)


   FREE := TRUE;
   INIT NEXT ( MAX_RESOURCE_USERS )
END;
```

```
                    (*$$$   MAILBOX   $$$*)
          (*$$$ Interprocess communication mailbox $$$*)


TYPE MAIL_BOX_MONITOR = MONITOR;
(*************************************************************
*   MAIL_BOX_MONITOR is simply a means for one process to   *
* receive messages from up to MAX_SENDER other processes.   *
*   It can store up to MAX_MAIL messages in it's FIFO       *
* controlled MAIL_BUFFER.                                   *
*   If the receiver process attempts to pick up mail when   *
* the buffer is empty, it is delayed until a sender process *
* deposits mail.                                            *
*   If a sender process attempts to deposit mail when the   *
* buffer is full, it is delayed until the receiver process  *
* picks up mail.                                            *
*:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
* PROGRAMMER:  RON ALBURY                                   *
* DATE WRITTEN: 3/25/82                                     *
* LANGUAGE: CONCURRENT PASCAL ( BRINCH HANSEN [ K.S.U ] )   *
* COMPUTER: INTERDATA 8/32                                  *
* Copyright 1982 by Ronald C. Albury                        *
*:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
*  EXTERNAL                                                 *
*     CONST                                                 *
*        MAX_SENDERS = Maximum number of processes that     *
*         will send messages to the receiver.               *
*        MAX_MAIL = Maximum number of messages the monitor  *
*         can hold in it's buffer.                          *
*     TYPE                                                  *
*        FIFO = Modified Brinch Hansen FIFO class to        *
*         handle a FIFO buffer.                             *
*        PACKET_TYPE = The record structure of the mail.    *
*:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
*  INTERNAL                                                 *
*     VAR                                                   *
*        RECEIVER: Queue variable to delay the receiver.    *
*        SENDER: Array of Queue variables used as a fifo    *
*         buffer for delaying senders.                      *
*        DELAYED_SENDERS: Fifo to control SENDER buffer.    *
*        MAIL_BUFFER: Array of packets used as a fifo       *
*         buffer for storing mail.                          *
*        NEXT_MAIL: Fifo to control MAIL_BUFFER.            *
*************************************************************)
VAR
   DELAYED_SENDERS, NEXT_MAIL: FIFO;
   MAIL_BUFFER: ARRAY [1..MAX_MAIL] OF PACKET_TYPE;
   RECEIVER: QUEUE;
   SENDER: ARRAY [1..MAX_SENDERS] OF QUEUE;
```

```
                    (*$$$   MAILBOX   $$$*)
          (*$$$ Interprocess communication mailbox $$$*)


 (***PROCEDURE ENTRY GET*****************************************
  *  PARAMETERS                                                  *
  *     OUT                                                      *
  *        OUTGOING_MAIL: Receives the oldest entry              *
  *         from the MAIL_BUFFER.                                *
  ************************************************************)
  PROCEDURE ENTRY GET ( VAR OUTGOING_MAIL: PACKET_TYPE );
(*Begin entry GET*)
  BEGIN
   (*If [there is no mail in the FIFO queue] then*)
     IF ( NEXT_MAIL.EMPTY ) THEN
      (*Put the receiver to sleep*)
        DELAY ( RECEIVER );
   (*Endif*)
   (*Set outgoing mail to the oldest packet in the queue*)
     OUTGOING_MAIL:= MAIL_BUFFER [NEXT_MAIL.DEPARTURE];
   (*If [there are senders sleeping] then*)
     IF ( DELAYED_SENDERS.OCCUPIED ) THEN
      (*Wake up the oldest sleeper*)
        CONTINUE ( SENDER [DELAYED_SENDERS.DEPARTURE] )
   (*Endif*)
(*End entry GET*)
  END;

 (***PROCEDURE ENTRY DEPOSIT**************************************
  *  PARAMETERS                                                  *
  *     IN                                                       *
  *        INCOMING_MAIL: A packet being deposited into the      *
  *         MAIL_BUFFER by a sender process.                     *
  ************************************************************)
  PROCEDURE ENTRY DEPOSIT ( INCOMING_MAIL: PACKET_TYPE );
(*Begin entry DEPOSIT*)
  BEGIN
   (*If [all known senders are delayed] then*)
     IF ( DELAYED_SENDERS.FULL ) THEN
        (**SHOULD NEVER HAPPEN UNLESS MAX_SENDER IS WRONG**)
           (***WE LOOSE THE MAIL***)
   (*Else*)
     ELSE
        BEGIN
      (*If [mail queue is full] then*)
        IF ( NEXT_MAIL.FULL )  THEN
         (*Put the sender to sleep*)
           DELAY ( SENDER [DELAYED_SENDERS.ARRIVAL] );
      (*Endif*)
      (*Store the mail in a FIFO queue*)
        MAIL_BUFFER [NEXT_MAIL.ARRIVAL] := INCOMING_MAIL;
      (*If [the receiver is sleeping] wake him up*)
        CONTINUE ( RECEIVER )
        END
   (*Endif*)
(*End entry DEPOSIT*)
```

```
                    (*$$$   MAILBOX   $$$*)
        (*$$$ Interprocess communication mailbox $$$*)


END;

BEGIN (*MONITOR INITIALIZATION*)
   INIT
      NEXT_MAIL (MAX_MAIL),
      DELAYED_SENDERS (MAX_SENDERS)
END; (*MAIL_BOX_MONITOR*)
```

```
                (*$$$   WORKER0   $$$*)
          (*$$$ Worker application process $$$*)


TYPE WORKER_PROCESS = PROCESS(CONSOLE: RESOURCE_MONITOR;
                              FROM_NET: MAIL_BOX_MONITOR;
                              TO_NET: MAIL_BOX_MONITOR);
(*****************************************************************
 *  The WORKER_PROCESS is an application layer process that      *
 *   transfers remote files to the operator console.             *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 * PROGRAMMER:  RON ALBURY                                       *
 * DATE WRITTEN: 6/28/82                                         *
 * COMPUTER: INTERDATA 8/32                                      *
 * Copyright 1982 by Ronald C. Albury                            *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  EXTERNAL                                                     *
 *     TYPE                                                      *
 *        MESSAGE_IO_CLASS = A class that uses supervisory       *
 *         calls to handle fixed record I/O to specified         *
 *         logical units.                                        *
 *        PACKET_TYPE = Record structure of the network          *
 *         packets.                                              *
 *        MESSAGE_TYPE = Array of characters.                    *
 *        ERROR_SVC1_TYPE = Record structure of the status       *
 *         bytes from the supervisory call.                      *
 *        MAIL_BOX_MONITOR = A monitor used for passing          *
 *         packets between processes.                            *
 *        RESOURCE_MONITOR = Allows only one process to          *
 *         access a resource at a time.                          *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  INTERNAL                                                     *
 *     VAR                                                       *
 *        OP: Used to write lines of the transfered file         *
 *         to the operator.                                      *
 *        PACKET: A network packet this process uses to          *
 *         communicate with the network.                         *
 *        TEXT: Array of characters used to communicate          *
 *         the operator.                                         *
 *        OP_STATUS: Recieves the status bytes from the          *
 *         MESSAGE_IO_CLASS.  Not used here, but necessary       *
 *         for the calls to OP.                                  *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  PARAMETERS                                                   *
 *     CONSOLE: The RESOURCE_MONITOR used to reserve the         *
 *      console for exclusive I/O.                               *
 *     FROM_NET: The monitor used to recieve packets from        *
 *      the network.                                             *
 *     TO_NET: The monitor used to send packets to the net       *
 *****************************************************************)
VAR
   OP: MESSAGE_IO_CLASS;
   PACKET: PACKET_TYPE;
   TEXT: MESSAGE_TYPE;
   OP_STATUS: ERROR_SVC1_TYPE;
```

```
                    (*$$$   WORKER0   $$$*)
              (*$$$ Worker application process $$$*)


(*Begin Worker process*)
  BEGIN
   (*Initialize the interface to the operator*)
     INIT OP;
   (*Cycle forever*)
     CYCLE
      (*Get the id for the file to be transfered*)
        CONSOLE.REQUEST;
        TEXT := 'ENTER FILE ID.    - ';
        TEXT [18] := FIRST_FILE_ID;
        TEXT [20] := LAST_FILE_ID;
        OP.WRITE (TERMINAL, TEXT, OP_STATUS);
        OP.READ (TERMINAL, TEXT, OP_STATUS);
        CONSOLE.RELEASE;
      (*Send the request to the server*)
        PACKET.TEXT := TEXT;
        TO_NET.DEPOSIT (PACKET);
      (**Transfer the file to the console*)
        CONSOLE.REQUEST;
      (*Repeat until end of file*)
        REPEAT
         (*Get a line from the network*)
           FROM_NET.GET (PACKET);
         (*Output it to the console*)
           OP.WRITE (TERMINAL, PACKET.TEXT, OP_STATUS);
      (*End repeat*)
        UNTIL (PACKET.TEXT [1] = '/')
         & (PACKET.TEXT [2] = '*');
        CONSOLE.RELEASE
   (*End cycle*)
     END
(*End Worker process*)
  END;
```

```
                    (*$$$   SERVER0   $$$*)
                (*$$$ Server application process $$$*)


TYPE SERVER_PROCESS = PROCESS (FROM_NET: MAIL_BOX_MONITOR;
                               TO_NET: MAIL_BOX_MONITOR);
(*****************************************************************
 *  The server process is an application layer process that      *
 *   does the disk I/O for a remote worker process.              *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 * PROGRAMMER:  RON ALBURY                                       *
 * DATE WRITTEN: 6/28/82                                         *
 * COMPUTER: INTERDATA 8/32                                      *
 * Copyright 1982 by Ronald C. Albury                            *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  EXTERNAL                                                     *
 *     TYPE                                                      *
 *        MESSAGE_IO_CLASS = A class that uses supervisory       *
 *         calls to handle fixed record I/O to specified         *
 *         logical units.                                        *
 *        PACKET_TYPE = Record structure of the network          *
 *         packets.                                              *
 *        MESSAGE_TYPE = Array of characters.                    *
 *        ERROR_SVC1_TYPE = Record structure of the status       *
 *         bytes from the supervisory call.                      *
 *        MAIL_BOX_MONITOR = A monitor used for passing          *
 *         packets between processes.                            *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  INTERNAL                                                     *
 *     VAR                                                       *
 *        DISK: Used to input lines of a disk file.              *
 *        PACKET: A network packet used to communicate with      *
 *         the network.                                          *
 *        TEXT: Array of characters used for the disk I/O.       *
 *        FILE_ID: The id of the file the worker process is      *
 *         requesting.                                           *
 *        VALID_FILE_IDS: A set of the valid id's this           *
 *         process can access.                                   *
 *        FILE_LU: An array of logical units that are            *
 *         subscripted with file id's. Used to look up the       *
 *         logical unit of a file.                               *
 *        NEXT_LU: Used in initializing FILE_LU.                 *
 *        INDEX: Used in initializing FILE_LU.                   *
 *        OP_STATUS: Recieves the status bytes form the          *
 *         MESSAGE_IO_CLASS.                                     *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  PARAMETERS                                                   *
 *     FROM_NET: The monitor used to recieve packets from        *
 *      the network.                                             *
 *     TO_NET: The monitor used to send packets to the net.      *
 *****************************************************************)
VAR
   DISK: MESSAGE_IO_CLASS;
   PACKET: PACKET_TYPE;
   TEXT: MESSAGE_TYPE;
   FILE_ID: CHAR;
```

```
                    (*$$$   SERVER0   $$$*)
              (*$$$ Server application process $$$*)


     VALID_FILE_IDS: SET OF CHAR;
     FILE_LU: ARRAY [FILE_RANGE] OF BYTE;
     NEXT_LU: BYTE;
     INDEX: FILE_RANGE;
     OP_STATUS: ERROR_SVC1_TYPE;

(*Begin Server process*)
  BEGIN
   (*Initialize the interface to the disk files*)
     INIT DISK;
   (**Set up an array to reference logical unit numbers*)
   (**by the character id's of the files*)
     NEXT_LU := TERMINAL + 1;
   (*For all file id's do*)
     FOR INDEX := FIRST_FILE_ID TO LAST_FILE_ID DO
        BEGIN
      (*Remember that it is a valid id*)
        VALID_FILE_IDS := VALID_FILE_IDS + [INDEX];
      (*Set it's logical unit number*)
        FILE_LU [INDEX] := NEXT_LU;
        NEXT_LU := NEXT_LU + 1
        END;
   (*Endfor*)
   (*Cycle forever*)
     CYCLE
      (*Get the request from the net*)
        FROM_NET.GET (PACKET);
        FILE_ID := PACKET.TEXT [1];
      (*If [it is a valid file id] then*)
        IF (FILE_ID IN VALID_FILE_IDS) THEN
         (**Transfer the file*)
           BEGIN
         (*Read in a line from the disk*)
           DISK.READ (FILE_LU [FILE_ID], TEXT, OP_STATUS);
         (*While not [end of file] do*)
           WHILE (OP_STATUS.DI = 0) AND (OP_STATUS.DD = 0) DO
              BEGIN
            (*Send it out on the network*)
              PACKET.TEXT := TEXT;
              TO_NET.DEPOSIT (PACKET);
            (*Read in a new line from the disk file*)
              DISK.READ (FILE_LU [FILE_ID], TEXT, OP_STATUS)
              END;
         (*Endwhile*)
         (*Rewind the disk file*)
           DISK.REWIND (FILE_LU [FILE_ID], OP_STATUS);
         (*Send an EOF packet out on the network*)
           PACKET.TEXT := '/*                    ';
           TO_NET.DEPOSIT (PACKET)
           END
      (*Else (an invalid file id)*)
        ELSE
```

```
                (*$$$   SERVER0   $$$*)
            (*$$$ Server application process $$$*)


          (*Send an error message*)
            BEGIN
            PACKET.TEXT := '/*  BAD FILE ID -   ';
            PACKET.TEXT [19] := FILE_ID;
            TO_NET.DEPOSIT (PACKET)
            END
        (*Endif*)
     (*End cycle*)
       END
(*End Server*)
  END;
```

```
                (*$$$   BLACKBOX   $$$*)
          (*$$$ Undefined layers of the network $$$*)


TYPE BLACKBOX_PROCESS =
                    PROCESS ( TO_APP: MAIL_BOX_MONITOR;
                              EVENT: MAIL_BOX_MONITOR;
                              NEXT_NODE: MAIL_BOX_MONITOR);
(*************************************************************
 * The BLACKBOX layer represents the hardware and software  *
 *  necessary for two processes to communiacte on a network *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 * PROGRAMMER:  RON ALBURY                                   *
 * DATE WRITTEN: 6/28/82                                     *
 * COMPUTER: INTERDATA 8/32                                  *
 * Copyright 1982 by Ronald C. Albury                        *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  EXTERNAL                                                 *
 *     TYPE                                                  *
 *        PACKET_TYPE = Record structure of the network      *
 *         packets.                                          *
 *        MAIL_BOX_MONITOR = A monitor used for passing      *
 *         packets between processes.                        *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  INTERNAL                                                 *
 *     VAR                                                   *
 *        PACKET: A network packet that the layer processes *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  PARAMETERS                                               *
 *     TO_APP: The monitor used to send packets up toward    *
 *      the application layer.                               *
 *     EVENT: The monitor this layer uses to recieve         *
 *      packets.                                             *
 *     NEXT_NODE: The monitor used to send packets to        *
 *      the next node in the network.                        *
 *************************************************************)
VAR
   PACKET: PACKET_TYPE;
BEGIN
 (*Cycle forever*)
   CYCLE
    (*Wait for a packet*)
      EVENT.GET (PACKET);
    (*If [an outgoing packet] then*)
      IF ( PACKET.DIRECTION = OUTGOING ) THEN
         BEGIN
       (*Set it as an incomming packet*)
         PACKET.DIRECTION := INCOMING;
       (*Pass it on to the next node*)
         NEXT_NODE.DEPOSIT (PACKET)
         END
    (*Else (an incomming packet)*)
      ELSE
       (*Pass it up to the application layer*)
         TO_APP.DEPOSIT (PACKET)
    (*Endif*)
```

```
                    (*$$$   BLACKBOX   $$$*)
              (*$$$ Undefined layers of the network $$$*)


    (*End cycle*)
      END
  (*End Blackbox*)
    END;
```

```
                    (*$$$   WORKER1   $$$*)
          (*$$$ Net1 Worker application process $$$*)


 TYPE WORKER_PROCESS = PROCESS(CONSOLE: RESOURCE_MONITOR;
                               FROM_NET: MAIL_BOX_MONITOR;
                               TO_NET: MAIL_BOX_MONITOR);
(*************************************************************
 *  The WORKER_PROCESS is an application layer process that  *
 *   transfers remote files to the operator console.         *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 * PROGRAMMER:  RON ALBURY                                    *
 * DATE WRITTEN: 6/28/82                                      *
 * COMPUTER: INTERDATA 8/32                                   *
 * Copyright 1982 by Ronald C. Albury                         *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  EXTERNAL                                                  *
 *     TYPE                                                   *
 *        MESSAGE_IO_CLASS = A class that uses supervisory    *
 *         calls to handle fixed record I/O to specified      *
 *         logical units.                                     *
 *        PACKET_TYPE = Record structure of the network       *
 *         packets.                                           *
 *        MESSAGE_TYPE = Array of characters.                 *
 *        ERROR_SVC1_TYPE = Record structure of the status    *
 *         bytes from the supervisory call.                   *
 *        MAIL_BOX_MONITOR = A monitor used for passing       *
 *         packets between processes.                         *
 *        RESOURCE_MONITOR = Allows only one process to       *
 *         access a resource at a time.                       *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  INTERNAL                                                  *
 *     VAR                                                    *
 *        OP: Used to write lines of the transfered file      *
 *         to the operator.                                   *
 *        PACKET: A network packet this process uses to       *
 *         communicate with the network.                      *
 *        TEXT: Array of characters used to communicate       *
 *         the operator.                                      *
 *        OP_STATUS: Recieves the status bytes from the       *
 *         MESSAGE_IO_CLASS.  Not used here, but necessary    *
 *         for the calls to OP.                               *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  PARAMETERS                                                *
 *     CONSOLE: The RESOURCE_MONITOR used to reserve the      *
 *      console for exclusive I/O.                            *
 *     FROM_NET: The monitor used to recieve packets from     *
 *      the network.                                          *
 *     TO_NET: The monitor used to send packets to the net    *
 *************************************************************)
 VAR
    OP: MESSAGE_IO_CLASS;
    PACKET: PACKET_TYPE;
    TEXT: MESSAGE_TYPE;
    OP_STATUS: ERROR_SVC1_TYPE;
```

```
                    (*$$$   WORKER1   $$$*)
            (*$$$ Net1 Worker application process $$$*)


(*Begin Worker process*)
  BEGIN
   (*Initialize the interface to the operator*)
     INIT OP;
   (*Cycle forever*)
     CYCLE
      (*Get the id for the file to be transfered*)
        CONSOLE.REQUEST;
        TEXT := 'ENTER FILE ID.    - ';
        TEXT [18] := FIRST_FILE_ID;
        TEXT [20] := LAST_FILE_ID;
        OP.WRITE (TERMINAL, TEXT, OP_STATUS);
        OP.READ (TERMINAL, TEXT, OP_STATUS);
        CONSOLE.RELEASE;
      (*Send the request to the server*)
        PACKET.DIRECTION := OUTGOING; (****)
        PACKET.TEXT := TEXT;
        TO_NET.DEPOSIT (PACKET);
      (**Transfer the file to the console*)
        CONSOLE.REQUEST;
      (*Repeat until end of file*)
        REPEAT
         (*Get a line from the network*)
           FROM_NET.GET (PACKET);
         (*Output it to the console*)
           OP.WRITE (TERMINAL, PACKET.TEXT, OP_STATUS);
      (*End repeat*)
        UNTIL (PACKET.TEXT [1] = '/')
         & (PACKET.TEXT [2] = '*');
        CONSOLE.RELEASE
   (*End cycle*)
     END
(*End Worker process*)
  END;
```

```
                    (*$$$   SERVER1   $$$*)
              (*$$$ Net1 Server application process $$$*)


TYPE SERVER_PROCESS = PROCESS (FROM_NET: MAIL_BOX_MONITOR;
                               TO_NET: MAIL_BOX_MONITOR);
(*****************************************************************
 *  The server process is an application layer process that      *
 *   does the disk I/O for a remote worker process.              *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 * PROGRAMMER:  RON ALBURY                                       *
 * DATE WRITTEN: 6/28/82                                         *
 * COMPUTER: INTERDATA 8/32                                      *
 * Copyright 1982 by Ronald C. Albury                            *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  EXTERNAL                                                     *
 *     TYPE                                                      *
 *        MESSAGE_IO_CLASS = A class that uses supervisory       *
 *         calls to handle fixed record I/O to specified         *
 *         logical units.                                        *
 *        PACKET_TYPE = Record structure of the network          *
 *         packets.                                              *
 *        MESSAGE_TYPE = Array of characters.                    *
 *        ERROR_SVC1_TYPE = Record structure of the status       *
 *         bytes from the supervisory call.                      *
 *        MAIL_BOX_MONITOR = A monitor used for passing          *
 *         packets between processes.                            *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  INTERNAL                                                     *
 *     VAR                                                       *
 *        DISK: Used to input lines of a disk file.              *
 *        PACKET: A network packet used to communicate with      *
 *         the network.                                          *
 *        TEXT: Array of characters used for the disk I/O.       *
 *        FILE_ID: The id of the file the worker process is      *
 *         requesting.                                           *
 *        VALID_FILE_IDS: A set of the valid id's this           *
 *         process can access.                                   *
 *        FILE_LU: An array of logical units that are            *
 *         subscripted with file id's. Used to look up the       *
 *         logical unit of a file.                               *
 *        NEXT_LU: Used in initializing FILE_LU.                 *
 *        INDEX: Used in initializing FILE_LU.                   *
 *        OP_STATUS: Recieves the status bytes form the          *
 *         MESSAGE_IO_CLASS.                                     *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  PARAMETERS                                                   *
 *     FROM_NET: The monitor used to recieve packets from        *
 *      the network.                                             *
 *     TO_NET: The monitor used to send packets to the net.      *
 *****************************************************************)
VAR
   DISK: MESSAGE_IO_CLASS;
   PACKET: PACKET_TYPE;
   TEXT: MESSAGE_TYPE;
   FILE_ID: CHAR;
```

```
                    (*$$$   SERVER1   $$$*)
          (*$$$ Net1 Server application process $$$*)


    VALID_FILE_IDS: SET OF CHAR;
    FILE_LU: ARRAY [FILE_RANGE] OF BYTE;
    NEXT_LU: BYTE;
    INDEX: FILE_RANGE;
    OP_STATUS: ERROR_SVC1_TYPE;

(*Begin Server process*)
  BEGIN
   (*Initialize the interface to the disk files*)
     INIT DISK;
   (**Set up an array to reference logical unit numbers*)
   (**by the character id's of the files*)
     NEXT_LU := TERMINAL + 1;
   (*For all file id's do*)
     FOR INDEX := FIRST_FILE_ID TO LAST_FILE_ID DO
        BEGIN
      (*Remember that it is a valid id*)
        VALID_FILE_IDS := VALID_FILE_IDS + [INDEX];
      (*Set it's logical unit number*)
        FILE_LU [INDEX] := NEXT_LU;
        NEXT_LU := NEXT_LU + 1
        END;
   (*Endfor*)
   (*Cycle forever*)
     CYCLE
      (*Get the request from the net*)
        FROM_NET.GET (PACKET);
        FILE_ID := PACKET.TEXT [1];
      (*If [it is a valid file id] then*)
        IF (FILE_ID IN VALID_FILE_IDS) THEN
         (**Transfer the file*)
           BEGIN
         (*Read in a line from the disk*)
           DISK.READ (FILE_LU [FILE_ID], TEXT, OP_STATUS);
         (*While not [end of file] do*)
           WHILE (OP_STATUS.DI = 0) AND (OP_STATUS.DD = 0) DO
              BEGIN
            (*Send it out on the network*)
              PACKET.DIRECTION := OUTGOING; (****)
              PACKET.TEXT := TEXT;
              TO_NET.DEPOSIT (PACKET);
            (*Read in a new line from the disk file*)
              DISK.READ (FILE_LU [FILE_ID], TEXT, OP_STATUS)
              END;
         (*Endwhile*)
         (*Rewind the disk file*)
           DISK.REWIND (FILE_LU [FILE_ID], OP_STATUS);
         (*Send an EOF packet out on the network*)
           PACKET.DIRECTION := OUTGOING; (****)
           PACKET.TEXT := '/*                    ';
           TO_NET.DEPOSIT (PACKET)
           END
```

```
                    (*$$$   SERVER1   $$$*)
            (*$$$ Net1 Server application process $$$*)


        (*Else (an invalid file id)*)
          ELSE
           (*Send an error message*)
             BEGIN
             PACKET.DIRECTION := OUTGOING; (****)
             PACKET.TEXT := '/*  BAD FILE ID -   ';
             PACKET.TEXT [19] := FILE_ID;
             TO_NET.DEPOSIT (PACKET)
             END
        (*Endif*)
     (*End cycle*)
       END
  (*End Server*)
    END;
```

```
                    (*$$$   CR2NL   $$$*)
 (*$$$ Presentation layer record delimiter conversion $$$*)


 TYPE CR_NL_CLASS = CLASS;
(*************************************************************
 * CR_NL_CLASS substitutes carrage return and new line      *
 *  characters in a message.                                 *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 * PROGRAMMER:  RON ALBURY                                   *
 * DATE WRITTEN: 4/5/82                                      *
 * Copyright 1982 by Ronald C. Albury                        *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  EXTERNAL                                                 *
 *     CONST                                                 *
 *        MESSAGE_LENGTH = Number of characters in the       *
 *         packet text.                                      *
 *     TYPE                                                  *
 *        MESSAGE_TYPE = ARRAY [ 1..MESSAGE_LENGTH ]         *
 *         OF CHAR                                           *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  INTERNAL                                                 *
 *     CONST                                                 *
 *        NL = ASCII representation of a 'new line'.         *
 *        CR = ASCII representation of a 'carrage return'.   *
 *************************************************************)
 CONST
    CR = '(:13:)';
    NL = '(:10:)';

(***PROCEDURE ENTRY CHANGE*************************************
 *  VARIABLES                                                *
 *     INDEX: Used to increment through the message.         *
 *     OLD_DELIM: The delimiter we wish to change.           *
 *     NEW_DELIM: The delimiter to change to.                *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  PARAMETERS                                               *
 *     IN                                                    *
 *        HOST_FILE_FORMAT: The format the file needs to     *
 *         be converted to.                                  *
 *     OUT                                                   *
 *        TEXT: The array of characters to be converted.     *
 *************************************************************)
 PROCEDURE ENTRY CHANGE ( VAR TEXT: MESSAGE_TYPE;
                              HOST_FORM: FILE_FORMAT_TYPE );
 VAR
    INDEX: 1..MESSAGE_LENGTH;
    OLD_DELIM, NEW_DELIM: CHAR;
(*Begin entry Change*)
 BEGIN
  (**Decide which characters need to be changed*)
    IF ( HOST_FORM = CR_DELIM ) THEN
       BEGIN
       OLD_DELIM := NL;
       NEW_DELIM := CR
       END
```

```
                    (*$$$   CR2NL   $$$*)
  (*$$$ Presentation layer record delimiter conversion $$$*)


     ELSE
        BEGIN
        OLD_DELIM := CR;
        NEW_DELIM := NL
        END;
     {ENDIF}
    (**Change all incorrect characters*)
      FOR INDEX := 1 TO MESSAGE_LENGTH DO
        IF ( TEXT [INDEX] = OLD_DELIM ) THEN
           TEXT [INDEX] := NEW_DELIM
       {ENDIF}
     {ENDFOR}
(*End entry Change*)
  END;

  BEGIN (*CLASS INITIALIZATION*)
  END;
```

```
                    (*$$$   CRIPTV   $$$*)
        (*$$$ Presentation layer data encryption $$$*)


TYPE CRIPT_CLASS = CLASS;
{*** VIGENERE SUBSTITUTION CIPHER ****}
(*************************************************************
* CRIPT_CLASS uses cryptographic methods to provide          *
*  security in data transfer.                                *
*:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
* PROGRAMMER:  RON ALBURY                                    *
* DATE WRITTEN: 4/2/82                                       *
* Copyright 1982 by Ronald C. Albury                         *
*:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
*  EXTERNAL                                                  *
*     CONST                                                  *
*        MESSAGE_LENGTH = The length of the message array.   *
*     TYPE                                                   *
*        MESSAGE_TYPE = Array of characters.                 *
*:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
*  INTERNAL                                                  *
*     CONST                                                  *
*        FIRST_CHAR = The first character in the ASCII       *
*         character set (null).                              *
*        LAST_CHAR = The last character in the ASCII         *
*         character set.                                     *
*     TYPE                                                   *
*        MSG_SYMBOLS = Subrange of acceptable symbols in     *
*         a message.                                         *
*        CRIPT_TABLE = A two dimensional array for all       *
*         acceptable symbols in a message.                   *
*     VAR                                                    *
*        ROW_ORD, COL_ORD: Integers used to calculate the    *
*         characters in the CRIPT_TABLEs during              *
*         initialization.                                    *
*        ROW_INDEX, COL_INDEX: MSG_SYMBOLS to increment      *
*         through the CRIPT_TABLEs at initialization.        *
*        ENCRPT, DECRPT: CRIPT_TABLES used to look up        *
*         character substitutions for encription and         *
*         decription.                                        *
*        SPAN: Used with a MOD function to 'fold' the        *
*         MSG_SYMBOLS around during initialization of the    *
*         CRIPT_TABLEs.                                      *
*        ORD_FIRST_CHAR, ORD_LAST_CHAR: Used to set SPAN.    *
*        MSG_SYM_SET: Set of acceptable symbols in a         *
*         message.                                           *
*************************************************************)
CONST
   FIRST_CHAR = '(:0:)';
   LAST_CHAR = '(:127:)';
TYPE
   MSG_SYMBOLS = FIRST_CHAR..LAST_CHAR;
   CRIPT_TABLE = ARRAY [MSG_SYMBOLS, MSG_SYMBOLS]
    OF CHAR;
VAR
   ROW_ORD, COL_ORD: INTEGER;
```

```
                    (*$$$   CRIPTV   $$$*)
          (*$$$ Presentation layer data encryption $$$*)


      ROW_INDEX, COL_INDEX: MSG_SYMBOLS;
      ENCRPT, DECRPT: CRIPT_TABLE;
      ORD_FIRST_CHAR, ORD_LAST_CHAR, SPAN: 0..128;
      MSG_SYM_SET: SET OF MSG_SYMBOLS;

   (***PROCEDURE ENTRY ENCODE*************************************
    *  VARIABLES                                                  *
    *     MSG_INDEX: Index to increment through the message.      *
    *     KEY_INDEX: Index to increment through the key.          *
    *  PARAMETERS                                                 *
    *     IN                                                      *
    *        KEY: The array of characters used as the key for     *
    *         encripting the message.                             *
    *     OUT                                                     *
    *        MESSAGE: The array of characters to be encripted.    *
    ************************************************************)
    PROCEDURE ENTRY ENCODE ( VAR MESSAGE: MESSAGE_TYPE;
                                 KEY: MESSAGE_TYPE );
    VAR
       MSG_INDEX: 1..MESSAGE_LENGTH;
       KEY_INDEX: 1..MESSAGE_LENGTH;
  (*Begin entry Encode*)
    BEGIN
     (*For all the characters in a message do*)
       FOR MSG_INDEX := 1 TO MESSAGE_LENGTH DO
          BEGIN
        (*Calculate which letter in the key to use*)
         (*@In case the key isn't the same length as a message*)
          KEY_INDEX := ( (MSG_INDEX-1) MOD MESSAGE_LENGTH )
           + 1;
        (*If [unable to translate this character] then*)
          IF NOT ( MESSAGE [MSG_INDEX] IN MSG_SYM_SET ) THEN
           (*Arbitrarily encode it as Last_char*)
             MESSAGE [MSG_INDEX] := LAST_CHAR
        (*Else (a good character)*)
          ELSE
           (*Look up the new value in the Encript table*)
             MESSAGE [MSG_INDEX] :=
              ENCRPT [KEY [KEY_INDEX], MESSAGE [MSG_INDEX]]
        (*Endif*)
          END
     (*Endfor*)
  (*End entry Encode*)
    END;

   (***PROCEDURE ENTRY DECODE*************************************
    *  VARIABLES                                                  *
    *     MSG_INDEX: Index to increment through the message.      *
    *     KEY_INDEX: index to increment through the key.          *
    *  PARAMETERS                                                 *
    *     IN                                                      *
    *       KEY: The array of characters used as the key for     *
```

```
                    (*$$$   CRIPTV   $$$*)
          (*$$$ Presentation layer data encryption $$$*)


  *         decripting the message.                              *
  *      OUT                                                     *
  *        MESSAGE: The array of characters to be decripted.     *
  ************************************************************)
  PROCEDURE ENTRY DECODE ( VAR MESSAGE: MESSAGE_TYPE;
                               KEY: MESSAGE_TYPE );
  VAR
     MSG_INDEX: 1..MESSAGE_LENGTH;
     KEY_INDEX: 1..MESSAGE_LENGTH;
(*Begin entry Decode*)
  BEGIN
   (*For all the characters in a message do*)
     FOR MSG_INDEX := 1 TO MESSAGE_LENGTH DO
        BEGIN
      (*Calculate which letter in the key to use (in case*)
      (*the key isn't the same length as the message)*)
        KEY_INDEX := ( (MSG_INDEX-1) MOD MESSAGE_LENGTH )
         + 1;
      (*If [unable to translate this character] then*)
        IF NOT ( MESSAGE [MSG_INDEX ] IN MSG_SYM_SET ) THEN
         (*Arbitrarily decode it as Last_char*)
           MESSAGE [MSG_INDEX] := LAST_CHAR
      (*Else (a good character)*)
        ELSE
         (*Look up the new value in the Decript table*)
           MESSAGE [MSG_INDEX] :=
            DECRPT [KEY [KEY_INDEX], MESSAGE [MSG_INDEX]]
      (*Endif*)
        END
   (*Endfor*)
(*End entry Decode*)
  END;

(*@The method of initializing the Encript and Decript*)
(*@tables allows for maximum flexibility if*)
(*@you decide to change the set of acceptable message symbols*)
(*@A section of the initialized encript table contains:*)
(*@     ::::::::::::*)
(*@     ...ABCDEF...*)
(*@     ...BCDEFG...*)
(*@     ...CDEFGH...*)
(*@     ...DEFGHI...*)
(*@     ::::::::::::*)
(*Begin Cript_class initialization*)
  BEGIN
     MSG_SYM_SET := [];
     ORD_FIRST_CHAR := ORD( FIRST_CHAR );
     ORD_LAST_CHAR := ORD( LAST_CHAR );
     SPAN := ORD_LAST_CHAR - ORD_FIRST_CHAR + 1;
     FOR ROW_INDEX := FIRST_CHAR TO LAST_CHAR DO
        BEGIN
        ROW_ORD := ORD(ROW_INDEX);
```

```
                    (*$$$   CRIPTV   $$$*)
          (*$$$ Presentation layer data encryption $$$*)


          MSG_SYM_SET := MSG_SYM_SET + [ROW_INDEX];
          FOR COL_INDEX := FIRST_CHAR TO LAST_CHAR DO
             BEGIN
             COL_ORD := ORD(COL_INDEX);
             ENCRPT [COL_INDEX, ROW_INDEX] :=
              CHR ( ( (ROW_ORD+COL_ORD) MOD SPAN )
              + ORD_FIRST_CHAR );
             DECRPT [COL_INDEX, ROW_INDEX] :=
              CHR ( ( (ROW_ORD+SPAN-COL_ORD) MOD SPAN )
              + ORD_FIRST_CHAR );
             END;
          {ENDFOR EACH COLUMN}
           END
       {ENDFOR EACH ROW}
  (*End Cript_class initialization*)
    END;
```

```
                    (*$$$   PRESENT   $$$*)
  (*$$$ Process to simulate the Presentation layer $$$*)


TYPE PRESENT_PROCESS = PROCESS (TO_APP: MAIL_BOX_MONITOR;
                                EVENT: MAIL_BOX_MONITOR;
                                TO_NET: MAIL_BOX_MONITOR;
                                HOST_FORM: FILE_FORMAT_TYPE);
(*************************************************************
 *  The PRESENTATION layer handles such tasks as encription  *
 *   and file format modification, before the packets are    *
 *   presented to the application layer.                     *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  PROGRAMMER:  RON ALBURY                                  *
 *  DATE WRITTEN:  6/29/82                                   *
 *  Copyright 1982 by Ronald C. Albury                       *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  EXTERNAL                                                 *
 *     TYPE                                                  *
 *        PACKET_TYPE: Record structure of the network       *
 *         packets.                                          *
 *        MAIL_BOX_MONITOR: A monitor used for passing       *
 *         packets between processes.                        *
 *        FILE_FORMAT_TYPE: If the file uses carriage return*
 *         or new line as a delimiter.                       *
 *        CRIPT_CLASS: A class which translates messages     *
 *         into or out of a cipher.                          *
 *        CR_NL_CLASS: A class which changes the format of   *
 *         messages between carrage return and new line      *
 *         delimiters.                                       *
 *       MESSAGE_TYPE: Array of characters.                  *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  INTERNAL                                                 *
 *     VAR                                                   *
 *        CIPHER: Handles encription for the layer.          *
 *        FORMAT: Handles changing the format of messages    *
 *         for the layer.                                    *
 *        PACKET: A network packet that the layer processes.*
 *        KEY: The cipher key used by CIPHER.                *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  PARAMETERS                                               *
 *     TO_APP: The monitor used to send packets to the       *
 *      application layer.                                   *
 *     EVENT: The monitor this layer uses to recieve         *
 *      packets.                                             *
 *     TO_NET: The monitor used to send packets down to the  *
 *      network.                                             *
 *     HOST_FORM: The file format this host uses.            *
 *************************************************************)
VAR
   CIPHER: CRIPT_CLASS;
   FORMAT: CR_NL_CLASS;
   PACKET: PACKET_TYPE;
   KEY: MESSAGE_TYPE;
```

```
                    (*$$$   PRESENT   $$$*)
    (*$$$ Process to simulate the Presentation layer $$$*)


(*Begin Present_process*)
  BEGIN
   (*Initialize the encription and format routines*)
     INIT CIPHER, FORMAT;
   (*Set the encription key*)
     KEY := 'TEMPORARY KEY &!)$  ';
   (*Cycle forever*)
     CYCLE
      (*Wait for a packet*)
        EVENT.GET (PACKET);
      (*If [packet is heading out] then*)
        IF ( PACKET.DIRECTION = OUTGOING ) THEN
           BEGIN
         (*If [the security level is secret] then*)
           IF ( PACKET.SECURITY = SECRET ) THEN
            (*Encode the text*)
              CIPHER.ENCODE (PACKET.TEXT,KEY);
          (Endif*)
         (*Identify the file format of the text*)
           PACKET.FILE_FORMAT := HOST_FORM;
         (*Send the packet out on the network*)
           TO_NET.DEPOSIT (PACKET)
           END
      (*Else (packet on it's way to application)*)
        ELSE
           BEGIN
         (*If [the packet is encripted] then*)
           IF ( PACKET.SECURITY = SECRET ) THEN
              BEGIN
            (*Decode it*)
              CIPHER.DECODE (PACKET.TEXT,KEY);
              PACKET.SECURITY := PUBLIC
              END;
         (*Endif*)
         (*If [wrong record delimiter] then*)
           IF (PACKET.FILE_FORMAT <> HOST_FORM) THEN
              BEGIN
            (*Modify the format to match the host*)
              FORMAT.CHANGE (PACKET.TEXT, HOST_FORM);
              PACKET.FILE_FORMAT := HOST_FORM
              END;
         (*Endif*)
         (*Pass the packet up to the application layer*)
           TO_APP.DEPOSIT (PACKET)
           END
      (*Endif*)
    (*End cycle*)
      END
(*End Present_process*)
  END;
```

```
                    (*$$$   WORKER2   $$$*)
          (*$$$ Net2 Worker application process $$$*)


 TYPE WORKER_PROCESS = PROCESS(CONSOLE: RESOURCE_MONITOR;
                               FROM_NET: MAIL_BOX_MONITOR;
                               TO_NET: MAIL_BOX_MONITOR);
(*************************************************************
 *  The WORKER_PROCESS is an application layer process that  *
 *   transfers remote files to the operator console.         *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 * PROGRAMMER:  RON ALBURY                                    *
 * DATE WRITTEN: 6/28/82                                      *
 * COMPUTER: INTERDATA 8/32                                   *
 * Copyright 1982 by Ronald C. Albury                         *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  EXTERNAL                                                  *
 *     TYPE                                                   *
 *        MESSAGE_IO_CLASS = A class that uses supervisory    *
 *         calls to handle fixed record I/O to specified      *
 *         logical units.                                     *
 *        PACKET_TYPE = Record structure of the network       *
 *         packets.                                           *
 *        MESSAGE_TYPE = Array of characters.                 *
 *        ERROR_SVC1_TYPE = Record structure of the status    *
 *         bytes from the supervisory call.                   *
 *        MAIL_BOX_MONITOR = A monitor used for passing       *
 *         packets between processes.                         *
 *        RESOURCE_MONITOR = Allows only one process to       *
 *         access a resource at a time.                       *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  INTERNAL                                                  *
 *     VAR                                                    *
 *        OP: Used to write lines of the transfered file      *
 *         to the operator.                                   *
 *        PACKET: A network packet this process uses to       *
 *         communicate with the network.                      *
 *        TEXT: Array of characters used to communicate       *
 *         the operator.                                      *
 *        OP_STATUS: Recieves the status bytes from the       *
 *         MESSAGE_IO_CLASS.  Not used here, but necessary    *
 *         for the calls to OP.                               *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  PARAMETERS                                                *
 *     CONSOLE: The RESOURCE_MONITOR used to reserve the      *
 *      console for exclusive I/O.                            *
 *     FROM_NET: The monitor used to recieve packets from     *
 *      the network.                                          *
 *     TO_NET: The monitor used to send packets to the net    *
 *************************************************************)
 VAR
    OP: MESSAGE_IO_CLASS;
    PACKET: PACKET_TYPE;
    TEXT: MESSAGE_TYPE;
    OP_STATUS: ERROR_SVC1_TYPE;
```

```
                    (*$$$   WORKER2   $$$*)
            (*$$$ Net2 Worker application process $$$*)


(*Begin Worker process*)
  BEGIN
   (*Initialize the interface to the operator*)
     INIT OP;
   (*Cycle forever*)
     CYCLE
      (*Get the id for the file to be transfered*)
        CONSOLE.REQUEST;
        TEXT := 'ENTER FILE ID.    - ';
        TEXT [18] := FIRST_FILE_ID;
        TEXT [20] := LAST_FILE_ID;
        OP.WRITE (TERMINAL, TEXT, OP_STATUS);
        OP.READ (TERMINAL, TEXT, OP_STATUS);
        CONSOLE.RELEASE;
      (*Send the request to the server*)
        PACKET.DIRECTION := OUTGOING;
        PACKET.SECURITY := PUBLIC;  (****)
        PACKET.TEXT := TEXT;
        TO_NET.DEPOSIT (PACKET);
      (**Transfer the file to the console*)
        CONSOLE.REQUEST;
      (*Repeat until end of file*)
        REPEAT
         (*Get a line from the network*)
           FROM_NET.GET (PACKET);
         (*Output it to the console*)
           OP.WRITE (TERMINAL, PACKET.TEXT, OP_STATUS);
      (*End repeat*)
        UNTIL (PACKET.TEXT [1] = '/')
         & (PACKET.TEXT [2] = '*');
        CONSOLE.RELEASE
   (*End cycle*)
     END
(*End Worker process*)
  END;
```

```
                    (*$$$   SERVER2   $$$*)
          (*$$$ Net2 Server application process $$$*)


 TYPE SERVER_PROCESS = PROCESS (FROM_NET: MAIL_BOX_MONITOR;
                                TO_NET: MAIL_BOX_MONITOR);
(*************************************************************
 *  The server process is an application layer process that  *
 *   does the disk I/O for a remote worker process.          *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 * PROGRAMMER:  RON ALBURY                                    *
 * DATE WRITTEN: 6/28/82                                     *
 * COMPUTER: INTERDATA 8/32                                  *
 * Copyright 1982 by Ronald C. Albury                        *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  EXTERNAL                                                 *
 *     TYPE                                                  *
 *        MESSAGE_IO_CLASS = A class that uses supervisory   *
 *         calls to handle fixed record I/O to specified     *
 *         logical units.                                    *
 *        PACKET_TYPE = Record structure of the network      *
 *         packets.                                          *
 *        MESSAGE_TYPE = Array of characters.                *
 *        ERROR_SVC1_TYPE = Record structure of the status   *
 *         bytes from the supervisory call.                  *
 *        MAIL_BOX_MONITOR = A monitor used for passing      *
 *         packets between processes.                        *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  INTERNAL                                                 *
 *     VAR                                                   *
 *        DISK: Used to input lines of a disk file.          *
 *        PACKET: A network packet used to communicate with  *
 *         the network.                                      *
 *        TEXT: Array of characters used for the disk I/O.   *
 *        FILE_ID: The id of the file the worker process is  *
 *         requesting.                                       *
 *        VALID_FILE_IDS: A set of the valid id's this       *
 *         process can access.                               *
 *        FILE_LU: An array of logical units that are        *
 *         subscripted with file id's. Used to look up the   *
 *         logical unit of a file.                           *
 *        NEXT_LU: Used in initializing FILE_LU.             *
 *        INDEX: Used in initializing FILE_LU.               *
 *        OP_STATUS: Recieves the status bytes form the      *
 *         MESSAGE_IO_CLASS.                                 *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  PARAMETERS                                               *
 *     FROM_NET: The monitor used to recieve packets from    *
 *      the network.                                         *
 *     TO_NET: The monitor used to send packets to the net.  *
 *************************************************************)
 VAR
    DISK: MESSAGE_IO_CLASS;
    PACKET: PACKET_TYPE;
    TEXT: MESSAGE_TYPE;
    FILE_ID: CHAR;
```

```
                    (*$$$   SERVER2   $$$*)
            (*$$$ Net2 Server application process $$$*)


    VALID_FILE_IDS: SET OF CHAR;
    FILE_LU: ARRAY [FILE_RANGE] OF BYTE;
    NEXT_LU: BYTE;
    INDEX: FILE_RANGE;
    OP_STATUS: ERROR_SVC1_TYPE;

(*Begin Server process*)
  BEGIN
   (*Initialize the interface to the disk files*)
     INIT DISK;
   (**Set up an array to reference logical unit numbers*)
   (**by the character id's of the files*)
     NEXT_LU := TERMINAL + 1;
   (*For all file id's do*)
     FOR INDEX := FIRST_FILE_ID TO LAST_FILE_ID DO
        BEGIN
      (*Remember that it is a valid id*)
        VALID_FILE_IDS := VALID_FILE_IDS + [INDEX];
      (*Set it's logical unit number*)
        FILE_LU [INDEX] := NEXT_LU;
        NEXT_LU := NEXT_LU + 1
        END;
   (*Endfor*)
   (*Cycle forever*)
     CYCLE
      (*Get the request from the net*)
        FROM_NET.GET (PACKET);
        FILE_ID := PACKET.TEXT [1];
      (*If [it is a valid file id] then*)
        IF (FILE_ID IN VALID_FILE_IDS) THEN
         (**Transfer the file*)
           BEGIN
         (*Read in a line from the disk*)
           DISK.READ (FILE_LU [FILE_ID], TEXT, OP_STATUS);
         (*While not [end of file] do*)
           WHILE (OP_STATUS.DI = 0) AND (OP_STATUS.DD = 0) DO
              BEGIN
            (*Send it out on the network*)
              PACKET.DIRECTION := OUTGOING;
              PACKET.SECURITY := SECRET;  (****)
              PACKET.TEXT := TEXT;
              TO_NET.DEPOSIT (PACKET);
            (*Read in a new line from the disk file*)
              DISK.READ (FILE_LU [FILE_ID], TEXT, OP_STATUS)
              END;
         (*Endwhile*)
         (*Rewind the disk file*)
           DISK.REWIND (FILE_LU [FILE_ID], OP_STATUS);
         (*Send an EOF packet out on the network*)
           PACKET.DIRECTION := OUTGOING;
           PACKET.SECURITY := SECRET;  (****)
           PACKET.TEXT := '/*                    ';
```

```
                    (*$$$   SERVER2   $$$*)
            (*$$$ Net2 Server application process $$$*)


              TO_NET.DEPOSIT (PACKET)
              END
          (*Else (an invalid file id)*)
            ELSE
             (*Send an error message*)
              BEGIN
              PACKET.DIRECTION := OUTGOING;
              PACKET.SECURITY := PUBLIC; (****)
              PACKET.TEXT := '/*  BAD FILE ID -   ';
              PACKET.TEXT [19] := FILE_ID;
              TO_NET.DEPOSIT (PACKET)
              END
          (*Endif*)
       (*End cycle*)
         END
    (*End Server*)
      END;
```

```
                    (*$$$   MAILBOX3   $$$*)
          (*$$$ Prioritized communication mailbox $$$*)


TYPE MAIL_BOX_MONITOR = MONITOR;
(*************************************************************
*   MAIL_BOX_MONITOR is simply a means for one process to    *
* receive prioritized messages from up to MAX_SENDER other   *
*processes.                                                  *
*   It can store up to MAX_MAIL messages in each of it's     *
* FIFO controlled MAIL_BUFFERs.                              *
*   If the receiver process attempts to pick up mail when    *
* the buffers are empty, it is delayed until a sender        *
* process deposits mail.                                     *
*   If a sender process attempts to deposit mail when        *
* that priority's buffer is full, it is delayed until the    *
* receiver process picks up mail.                            *
*:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
* PROGRAMMER:  RONALD C. ALBURY                              *
* DATE WRITTEN: 3/25/82                                      *
* COMPUTER: INTERDATA 8/32                                   *
* COPYRIGHT 1982 BY RONALD C. ALBURY                         *
*:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
*  EXTERNAL                                                  *
*     CONST                                                  *
*        MAX_SENDERS = Maximum number of processes that      *
*         will send messages to the receiver.                *
*        MAX_MAIL = Maximum number of messages the monitor   *
*         can hold in one priority's buffer.                 *
*     TYPE                                                   *
*        FIFO = Modified Brinch Hansen FIFO class to         *
*         handle a FIFO buffer.                              *
*        PACKET_TYPE = The record structure of the mail.     *
*        PRIORITY_TYPE = Enumerations of the various         *
*         priorities a packet can have.                      *
*:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
*  INTERNAL                                                  *
*     CONST - NONE                                           *
*     TYPE _ NONE                                            *
*     VAR                                                    *
*        RECEIVER: Queue variable to delay the receiver.     *
*        SENDER: Array of Queue variables used as a fifo     *
*         buffer for delaying senders.                       *
*        DELAYED_SENDERS: Fifos to control SENDER buffers.   *
*        MAIL_BUFFER: Array of packets used as a             *
*         fifo / priority buffer for storing mail.           *
*        NEXT_MAIL: Fifos to control MAIL_BUFFER.            *
*        INDEX: Used to initialize FIFO's.                   *
*************************************************************)
VAR
   DELAYED_SENDERS: ARRAY [PRIORITY_TYPE] OF FIFO;
   NEXT_MAIL: ARRAY [PRIORITY_TYPE] OF FIFO;
   MAIL_BUFFER: ARRAY [1..MAX_MAIL, PRIORITY_TYPE]
    OF PACKET_TYPE;
   RECEIVER: QUEUE;
   SENDER: ARRAY [1..MAX_SENDERS, PRIORITY_TYPE] OF QUEUE;
```

```
                    (*$$$   MAILBOX3   $$$*)
          (*$$$ Prioritized communication mailbox $$$*)


     INDEX: PRIORITY_TYPE;

 (***PROCEDURE ENTRY GET*****************************************
  *  INTERNAL                                                    *
  *     VAR                                                      *
  *        NEXT: Used to simplify code.  Receives the index      *
  *         of the next entry in the MAIL_BUFFER to go.          *
  *        ALL_EMPTY: Boolean variable to show if all            *
  *         of the various priorities buffers' are empty.        *
  *        PRI: Loop variable used to set ALL_EMPTY and          *
  *         NEXT.                                                *
  *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
  *  PARAMETERS                                                  *
  *     OUT                                                      *
  *        OUTGOING_MAIL: Receives the oldest/highest            *
  *         priority entry in the MAIL_BUFFER.                   *
  *************************************************************)
  PROCEDURE ENTRY GET ( VAR OUTGOING_MAIL: PACKET_TYPE );
  VAR
     NEXT: 1..MAX_MAIL;
     ALL_EMPTY: BOOLEAN;
     PRI: PRIORITY_TYPE;
 (*Begin entry GET*)
  BEGIN
   (*Check if we have mail*)
     ALL_EMPTY := TRUE;     (****)
     FOR PRI := LOW_PRI TO HIGH_PRI DO
        ALL_EMPTY := ALL_EMPTY AND NEXT_MAIL [PRI].EMPTY;
    {Endfor}
   (*If [there is no mail] then*)
     IF ( ALL_EMPTY ) THEN
      (*Put the receiver to sleep*)
        DELAY ( RECEIVER );
   (*Endif*)
   (*Set outgoing mail to the oldest packet in the queue*)
   (*with the highest priority*)
  (*@We are guaranteed to have mail at this point.*)
     PRI := HIGH_PRI;       (****)
     WHILE (NEXT_MAIL [PRI].EMPTY) DO
        PRI := PRED (PRI );
    {Endwhile}
     NEXT := NEXT_MAIL [PRI].DEPARTURE;
     OUTGOING_MAIL := MAIL_BUFFER [NEXT, PRI];
   (*If [there are senders sleeping] then*)
     IF ( DELAYED_SENDERS [PRI].OCCUPIED ) THEN
      (*Wake up the oldest sleeper*)
        CONTINUE (SENDER [DELAYED_SENDERS [PRI].DEPARTURE, PRI])
   (*Endif*)
 (*End entry GET*)
  END;
```

```
                    (*$$$   MAILBOX3   $$$*)
          (*$$$ Prioritized communication mailbox $$$*)


 (***PROCEDURE ENTRY DEPOSIT*************************************
  *  INTERNAL                                                    *
  *     VAR                                                      *
  *        PRI: Used to simplify code.  Receives the             *
  *         priority of the incomming mail.                      *
  *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
  *  PARAMETERS                                                  *
  *     IN                                                       *
  *        INCOMING_MAIL: A packet being deposited into the      *
  *         MAIL_BUFFER by a sender process.                     *
  *************************************************************)
  PROCEDURE ENTRY DEPOSIT ( INCOMING_MAIL: PACKET_TYPE );
  VAR
     PRI: PRIORITY_TYPE;
(*Begin entry DEPOSIT*)
  BEGIN
     PRI := INCOMING_MAIL.PRIORITY;
   (*If [all known senders are delayed] then*)
     IF ( DELAYED_SENDERS [PRI].FULL ) THEN
       (*@@SHOULD NEVER HAPPEN UNLESS MAX_SENDER IS WRONG@@*)
          (***WE LOOSE THE MAIL****)
   (*Else*)
     ELSE
        BEGIN
      (*If [mail queue is full] then*)
        IF ( NEXT_MAIL [PRI].FULL )  THEN
         (*Put the sender to sleep*)
           DELAY (SENDER [DELAYED_SENDERS [PRI].ARRIVAL, PRI]);
      (*Endif*)
      (*Store the mail in a FIFO queue*)
        MAIL_BUFFER [NEXT_MAIL [PRI].ARRIVAL, PRI ]
         := INCOMING_MAIL;
      (*If [the receiver is sleeping] wake him up*)
        CONTINUE ( RECEIVER )
        END
   (*Endif*)
(*End entry DEPOSIT*)
  END;

 BEGIN (*MONITOR INITIALIZATION*)
     FOR INDEX := LOW_PRI TO HIGH_PRI DO
        INIT NEXT_MAIL [INDEX] (MAX_MAIL),
             DELAYED_SENDERS [INDEX] (MAX_SENDERS)
   {*Endfor}
  END; (*MAIL_BOX_MONITOR*)
```

```
                    (*$$$   NETIO   $$$*)
          (*$$$ Standard entries to the network $$$*)


 TYPE NET_IO_CLASS = CLASS (FROM_NET: MAIL_BOX_MONITOR;
                            TO_NET: MAIL_BOX_MONITOR);
(*************************************************************
 *    NET_IO_CLASS provides standard entry points for        *
 * interfacing with the network layers.  Allows creation     *
 * and distruction of sessions, and data transferal.         *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 * Programmer: Ronald C. Albury                              *
 * Date Written: 10/08/82                                    *
 * Computer: Interdata 8/32                                  *
 * Copyright 1982 by Ronald C. Albury                        *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  EXTERNAL                                                 *
 *     TYPE                                                  *
 *        MAIL_BOX_MONITOR: Interprocess communication       *
 *         mailbox.                                          *
 *        PACKET_TYPE: Record structure of the network       *
 *         packets.                                          *
 *        MESSAGE_TYPE: Array of characters.                 *
 *        PKT_STATUS_TYPE: A field of the Packet_type        *
 *         record, for error flags.                          *
 *        CHAIN_TYPE: The subrange of session commands       *
 *         dealing with chaining messages.                   *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  INTERNAL                                                 *
 *     VAR                                                   *
 *        PACKET: The network packet that is assembled       *
 *         and passed to the lower layers.                   *
 *************************************************************)
 VAR
    PACKET: PACKET_TYPE;

(***PROCEDURE ENTRY NET_LISTEN*********************************
 *  PARAMETERS                                               *
 *     OUT                                                   *
 *        STATUS: Error flags indicating the status of the   *
 *         listen.                                           *
 *************************************************************)
 PROCEDURE ENTRY NET_LISTEN (VAR STATUS: PKT_STATUS_TYPE);
(*Begin entry Net_listen*)
 BEGIN
  (*Set the network parameters for a listen*)
    PACKET.TEXT := '                    ';
    PACKET.SECURITY := PUBLIC;
    PACKET.DIRECTION := OUTGOING;
    PACKET.PRIORITY := HIGH_PRI;
    PACKET.SESSION_CMD := LISTEN;
  (*Issue the listen to the network and wait for*)
  (*a response*)
    TO_NET.DEPOSIT (PACKET);
    FROM_NET.GET (PACKET);
  (*Set the status flags*)
```

```
    STATUS := PACKET.STATUS
(*End entry Net_listen*)
  END;

 (***PROCEDURE ENTRY MAKE_SESSION*****************************
  *  PARAMETERS                                               *
  *     IN                                                    *
  *        PASSWORD: Array of characters containing the       *
  *         the password to be sent to the destination        *
  *         process when the session request is issued.       *
  *     OUT                                                   *
  *        STATUS: Error flags indicating the status of the   *
  *         session request.                                  *
  ************************************************************)
  PROCEDURE ENTRY MAKE_SESSION (    PASSWORD: MESSAGE_TYPE;
                                VAR STATUS: PKT_STATUS_TYPE);
(*Begin entry Make_session*)
  BEGIN
   (*Set the network parameters for a session request*)
     PACKET.TEXT := PASSWORD;
     PACKET.SECURITY := PUBLIC;
     PACKET.DIRECTION := OUTGOING;
     PACKET.STATUS := [];
     PACKET.SESSION_CMD := ESTABLISH;
     PACKET.PRIORITY := HIGH_PRI;
   (*Issue the session request to the network and wait*)
   (*for a response*)
     TO_NET.DEPOSIT (PACKET);
     FROM_NET.GET (PACKET);
   (*Set the status flags*)
     STATUS := PACKET.STATUS
(*End entry Make_session*)
  END;

 (***PROCEDURE ENTRY CLEAR_SESSION*****************************
  *  PARAMETERS                                               *
  *     OUT                                                   *
  *        STATUS: Error flags indicating the status of the   *
  *         clear.                                            *
  ************************************************************)
  PROCEDURE ENTRY CLEAR_SESSION (VAR STATUS: PKT_STATUS_TYPE);
(*Begin entry Clear_session*)
  BEGIN
   (*Set the network parameters for a clear*)
     PACKET.TEXT := '                    ';
     PACKET.SECURITY := PUBLIC;
     PACKET.DIRECTION := OUTGOING;
     PACKET.STATUS := [];
     PACKET.SESSION_CMD := BREAK;
   (*Make sure it arrives after outstanding messages*)
     PACKET.PRIORITY := LOW_PRI;
   (*Issue the clear to the network and wait for a*)
```

```
                    (*$$$   NETIO   $$$*)
          (*$$$ Standard entries to the network $$$*)


   (*response*)
     TO_NET.DEPOSIT (PACKET);
     FROM_NET.GET (PACKET);
   (*Set the status flags*)
     STATUS := PACKET.STATUS
(*End entry Clear_session*)
  END;

 (***PROCEDURE ENTRY NET_READ**********************************
  *  PARAMETERS                                                *
  *     OUT                                                    *
  *        TEXT: Array of characters to recieve the message    *
  *         from the network.                                  *
  *        STATUS: Error flags indicating the status of the    *
  *         read.                                              *
  ************************************************************)
  PROCEDURE ENTRY NET_READ (VAR TEXT: MESSAGE_TYPE;
                            VAR STATUS: PKT_STATUS_TYPE);
(*Begin entry Net_read*)
  BEGIN
   (*Get the packet from the network*)
     FROM_NET.GET (PACKET);
   (*Extract the Text and Status flags from the packet*)
     TEXT := PACKET.TEXT;
     STATUS := PACKET.STATUS
(*End entry Net_read*)
  END;

 (***PROCEDURE ENTRY NET_WRITE*********************************
  *  PARAMETERS                                                *
  *     IN                                                     *
  *        TEXT: Array of characters to send on the network.   *
  *        XFER: The session layer chain command for this      *
  *         data transfer.                                     *
  *        SECURITY: The security level desired for this       *
  *         data item.                                         *
  *     OUT                                                    *
  *        STATUS: Error flags indicating the status of the    *
  *         write.                                             *
  ************************************************************)
  PROCEDURE ENTRY NET_WRITE (TEXT: MESSAGE_TYPE;
                             XFER: CHAIN_TYPE;
                             SECURITY: SECURITY_TYPE;
                         VAR STATUS: PKT_STATUS_TYPE);
(*Begin entry Net_write*)
  BEGIN
   (*Set the network parameters for a write.*)
     PACKET.TEXT := TEXT;
     PACKET.SECURITY := SECURITY;
     PACKET.DIRECTION := OUTGOING;
     PACKET.STATUS := [];
     PACKET.SESSION_CMD := XFER;
```

```
                    (*$$$   NETIO   $$$*)
          (*$$$ Standard entries to the network $$$*)


    PACKET.PRIORITY := MED_PRI;
  (*Issue the write to the net and wait for a response*)
    TO_NET.DEPOSIT (PACKET);
    FROM_NET.GET (PACKET);
  (*Set the status flags*)
    STATUS := PACKET.STATUS
(*End entry Net_write*)
  END;

  BEGIN
  END;
```

```
                    (*$$$   ERROR   $$$*)
          (*$$$ Class for reporting network errors $$$*)


TYPE ERROR_CLASS = CLASS (CONSOLE: RESOURCE_MONITOR);
(*************************************************************
 *   Error_class interprets and displays network errors to   *
 * the terminal.                                             *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 * Programmer: Ronald C. Albury                              *
 * Date Written: 10/02/82                                    *
 * Copyright 1982 by Ronald C. Albury                        *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  EXTERNAL                                                 *
 *     CONST                                                 *
 *        First_Error: The network error with the lowest     *
 *         ordinal value.                                    *
 *        Last_Error: The network error with the highest     *
 *         ordinal value.                                    *
 *     TYPE                                                  *
 *        Resource_Monitor: Standard Brinch Hansen Resource  *
 *         to control access to the terminal.                *
 *        Message_IO_Class: A class that provides fixed      *
 *         record I/O to specified logical units.           *
 *        Message_Type: Array of characters.                 *
 *        Pkt_Status_Type: Set of possible errors that can   *
 *         be encountered in the network.                    *
 *        Status_Type: Enumerations of network errors.       *
 *        Error_Svc1_Type: Record structure of the status    *
 *         bytes returned by Message_IO_Class.              *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  INTERNAL                                                 *
 *     VAR                                                   *
 *         Op: An instance of Message_IO_Class to handle     *
 *          I/O to the terminal.                             *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  PARAMETERS                                               *
 *     Console: A resource monitor to assure no other        *
 *      other process is using the terminal while the        *
 *      error messages are being displayed.                  *
 *************************************************************)
VAR
   OP: MESSAGE_IO_CLASS;

(***Procedure Entry Report*************************************
 *  INTERNAL                                                 *
 *     VAR                                                   *
 *        STATUS_INDEX: Loop variable for testing which      *
 *         errors are in the status word.                    *
 *        OP_STATUS: Recieves the status bytes from the      *
 *         terminal I/O.                                     *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  PARAMETERS                                               *
 *     IN                                                    *
 *        LOCATION: A string of characters indicating where  *
 *         the class is being called from.                   *
```

```
                    (*$$$   ERROR   $$$*)
          (*$$$ Class for reporting network errors $$$*)


  *         STATUS: The status word to be checked for error    *
  *          flags.                                            *
  ************************************************************)
  PROCEDURE ENTRY REPORT (LOCATION: MESSAGE_TYPE;
                          STATUS: PKT_STATUS_TYPE);
  VAR
     STATUS_INDEX: STATUS_TYPE;
     OP_STATUS: ERROR_SVC1_TYPE;
(*Begin entry Report*)
  BEGIN
   (*If [there are error flags in the status word] then*)
     IF (STATUS <> []) THEN
        BEGIN
      (*Request the console and display Location*)
        CONSOLE.REQUEST;
        OP.WRITE (TERMINAL, LOCATION, OP_STATUS);
     (**Display all errors in the status word*)
        FOR STATUS_INDEX := FIRST_ERROR TO LAST_ERROR DO
           IF (STATUS_INDEX IN STATUS) THEN
              OP.WRITE (TERMINAL, ERROR_MSG [STATUS_INDEX],
               OP_STATUS);
          {Endif}
       {Endfor}
        CONSOLE.RELEASE
        END
   (*ENDIF*)
(*End entry Report*)
  END;

  BEGIN
     INIT OP
  END;
```

```
                    (*$$$   SESSION   $$$*)
          (*$$$ Process to simulate Session layer $$$*)


TYPE SESSION_PROCESS = PROCESS (TO_APP: MAIL_BOX_MONITOR;
                                EVENT: MAIL_BOX_MONITOR;
                                TO_NET: MAIL_BOX_MONITOR;
                                HOST_ID: HOST_ID_TYPE);
(*************************************************************
 * The session layer handles the initial set up of a        *
 *  session between two hosts.  It also is capable of       *
 *  chaining a group of related messages together to         *
 *  make sure that, in the event of network failure,         *
 *  the reciever is not in the middle of a transmission.    *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 * PROGRAMMER:  RON ALBURY                                   *
 * DATE WRITTEN: 4/2/82                                      *
 * COMPUTER: INTERDATA 8/32                                  *
 * Copyright 1982 by Ronald C. Albury                        *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  EXTERNAL                                                 *
 *     CONST                                                 *
 *        PASSWORD: A structured constant containing the     *
 *         passwords of the hosts on the network.            *
 *        MAX_SESSION_WAIT: The maximum number of pending    *
 *         requests the host is allowed to queue up.         *
 *        MAX_CHAIN: The maximum number of packets the       *
 *         layer can chain before delivering them to the     *
 *         application layer.                                *
 *     TYPE                                                  *
 *        PACKET_TYPE: Record structure of the network       *
 *         packet.                                           *
 *        MAIL_BOX_MONITOR: A monitor used for passing       *
 *         packets between processes.                        *
 *        HOST_ID_TYPE: Enumeration of hosts in network.     *
 *        MESSAGE_TYPE: Array of characters.                 *
 *        FIFO: Modified Brinch Hansen FIFO class to         *
 *         handle a fifo buffer.                             *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  INTERNAL                                                 *
 *     TYPE                                                  *
 *        SESSION_STATE_TYPE: Enumeration of the states      *
 *         a session layer can be in.                        *
 *     VAR                                                   *
 *        PASS_WORD: Contains this host's password. Used     *
 *         to check if incoming requests have access         *
 *         rights to this host.                              *
 *        PACKET: The network packet this process uses to    *
 *         communicate with.                                 *
 *        WAIT_BUFF: A fifo controlled buffer used to        *
 *         store waiting request packets.                    *
 *        WAITING_REQ: A FIFO class to control WAIT_BUFF.    *
 *        CHAIN_BUFF: An array of packets used to store      *
 *         chained packets so they can be delivered to       *
 *         application layer as a group.                     *
 *        CHAIN_PTR: Integer used to control CHAIN_BUFF.     *
```

```
                    (*$$$   SESSION   $$$*)
          (*$$$ Process to simulate Session layer $$$*)


  *        CHAIN_INDEX: Integer used to increment through    *
  *         the CHAIN_BUFF when delivering the packets .     *
  *        STATE: The current state of the session layer.    *
  *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
  *  PARAMETERS                                              *
  *     TO_APP: The monitor used to send packets to the      *
  *      application layer.                                  *
  *     EVENT: The monitor this layer uses to recieve        *
  *      packets.                                            *
  *     TO_NET: The monitor used to send packets to the      *
  *      network.                                            *
  *     HOST_ID: The id given to this host when the network  *
  *      is brought up.                                      *
  ***********************************************************)

  TYPE
     SESSION_STATE_TYPE = (NO_SESSION, LISTENING, REQUESTING,
      IN_SESSION);
  VAR
     PASS_WORD: MESSAGE_TYPE;
     PACKET: PACKET_TYPE;
     CHAIN_INDEX: INTEGER;
     CHAIN_PTR: INTEGER;
     CHAIN_BUFF: ARRAY [1..MAX_CHAIN] OF PACKET_TYPE;
     STATE: SESSION_STATE_TYPE;

(*Begin Session_process*)
  BEGIN
   (*Initialize the host's password*)
     PASS_WORD := PASSWORD [HOST_ID];
   (*Initialize the state to No_session*)
     STATE := NO_SESSION;
   (*Cycle forever*)
     CYCLE
        EVENT.GET (PACKET);
      (*Process the packet based on current state*)
        CASE STATE OF
         (*When [State = No_session]*)
           NO_SESSION:
            (*If [packet is from application layer] then*)
              IF (PACKET.DIRECTION = OUTGOING) THEN
                 CASE PACKET.SESSION_CMD OF
                  (*When [Cmd = Listen]*)
                    LISTEN:
                     (*Go into Listening state*)
                       STATE := LISTENING;
                  (*When [Cmd = Establish]*)
                    ESTABLISH:
                       BEGIN
                     (*Go into Requesting state*)
                       STATE := REQUESTING;
                     (*Issue the request*)
```

```
          (*$$$   SESSION   $$$*)
(*$$$ Process to simulate Session layer $$$*)


                PACKET.SESSION_CMD := REQUEST;
                TO_NET.DEPOSIT (PACKET)
                END;
            (*Otherwise*)
              ELSE:
                BEGIN
               (*Notify application layer of illegal*)
               (*command*)
                PACKET.STATUS := PACKET.STATUS
                 + [NO_LOCAL_SESSION];
                PACKET.DIRECTION := INCOMING;
                TO_APP.DEPOSIT (PACKET)
                END
          END(*CASE*)
     (*Else (packet from the net)*)
       ELSE
          CASE PACKET.SESSION_CMD OF
           (*When [Cmd = Break]*)
             BREAK:
              (*Do nothing*)
                STATE := NO_SESSION;
           (*Otherwise*)
              (*@Such as a request when not listening,*)
              (*@or data transfer when not in session*)
              (*Should be prevented by protocol*)
          END;(*CASE*)
     (*Endif*)
(*When [State = requesting]*)
  REQUESTING:
    (*If [Packet is from Application layer] then*)
      IF (PACKET.DIRECTION = OUTGOING) THEN
         BEGIN
        (*@Application process should be blocked,*)
        (*@so this can not happen.*)
        (*Notify Application layer of error*)
          PACKET.DIRECTION := INCOMING;
          PACKET.STATUS := PACKET.STATUS
           + [NO_LOCAL_SESSION];
          TO_APP.DEPOSIT (PACKET)
          END
     (*Else (packet from the net)*)
       ELSE
          CASE PACKET.SESSION_CMD OF
           (*When [Cmd = Start]*)
             START:
                BEGIN
              (*Go into In_Session state*)
                STATE := IN_SESSION;
              (*Send up any piggy backed data*)
                TO_APP.DEPOSIT (PACKET)
                END;
           (*When [Cmd = Break]*)
```

```
          (*$$$   SESSION   $$$*)
(*$$$ Process to simulate Session layer $$$*)


          BREAK:
             BEGIN
            (*Go into No_Session state*)
              STATE := NO_SESSION;
              PACKET.STATUS := PACKET.STATUS
               + [SESSION_ENDING];
            (*Send up any piggy backed data*)
              TO_APP.DEPOSIT (PACKET)
              END;
         (*Otherwise*)
            (*@Should be prevented by protocol*)
       END(*Case*);
  (*Endif*)
(*When [State = Listening]*)
 LISTENING:
  (*If [packet from application layer] then*)
    IF (PACKET.DIRECTION = OUTGOING) THEN
       BEGIN
     (*@Application layer should be blocked so*)
     (*@this can not happen*)
     (*Notify application layer of error*)
       PACKET.STATUS := PACKET.STATUS +
        [NO_LOCAL_SESSION];
       PACKET.DIRECTION := INCOMING;
       TO_APP.DEPOSIT (PACKET)
       END
  (*Else (packet from network)*)
    ELSE
       CASE PACKET.SESSION_CMD OF
        (*When [Cmd = Request]*)
          REQUEST:
             BEGIN
           (*If [it has the right password] then*)
             IF (PACKET.TEXT = PASS_WORD) THEN
                BEGIN
              (*Set up packet for a favorable reply*)
                PACKET.SESSION_CMD := START;
              (*Go to In_Session state*)
                STATE := IN_SESSION
                TO_APP.DEPOSIT (PACKET)
                END
           (*Else (bad password)*)
             ELSE
                BEGIN
                PACKET.SESSION_CMD := BREAK;
              (*Set up packet for a refusal*)
                PACKET.STATUS := PACKET.STATUS
                 + [BAD_PASSWORD]
                END;
           (*ENDIF*)
           (*Send a return packet*)
             PACKET.DIRECTION := OUTGOING;
```

```
          (*$$$   SESSION   $$$*)
(*$$$ Process to simulate Session layer $$$*)


              TO_NET.DEPOSIT (PACKET)
              END;
          (*Otherwise*)
            ELSE:
              BEGIN
             (*@Should be prevented by protocol*)
             (*Notify source of error*)
              PACKET.STATUS := PACKET.STATUS
               + [NO_REMOTE_SESSION];
              PACKET.SESSION_CMD := BREAK;
              PACKET.DIRECTION := OUTGOING;
              TO_NET.DEPOSIT (PACKET)
              END
        END;(*CASE*)
   (*Endif*)
(*When [State = In_session]*)
  IN_SESSION:
   (*If [packet is from application layer] then*)
     IF (PACKET.DIRECTION = OUTGOING) THEN
        CASE PACKET.SESSION_CMD OF
         (*When [Cmd is a data transfer type]*)
           CHAIN, END_CHAIN, ABORT_CHAIN, IMMEDIATE:
              BEGIN
             (*Send data*)
              TO_NET.DEPOSIT (PACKET)
               PACKET.DIRECTION := INCOMING;
               TO_APP.DEPOSIT (PACKET)
              END;
         (*When [Cmd = Break]*)
           BREAK:
              BEGIN
             (*Go to No_Session state*)
              STATE := NO_SESSION;
             (*Send a Break to partner*)
              TO_NET.DEPOSIT (PACKET);
              PACKET.STATUS := PACKET.STATUS
             (*Notify Application layer of status*)
             (*of Break*)
               + [SESSION_ENDING];
              PACKET.DIRECTION := INCOMING;
              TO_APP.DEPOSIT (PACKET)
              END;
         (*Otherwise*)
           ELSE:
              BEGIN
             (*Notify Application layer it has made a*)
             (*mistake*)
              PACKET.STATUS := PACKET.STATUS
               + [LOCAL_IN_SESSION];
               PACKET.DIRECTION := INCOMING;
               TO_APP.DEPOSIT (PACKET)
               END
```

```
          (*$$$   SESSION   $$$*)
(*$$$ Process to simulate Session layer $$$*)


      END(*CASE*)
  (*Else (packet from the network)*)
    ELSE
      CASE PACKET.SESSION_CMD OF
       (*When [Cmd = Break]*)
         BREAK:
           BEGIN
          (*Go to No_Session state*)
           STATE := NO_SESSION;
          (*Send up any messages left in the chain*)
          (*buffer*)
           FOR CHAIN_INDEX := 1 TO CHAIN_PTR DO
              TO_APP.DEPOSIT
               (CHAIN_BUFF [CHAIN_INDEX]);
           {ENDFOR}
           CHAIN_PTR := 0;
           PACKET.STATUS := PACKET.STATUS
            + [SESSION_ENDING];
          (*Notify Application of session ending*)
           TO_APP.DEPOSIT (PACKET)
           END;
       (*When [Cmd = Request]*)
         REQUEST:
           BEGIN
          (*Send back a busy signal*)
           PACKET.STATUS := PACKET.STATUS
            + [BUSY];
           PACKET.SESSION_CMD := BREAK;
           PACKET.DIRECTION := OUTGOING;
           TO_NET.DEPOSIT (PACKET)
           END;
       (*When [Cmd = Immediate]*)
         IMMEDIATE:
          (*Immediately pass it to Application*)
           TO_APP.DEPOSIT (PACKET);
       (*When [Cmd = Chain]*)
         CHAIN:
           BEGIN
          (*Store the message in the Chain buffer*)
           CHAIN_PTR := CHAIN_PTR + 1;
          (*@NOTE-possible Chain_Index range error*)
           CHAIN_BUFF [CHAIN_PTR] := PACKET
           END;
       (*When [Cmd = End_Chain]*)
         END_CHAIN:
           BEGIN
          (*Pass up all messages stored in the*)
          (*Chain buffer*)
           FOR CHAIN_INDEX := 1 TO CHAIN_PTR DO
              TO_APP.DEPOSIT
               (CHAIN_BUFF [CHAIN_INDEX]);
           {ENDFOR}
```

```
                    (*$$$   SESSION   $$$*)
          (*$$$ Process to simulate Session layer $$$*)


                        CHAIN_PTR := 0;
                        TO_APP.DEPOSIT (PACKET)
                        END;
                    (*When [Cmd = Abort_Chain]*)
                      ABORT_CHAIN:
                       (*Empty the Chain buffer*)
                        CHAIN_PTR := 0;
                    (*Otherwise*)
                      ELSE:
                       (*@Should be prevented by protocol*)
                        BEGIN
                       (*Disconnect everyone and start over*)
                        PACKET.STATUS := PACKET.STATUS +
                         [REMOTE_IN_SESSION];
                        PACKET.SESSION_CMD := BREAK;
                        PACKET.DIRECTION := OUTGOING;
                        TO_NET.DEPOSIT (PACKET)
                        END
                  END(*CASE*);
              (*Endif*)
         END(*CASE*)
    (*End cycle*)
      END
(*End Session_process*)
  END;
```

```
                (*$$$   WORKER3   $$$*)
          (*$$$ Net3 Worker application process $$$*)


TYPE WORKER_PROCESS = PROCESS(CONSOLE: RESOURCE_MONITOR;
                              FROM_NET: MAIL_BOX_MONITOR;
                              TO_NET: MAIL_BOX_MONITOR);
(*************************************************************
 *  The WORKER_PROCESS is an application layer process that  *
 *   transfers remote files to the operator console.         *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 * PROGRAMMER:  RON ALBURY                                   *
 * DATE WRITTEN: 6/28/82                                     *
 * COMPUTER: INTERDATA 8/32                                  *
 * Copyright 1982 by Ronald C. Albury                        *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  EXTERNAL                                                 *
 *    CONST                                                  *
 *       ERROR_MSG = Structured constant containing text     *
 *        explainations of possible packet errors.          *
 *     TYPE                                                  *
 *        MESSAGE_IO_CLASS = A class that uses supervisory   *
 *         calls to handle fixed record I/O to specified     *
 *         logical units.                                    *
 *        PACKET_TYPE = Record structure of the network      *
 *         packets.                                          *
 *        MESSAGE_TYPE = Array of characters.                *
 *        ERROR_SVC1_TYPE = Record structure of the status   *
 *         bytes from the supervisory call.                  *
 *        MAIL_BOX_MONITOR = A monitor used for passing      *
 *         packets between processes.                        *
 *        RESOURCE_MONITOR = Allows only one process to      *
 *         access a resource at a time.                      *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  INTERNAL                                                 *
 *     VAR                                                   *
 *        STATUS_INDEX: Used to report packet errors.        *
 *        OP: Used to write lines of the transfered file     *
 *         to the operator.                                  *
 *        PACKET: A network packet this process uses to      *
 *         communicate with the network.                     *
 *        TEXT: Array of characters used to communicate      *
 *         the operator.                                     *
 *        OP_STATUS: Recieves the status bytes from the      *
 *         MESSAGE_IO_CLASS.  Not used here, but necessary   *
 *         for the calls to OP.                              *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  PARAMETERS                                               *
 *     CONSOLE: The RESOURCE_MONITOR used to reserve the     *
 *      console for exclusive I/O.                           *
 *     FROM_NET: The monitor used to recieve packets from    *
 *      the network.                                         *
 *     TO_NET: The monitor used to send packets to the net   *
 *************************************************************)
VAR
   OP: MESSAGE_IO_CLASS;
```

```
                    (*$$$   WORKER3   $$$*)
          (*$$$ Net3 Worker application process $$$*)


     ERROR: ERROR_CLASS;
     OS: NET_IO_CLASS;
     NET_STATUS: PKT_STATUS_TYPE;
     TEXT: MESSAGE_TYPE;
     OP_STATUS: ERROR_SVC1_TYPE;  (****)

(*Begin Worker process*)
  BEGIN
   (*Initialize the interface to the operator*)
     INIT OP;
     INIT ERROR (CONSOLE);
     INIT OS (FROM_NET, TO_NET);
   (*Cycle forever*)
     CYCLE
        CONSOLE.REQUEST;
        OP.WRITE (TERMINAL, 'ENTER SERVE PASSWORD', OP_STATUS);
        OP.READ (TERMINAL, TEXT, OP_STATUS);
        CONSOLE.RELEASE;
      (**Request a session**)  (****)
        OS.MAKE_SESSION (TEXT, NET_STATUS);
        ERROR.REPORT ('WORKER 10           ', NET_STATUS);
      (*If [we  connect] then*)
        IF (NET_STATUS = []) THEN  (****)
           BEGIN
           REPEAT
              TEXT := 'ENTER FILE ID.    - ';
              TEXT [18] := FIRST_FILE_ID;
              TEXT [20] := LAST_FILE_ID;
              CONSOLE.REQUEST;
              OP.WRITE (TERMINAL, TEXT, OP_STATUS);
              OP.READ (TERMINAL, TEXT, OP_STATUS);
              CONSOLE.RELEASE;
            (*Send the request to the server*)
              OS.NET_WRITE (TEXT,IMMEDIATE,PUBLIC,NET_STATUS);
              ERROR.REPORT (' WORKER 20          ', NET_STATUS);
            (**Transfer the file to the console*)
              CONSOLE.REQUEST;
            (*Repeat until end of file*)
              REPEAT
               (*Get a line from the network*)
                 OS.NET_READ (TEXT, NET_STATUS);
               (*Output it to the console*)
                 OP.WRITE (TERMINAL, TEXT, OP_STATUS);
            (*End repeat*)
              UNTIL ((TEXT[1] = '/') AND (TEXT[2] = '*'))
               OR (SESSION_ENDING IN NET_STATUS);
              CONSOLE.RELEASE;
              ERROR.REPORT ('WORKER 30           ', NET_STATUS);
              CONSOLE.REQUEST;
              OP.WRITE (TERMINAL, 'MORE FILES   Y/N    ',
               OP_STATUS);
              OP.READ (TERMINAL, TEXT, OP_STATUS);
```

```
                (*$$$   WORKER3   $$$*)
          (*$$$ Net3 Worker application process $$$*)


             CONSOLE.RELEASE
           UNTIL (TEXT [1] = 'N');
           OS.CLEAR_SESSION (NET_STATUS);
           ERROR.REPORT ('WORKER 40           ', NET_STATUS)
           END
       (*Endif*)
    (*End cycle*)
      END
(*End Worker process*)
  END;
```

```
                    (*$$$   SERVER3   $$$*)
          (*$$$ Net3 Server application process $$$*)


TYPE SERVER_PROCESS = PROCESS (CONSOLE: RESOURCE_MONITOR;
                               FROM_NET: MAIL_BOX_MONITOR;
                               TO_NET: MAIL_BOX_MONITOR);
(*****************************************************************
 *  The server process is an application layer process that      *
 *   does the disk I/O for a remote worker process.              *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 * PROGRAMMER:  RON ALBURY                                       *
 * DATE WRITTEN: 6/28/82                                         *
 * COMPUTER: INTERDATA 8/32                                      *
 * Copyright 1982 by Ronald C. Albury                            *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  EXTERNAL                                                     *
 *     TYPE                                                      *
 *        MESSAGE_IO_CLASS = A class that uses supervisory       *
 *         calls to handle fixed record I/O to specified         *
 *         logical units.                                        *
 *        PACKET_TYPE = Record structure of the network          *
 *         packets.                                              *
 *        MESSAGE_TYPE = Array of characters.                    *
 *        ERROR_SVC1_TYPE = Record structure of the status       *
 *         bytes from the supervisory call.                      *
 *        MAIL_BOX_MONITOR = A monitor used for passing          *
 *         packets between processes.                            *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  INTERNAL                                                     *
 *     VAR                                                       *
 *        DISK: Used to input lines of a disk file.              *
 *        PACKET: A network packet used to communicate with      *
 *         the network.                                          *
 *        TEXT: Array of characters used for the disk I/O.       *
 *        FILE_ID: The id of the file the worker process is      *
 *         requesting.                                           *
 *        VALID_FILE_IDS: A set of the valid id's this           *
 *         process can access.                                   *
 *        FILE_LU: An array of logical units that are            *
 *         subscripted with file id's. Used to look up the       *
 *         logical unit of a file.                               *
 *        NEXT_LU: Used in initializing FILE_LU.                 *
 *        INDEX: Used in initializing FILE_LU.                   *
 *        OP_STATUS: Recieves the status bytes form the          *
 *         MESSAGE_IO_CLASS.                                     *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  PARAMETERS                                                   *
 *     FROM_NET: The monitor used to recieve packets from        *
 *      the network.                                             *
 *     TO_NET: The monitor used to send packets to the net.      *
 *****************************************************************)
VAR
   DISK: MESSAGE_IO_CLASS;
   OS: NET_IO_CLASS;
   NET_STATUS: PKT_STATUS_TYPE;
```

```
                    (*$$$   SERVER3   $$$*)
            (*$$$ Net3 Server application process $$$*)


      ERROR: ERROR_CLASS;
      TEXT: MESSAGE_TYPE;
      FILE_ID: CHAR;
      VALID_FILE_IDS: SET OF CHAR;
      FILE_LU: ARRAY [FILE_RANGE] OF BYTE;
      NEXT_LU: BYTE;
      INDEX: FILE_RANGE;
      OP_STATUS: ERROR_SVC1_TYPE;

  (*Begin Server process*)
    BEGIN
     (*Initialize the interface to the disk files*)
       INIT DISK;
       INIT OS (FROM_NET, TO_NET);
       INIT ERROR (CONSOLE);
     (**Set up an array to reference logical unit numbers*)
     (**by the character id's of the files*)
       NEXT_LU := TERMINAL + 1;
     (*For all file id's do*)
       FOR INDEX := FIRST_FILE_ID TO LAST_FILE_ID DO
          BEGIN
        (*Remember that it is a valid id*)
          VALID_FILE_IDS := VALID_FILE_IDS + [INDEX];
        (*Set it's logical unit number*)
          FILE_LU [INDEX] := NEXT_LU;
          NEXT_LU := NEXT_LU + 1
          END;
     (*Endfor*)
     (*Cycle forever*)
       CYCLE
        (**Put your ears up**)  (****)
          OS.NET_LISTEN (NET_STATUS);
          ERROR.REPORT ('SERVER 10          ', NET_STATUS);
        (*Get the request from the net*)
          OS.NET_READ (TEXT, NET_STATUS);
          ERROR.REPORT ('SERVER 15          ', NET_STATUS);
          FILE_ID := TEXT [1];
          WHILE NOT(SESSION_ENDING IN NET_STATUS) DO
             BEGIN
           (*If [it is a valid file id] then*)
             IF (FILE_ID IN VALID_FILE_IDS) THEN
              (**Transfer the file*)
                BEGIN
              (*Read in a line from the disk*)
                DISK.READ (FILE_LU [FILE_ID], TEXT, OP_STATUS);
              (*While not [end of file] do*)
                WHILE (OP_STATUS.DI = 0) AND (OP_STATUS.DD = 0) DO
                   BEGIN
                 (*Send it out on the network*)
                   OS.NET_WRITE (TEXT, IMMEDIATE, SECRET,
                     NET_STATUS);
                   ERROR.REPORT ('SERVER 20          ',
```

```
                    (*$$$   SERVER3   $$$*)
            (*$$$ Net3 Server application process $$$*)


                      NET_STATUS);
                   (*Read in a new line from the disk file*)
                     DISK.READ (FILE_LU [FILE_ID], TEXT, OP_STATUS)
                     END;
                 (*Endwhile*)
                 (*Rewind the disk file*)
                   DISK.REWIND (FILE_LU [FILE_ID], OP_STATUS);
                 (*Send an EOF packet out on the network*)
                   OS.NET_WRITE ('/*                    ',
                    IMMEDIATE, PUBLIC, NET_STATUS);
                   ERROR.REPORT ('SERVER 30             ',NET_STATUS);
                   END
               (*Else (an invalid file id)*)
                 ELSE
                  (*Send an error message*)
                    BEGIN
                    TEXT := '/*  BAD FILE ID -   ';
                    TEXT [19] := FILE_ID;
                    OS.NET_WRITE (TEXT,IMMEDIATE,PUBLIC,NET_STATUS);
                    ERROR.REPORT ('SERVER 40             ',NET_STATUS);
                    END;
               (*Endif*)
                 OS.NET_READ (TEXT, NET_STATUS);
                 FILE_ID := TEXT [1];
                 ERROR.REPORT ('SERVER 50           ', NET_STATUS)
                 END
          (*Endwhile*)
      (*End cycle*)
        END
  (*End Server*)
    END;
```

```
                    (*$$$   LOCNET   $$$*)
    (*$$$ Process to simulate a Local Area Network $$$*)


TYPE NETWORK_PROCESS =
                      PROCESS ( TO_APP: MAIL_BOX_MONITOR;
                                EVENT: MAIL_BOX_MONITOR;
                                NEXT_NODE: MAIL_BOX_MONITOR;
                                NODE_ID: HOST_ID_TYPE);
(*****************************************************************
 * The network layer represents the hardware and software       *
 *  necessary to transmit packets across a local area           *
 *  network.                                                    *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 * PROGRAMMER:  RON ALBURY                                      *
 * DATE WRITTEN: 6/28/82                                        *
 * COPYRIGHT 1982 by Ronald C. Albury                           *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  EXTERNAL                                                    *
 *     TYPE                                                     *
 *        PACKET_TYPE = Record structure of the network         *
 *         packets.                                            *
 *        MAIL_BOX_MONITOR = A monitor used for passing         *
 *         packets between processes.*)                        *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  INTERNAL                                                    *
 *     VAR                                                      *
 *        PACKET: A network packet that the layer processes     *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  PARAMETERS                                                  *
 *     TO_APP: The monitor used to send packets up toward       *
 *      the application layer.                                  *
 *     EVENT: The monitor this layer uses to recieve            *
 *      packets.                                                *
 *     NEXT_NODE: The monitor used to send packets to           *
 *      the next node in the network.                           *
 *     NODE_ID: Tells the process which node it is serving.     *
 *****************************************************************)
VAR
   PACKET: PACKET_TYPE;

BEGIN
 (*Cycle forever*)
   CYCLE
    (*Wait for a packet*)
      EVENT.GET (PACKET);
    (*If [an outgoing packet] then*)
      IF ( PACKET.DIRECTION = OUTGOING ) THEN
         BEGIN
       (*Set it as an incoming packet*)
         PACKET.DIRECTION := INCOMING;
       (*Pass it on to the next node*)
         NEXT_NODE.DEPOSIT (PACKET)
         END
    (*Else (an incoming packet)*)
      ELSE
```

```
                    (*$$$   LOCNET   $$$*)
      (*$$$ Process to simulate a Local Area Network $$$*)


          (*If [this is the packets destination] then*)
            IF (PACKET.DESTINATION = NODE_ID) THEN
             (*Pass it up to the application layer*)
               TO_APP.DEPOSIT (PACKET)
          (*Else it is bound for another node*)
            ELSE
             (*If [it hasn't made it around the ring] then*)
               IF (PACKET.SOURCE <> NODE_ID) THEN
                (*Send it on*)
                  NEXT_NODE.DEPOSIT (PACKET)
             (*Else destination node must be down*)
               ELSE
                  BEGIN
                (*Notify host*)
                  PACKET.DIRECTION := INCOMING;
                  PACKET.STATUS := PACKET.STATUS
                   + [DESTINATION_NODE_DOWN];
                  PACKET.TRANS_CMD := DISCONNECT;
                  TO_APP.DEPOSIT (PACKET)
                  END
             (*Endif made it around ring*)
          (*Endif belongs at this node*)
       (*Endif packet direction*)
    (*End cycle*)
      END
  (*End Network process*)
    END;
```

```
                    (*$$$ NETIO4   $$$*)
                (*$$$ Revised Network Entries $$$*)

  TYPE NET_IO_CLASS = CLASS (FROM_NET: MAIL_BOX_MONITOR;
                             TO_NET: MAIL_BOX_MONITOR);
 (*************************************************************
  *    NET_IO_CLASS provides standard entry points for       *
  * interfacing with the network layers.  Allows creation    *
  * and distruction of sessions, and data transferal.        *
  *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
  * Programmer: Ronald C. Albury                             *
  * Date Written: 10/08/82                                   *
  * Computer: Interdata 8/32                                 *
  * Copyright 1982 by Ronald C. Albury                       *
  *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
  *  EXTERNAL                                                *
  *     TYPE                                                 *
  *        MAIL_BOX_MONITOR: Interprocess communication      *
  *         mailbox.                                         *
  *        PACKET_TYPE: Record structure of the network      *
  *         packets.                                         *
  *        MESSAGE_TYPE: Array of characters.                *
  *        PKT_STATUS_TYPE: A field of the Packet_type       *
  *         record, for error flags.                         *
  *        CHAIN_TYPE: The subrange of session commands      *
  *         dealing with chaining messages.                  *
  *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
  *  INTERNAL                                                *
  *     VAR                                                  *
  *        PACKET: The network packet that is assembled      *
  *         and passed to the lower layers.                  *
  *************************************************************)
  VAR
     PACKET: PACKET_TYPE;

 (***PROCEDURE ENTRY NET_LISTEN*********************************
  *  PARAMETERS                                              *
  *     OUT                                                  *
  *        STATUS: Error flags indicating the status of the  *
  *         listen.                                          *
  *************************************************************)
  PROCEDURE ENTRY NET_LISTEN (VAR STATUS: PKT_STATUS_TYPE);
(*Begin entry Net_listen*)
  BEGIN
   (*Set the network parameters for a listen*)
     PACKET.TEXT := '                    ';
     PACKET.SECURITY := PUBLIC;
     PACKET.DIRECTION := OUTGOING;
     PACKET.PRIORITY := MED_PRI;
     PACKET.SESSION_CMD := LISTEN;
     PACKET.NAME := 'APPLI CMD LISTEN    ';  (****)
   (*Issue the listen to the network and wait for*)
   (*a response*)
     TO_NET.DEPOSIT (PACKET);
     FROM_NET.GET (PACKET);
```

```
   (*Set the status flags*)
     STATUS := PACKET.STATUS
(*End entry Net_listen*)
  END;

 (***PROCEDURE ENTRY MAKE_SESSION*****************************
  *  PARAMETERS                                               *
  *     IN                                                    *
  *        PASSWORD: Array of characters containing the       *
  *         the password to be sent to the destination        *
  *         process when the session request is issued.       *
  *        NAME: Array of characters containing the common    *
  *         name of the destination process.                  *
  *     OUT                                                   *
  *        STATUS: Error flags indicating the status of the   *
  *         session request.                                  *
  ************************************************************)
  PROCEDURE ENTRY MAKE_SESSION (    PASSWORD: MESSAGE_TYPE;
                                    NAME: MESSAGE_TYPE;
                                VAR STATUS: PKT_STATUS_TYPE);
(*Begin entry Make_session*)
  BEGIN
   (*Set the network parameters for a session request*)
     PACKET.NAME := NAME;  (****)
     PACKET.TEXT := PASSWORD;
     PACKET.SECURITY := PUBLIC;
     PACKET.DIRECTION := OUTGOING;
     PACKET.STATUS := [];
     PACKET.SESSION_CMD := ESTABLISH;
     PACKET.PRIORITY := LOW_PRI;
   (*Issue the session request to the network and wait*)
   (*for a response*)
     TO_NET.DEPOSIT (PACKET);
     FROM_NET.GET (PACKET);
   (*Set the status flags*)
     STATUS := PACKET.STATUS
(*End entry Make_session*)
  END;

 (***PROCEDURE ENTRY CLEAR_SESSION*****************************
  *  PARAMETERS                                               *
  *     OUT                                                   *
  *        STATUS: Error flags indicating the status of the   *
  *         clear.                                            *
  ************************************************************)
  PROCEDURE ENTRY CLEAR_SESSION (VAR STATUS: PKT_STATUS_TYPE);
(*Begin entry Clear_session*)
  BEGIN
   (*Set the network parameters for a clear*)
     PACKET.TEXT := '                    ';
     PACKET.SECURITY := PUBLIC;
     PACKET.DIRECTION := OUTGOING;
```

```
    PACKET.STATUS := [];
    PACKET.SESSION_CMD := BREAK;
    PACKET.PRIORITY := MED_PRI;
    PACKET.NAME := 'APPLI CMD CLEAR SESS';  (****)
   (*Issue the clear to the network and wait for a*)
   (*response*)
    TO_NET.DEPOSIT (PACKET);
    FROM_NET.GET (PACKET);
   (*Set the status flags*)
    STATUS := PACKET.STATUS
(*End entry Clear_session*)
  END;

 (***PROCEDURE ENTRY NET_READ**********************************
  *  PARAMETERS                                                *
  *     OUT                                                    *
  *        TEXT: Array of characters to recieve the message    *
  *         from the network.                                  *
  *        STATUS: Error flags indicating the status of the    *
  *         read.                                              *
  ************************************************************)
  PROCEDURE ENTRY NET_READ (VAR TEXT: MESSAGE_TYPE;
                            VAR STATUS: PKT_STATUS_TYPE);
(*Begin entry Net_read*)
  BEGIN
   (*Get the packet from the network*)
    FROM_NET.GET (PACKET);
   (*Extract the Text and Status flags from the packet*)
    TEXT := PACKET.TEXT;
    STATUS := PACKET.STATUS
(*End entry Net_read*)
  END;

 (***PROCEDURE ENTRY NET_WRITE*********************************
  *  PARAMETERS                                                *
  *     IN                                                     *
  *        TEXT: Array of characters to send on the network.   *
  *        XFER: The session layer chain command for this      *
  *         data transfer.                                     *
  *        SECURITY: The security level desired for this       *
  *         data item.                                         *
  *     OUT                                                    *
  *        STATUS: Error flags indicating the status of the    *
  *         write.                                             *
  ************************************************************)
  PROCEDURE ENTRY NET_WRITE (TEXT: MESSAGE_TYPE;
                             XFER: CHAIN_TYPE;
                             SECURITY: SECURITY_TYPE;
                         VAR STATUS: PKT_STATUS_TYPE);
(*Begin entry Net_write*)
  BEGIN
   (*Set the network parameters for a write.*)
```

```
    PACKET.TEXT := TEXT;
    PACKET.SECURITY := SECURITY;
    PACKET.DIRECTION := OUTGOING;
    PACKET.STATUS := [];
    PACKET.SESSION_CMD := XFER;
    PACKET.PRIORITY := MED_PRI;
    PACKET.NAME := 'APPLI CMD WRITE     ';  (****)
  (*Issue the write to the net and wait for a response*)
    TO_NET.DEPOSIT (PACKET);
    FROM_NET.GET (PACKET);
  (*Set the status flags*)
    STATUS := PACKET.STATUS
(*End entry Net_write*)
  END;

  BEGIN
  END;
```

```
                    (*$$$   SESSION4   $$$*)
                  (*$$$ Revised Session layer $$$*)


TYPE SESSION_PROCESS = PROCESS (TO_APP: MAIL_BOX_MONITOR;
                                EVENT: MAIL_BOX_MONITOR;
                                TO_NET: MAIL_BOX_MONITOR;
                                HOST_ID: HOST_ID_TYPE);
(*****************************************************************
 * The session layer handles the initial set up of a            *
 *  session between two hosts.  It also is capable of           *
 *  chaining a group of related messages together to            *
 *  make sure that, in the event of network failure,            *
 *  the reciever is not in the middle of a transmission.        *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 * PROGRAMMER:  RON ALBURY                                      *
 * DATE WRITTEN: 4/2/82                                         *
 * COMPUTER: INTERDATA 8/32                                     *
 * Copyright 1982 by Ronald C. Albury                           *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  EXTERNAL                                                    *
 *     CONST                                                    *
 *        PASSWORD: A structured constant containing the        *
 *         passwords of the hosts on the network.               *
 *        MAX_SESSION_WAIT: The maximum number of pending       *
 *         requests the host is allowed to queue up.            *
 *        MAX_CHAIN: The maximum number of packets the          *
 *         layer can chain before delivering them to the        *
 *         application layer.                                   *
 *     TYPE                                                     *
 *        PACKET_TYPE: Record structure of the network          *
 *         packet.                                              *
 *        MAIL_BOX_MONITOR: A monitor used for passing          *
 *         packets between processes.                           *
 *        HOST_ID_TYPE: Enumeration of hosts in network.        *
 *        MESSAGE_TYPE: Array of characters.                    *
 *        FIFO: Modified Brinch Hansen FIFO class to            *
 *         handle a fifo buffer.                                *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  INTERNAL                                                    *
 *     TYPE                                                     *
 *        SESSION_STATE_TYPE: Enumeration of the states         *
 *         a session layer can be in.                           *
 *     VAR                                                      *
 *        PASS_WORD: Contains this host's password. Used        *
 *         to check if incoming requests have access            *
 *         rights to this host.                                 *
 *        PACKET: The network packet this process uses to       *
 *         communicate with.                                    *
 *        WAIT_BUFF: A fifo controlled buffer used to           *
 *         store waiting request packets.                       *
 *        WAITING_REQ: A FIFO class to control WAIT_BUFF.       *
 *        CHAIN_BUFF: An array of packets used to store         *
 *         chained packets so they can be delivered to          *
 *         application layer as a group.                        *
 *        CHAIN_PTR: Integer used to control CHAIN_BUFF.        *
```

```
                    (*$$$   SESSION4   $$$*)
                  (*$$$ Revised Session layer $$$*)


  *         CHAIN_INDEX: Integer used to increment through     *
  *          the CHAIN_BUFF when delivering the packets .      *
  *         STATE: The current state of the session layer.     *
  *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
  *  PARAMETERS                                                *
  *     TO_APP: The monitor used to send packets to the        *
  *      application layer.                                    *
  *     EVENT: The monitor this layer uses to recieve          *
  *      packets.                                              *
  *     TO_NET: The monitor used to send packets to the        *
  *      network.                                              *
  *     HOST_ID: The id given to this host when the network    *
  *      is brought up.                                        *
  ************************************************************)

  TYPE
     SESSION_STATE_TYPE = (NO_SESSION, LISTENING, REQUESTING,
      IN_SESSION);
  VAR
     PASS_WORD: MESSAGE_TYPE;
     PACKET: PACKET_TYPE;
     CHAIN_INDEX: INTEGER;
     CHAIN_PTR: INTEGER;
     CHAIN_BUFF: ARRAY [1..MAX_CHAIN] OF PACKET_TYPE;
     STATE: SESSION_STATE_TYPE;

(*Begin Session_process*)
  BEGIN
   (*Initialize the host's password*)
     PASS_WORD := PASSWORD [HOST_ID];
   (*Initialize the state to No_session*)
     STATE := NO_SESSION;
   (*Cycle forever*)
     CYCLE
        EVENT.GET (PACKET);
      (*Process the packet based on current state*)
        CASE STATE OF
         (*When [State = No_session]*)
           NO_SESSION:
            (*If [packet is from application layer] then*)
              IF (PACKET.DIRECTION = OUTGOING) THEN
                 CASE PACKET.SESSION_CMD OF
                  (*When [Cmd = Listen]*)
                    LISTEN:
                     (*Go into Listening state*)
                       STATE := LISTENING;
                  (*When [Cmd = Establish]*)
                    ESTABLISH:
                       BEGIN
                     (*Go into Requesting state*)
                       STATE := REQUESTING;
                     (*Piggy back a session request on a*)
```

```
        (*$$$   SESSION4   $$$*)
      (*$$$ Revised Session layer $$$*)


          (*Transport Connect command*)
            PACKET.TRANS_CMD := CONNECT;  (****)
            PACKET.SESSION_CMD := REQUEST;
            TO_NET.DEPOSIT (PACKET)
            END;
        (*Otherwise*)
          ELSE:
            BEGIN
           (*Notify application layer of illegal*)
           (*command*)
            PACKET.STATUS := PACKET.STATUS
             + [NO_LOCAL_SESSION];
            PACKET.DIRECTION := INCOMING;
            TO_APP.DEPOSIT (PACKET)
            END
      END(*CASE*)
  (*Else (packet from the net)*)
    ELSE
      CASE PACKET.SESSION_CMD OF
       (*When [Cmd = Break]*)
         BREAK:
          (*Do nothing*)
            STATE := NO_SESSION;
       (*Otherwise*)
          (*@Such as a request when not listening,*)
          (*@or data transfer when not in session*)
          (*Should be prevented by protocol*)
      END;(*CASE*)
  (*Endif*)
(*When [State = requesting]*)
  REQUESTING:
   (*If [Packet is from Application layer] Ththen*)
     IF (PACKET.DIRECTION = OUTGOING) THEN
        BEGIN
      (*@Application process should be blocked,*)
      (*@so this can not happen.*)
      (*Notify Application layer of error*)
        PACKET.DIRECTION := INCOMING;
        PACKET.STATUS := PACKET.STATUS
         + [NO_LOCAL_SESSION];
        TO_APP.DEPOSIT (PACKET)
        END
   (*Else (packet from the net)*)
     ELSE
        CASE PACKET.SESSION_CMD OF
         (*When [Cmd = Start]*)
           START:
              BEGIN
            (*@Assume it came from Transport layer*)
            (*@on a Data_xfer.*)
            (*Go into In_Session state*)
              STATE := IN_SESSION;
```

```
            (*$$$   SESSION4   $$$*)
          (*$$$ Revised Session layer $$$*)


              (*Send up any piggy backed data*)
                TO_APP.DEPOSIT (PACKET)
                END;
            (*When [Cmd = Break]*)
              BREAK:
                BEGIN
              (*@Assume it came from Transport layer on*)
              (*@a Disconnect*)
              (*Go into No_Session state*)
                STATE := NO_SESSION;
                PACKET.STATUS := PACKET.STATUS
                 + [SESSION_ENDING];
              (*Send up any piggy backed data*)
                TO_APP.DEPOSIT (PACKET)
                END;
            (*Otherwise*)
                (*@Should be prevented by protocol*)
          END(*Case*);
    (*Endif*)
(*When [State = Listening]*)
  LISTENING:
    (*If [packet from application layer] then*)
      IF (PACKET.DIRECTION = OUTGOING) THEN
         BEGIN
       (*@Application layer should be blocked so*)
       (*@this can not happen*)
       (*Notify application layer of error*)
         PACKET.STATUS := PACKET.STATUS +
          [NO_LOCAL_SESSION];
         PACKET.DIRECTION := INCOMING;
         TO_APP.DEPOSIT (PACKET)
         END
    (*Else (packet from network)*)
      ELSE
         CASE PACKET.SESSION_CMD OF
          (*When [Cmd = Request]*)
            REQUEST:
               BEGIN
            (*If [it has the right password] then*)
              IF (PACKET.TEXT = PASS_WORD) THEN
                 BEGIN
               (*Set up packet for a favorable reply*)
                 PACKET.SESSION_CMD := START;
                 PACKET.TRANS_CMD := DATA_XFER; (****)
                 PACKET.NAME := 'SESSION STARTS      ';
               (*Go to In_Session state*)
                 STATE := IN_SESSION
               (*@Do not unblock Application process*)
               (*@Let the Transport Ack do that*)
                 END
            (*Else (bad password)*)
              ELSE
```

```
                    (*$$$   SESSION4   $$$*)
                  (*$$$ Revised Session layer $$$*)


                              BEGIN
                              PACKET.SESSION_CMD := BREAK;
                             (*Set up packet for a refusal*)
                              PACKET.TRANS_CMD := DISCONNECT; (****)
                              PACKET.NAME := 'BAD PASSWORD        ';
                              PACKET.STATUS := PACKET.STATUS
                               + [BAD_PASSWORD]
                              END;
                          (*ENDIF*)
                          (*Send a return packet*)
                            PACKET.DIRECTION := OUTGOING;
                            TO_NET.DEPOSIT (PACKET)
                            END;
                       (*Otherwise*)
                         ELSE:
                            BEGIN
                          (*@Should be prevented by protocol*)
                          (*Notify source of error*)
                            PACKET.STATUS := PACKET.STATUS
                             + [NO_REMOTE_SESSION];
                            PACKET.SESSION_CMD := BREAK;
                            PACKET.TRANS_CMD := DISCONNECT; (****)
                            PACKET.DIRECTION := OUTGOING;
                            TO_NET.DEPOSIT (PACKET)
                            END
                    END;(*CASE*)
                (*Endif*)
             (*When [State = In_session]*)
               IN_SESSION:
                (*If [packet is from application layer] then*)
                 IF (PACKET.DIRECTION = OUTGOING) THEN
                    CASE PACKET.SESSION_CMD OF
                     (*When [Cmd is a data transfer type]*)
                       CHAIN, END_CHAIN, ABORT_CHAIN, IMMEDIATE:
                          BEGIN
                        (*Set packet as a data transfer*)
                          PACKET.TRANS_CMD := DATA_XFER; (****)
                        (*Send data*)
                          TO_NET.DEPOSIT (PACKET)
(*@This is taken over    PACKET.DIRECTION := INCOMING;**)
(*@by transport layer    TO_APP.DEPOSIT (PACKET)**)
                          END;
                     (*When [Cmd = Break]*)
                       BREAK:
                          BEGIN
                        (*Go to No_Session state*)
                          STATE := NO_SESSION;
                        (*Piggy back break on disconnect*)
                          PACKET.TRANS_CMD := DISCONNECT; (****)
                          PACKET.NAME := 'SESSION ENDING      ';
                        (*Send a Break to partner*)
                          TO_NET.DEPOSIT (PACKET);
```

```
        (*$$$   SESSION4   $$$*)
      (*$$$ Revised Session layer $$$*)


            PACKET.STATUS := PACKET.STATUS
          (*Notify Application layer of status*)
          (*of Break*)
             + [SESSION_ENDING];
            PACKET.DIRECTION := INCOMING;
            TO_APP.DEPOSIT (PACKET)
            END;
        (*Otherwise*)
          ELSE:
             BEGIN
          (*Notify Application layer it has made a*)
          (*mistake*)
            PACKET.STATUS := PACKET.STATUS
             + [LOCAL_IN_SESSION];
             PACKET.DIRECTION := INCOMING;
             TO_APP.DEPOSIT (PACKET)
             END
      END(*CASE*)
  (*Else (packet from the network)*)
    ELSE
      CASE PACKET.SESSION_CMD OF
       (*When [Cmd = Break]*)
         BREAK:
          (*@Assume transport connection broken*)
            BEGIN
          (*Go to No_Session state*)
            STATE := NO_SESSION;
          (*Send up any messages left in the chain*)
          (*buffer*)
            FOR CHAIN_INDEX := 1 TO CHAIN_PTR DO
               TO_APP.DEPOSIT
                (CHAIN_BUFF [CHAIN_INDEX]);
           {ENDFOR}
            CHAIN_PTR := 0;
            PACKET.STATUS := PACKET.STATUS
             + [SESSION_ENDING];
          (*Notify Application of session ending*)
            TO_APP.DEPOSIT (PACKET)
            END;
        (*When [Cmd = Request]*)
          REQUEST:
             BEGIN
          (*@Should be prevented by Transport layer*)
          (*Send back a busy signal*)
            PACKET.STATUS := PACKET.STATUS
             + [BUSY];
            PACKET.SESSION_CMD := BREAK;
            PACKET.DIRECTION := OUTGOING;
            TO_NET.DEPOSIT (PACKET)
            END;
        (*When [Cmd = Immediate]*)
          IMMEDIATE:
```

```
                    (*$$$   SESSION4   $$$*)
                  (*$$$ Revised Session layer $$$*)


                      (*Immediately pass it to Application*)
                        TO_APP.DEPOSIT (PACKET);
                    (*When [Cmd = Chain]*)
                      CHAIN:
                        BEGIN
                       (*Store the message in the Chain buffer*)
                        CHAIN_PTR := CHAIN_PTR + 1;
                       (*@NOTE-possible Chain_Index range error*)
                        CHAIN_BUFF [CHAIN_PTR] := PACKET
                        END;
                    (*When [Cmd = End_Chain]*)
                      END_CHAIN:
                        BEGIN
                       (*Pass up all messages stored in the*)
                       (*Chain buffer*)
                        FOR CHAIN_INDEX := 1 TO CHAIN_PTR DO
                           TO_APP.DEPOSIT
                            (CHAIN_BUFF [CHAIN_INDEX]);
                         {ENDFOR}
                        CHAIN_PTR := 0;
                        TO_APP.DEPOSIT (PACKET)
                        END;
                    (*When [Cmd = Abort_Chain]*)
                      ABORT_CHAIN:
                       (*Empty the Chain buffer*)
                        CHAIN_PTR := 0;
                    (*Otherwise*)
                      ELSE:
                       (*@Should be prevented by Transport layer*)
                        BEGIN
                       (*Disconnect everyone and start over*)
                        PACKET.STATUS := PACKET.STATUS +
                         [REMOTE_IN_SESSION];
                        PACKET.SESSION_CMD := BREAK;
                        PACKET.DIRECTION := OUTGOING;
                        TO_NET.DEPOSIT (PACKET)
                        END
                  END(*CASE*);
              (*Endif*)
          END(*CASE*)
    (*End cycle*)
      END
(*End Session_process*)
  END;
```

```
                    (*$$$   CLOCK   $$$*)
          (*$$$ Monitor for controling time-outs $$$*)


 TYPE CLOCK_MONITOR = MONITOR;
(*****************************************************************
 *  The CLOCK_MONITOR is the interface between the Transport*
 * layer and the Timeout_Process.                                 *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  Programmer: Ronald C. Albury                                  *
 *  Date Written: 10/10/82                                        *
 *  Copyright 1982 by Ronald C. Albury                            *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  EXTERNAL                                                      *
 *     TYPE                                                       *
 *        TRANSPORT_COMMANDS: Enumerations of all possible  *
 *         commands the Transport layer will respond to.    *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  INTERNAL                                                      *
 *     VAR                                                        *
 *        LIMIT: Stores the number of seconds the                 *
 *         Timeout process should wait before sending a     *
 *         packet to the Transport process.                       *
 *        ELAPSED: The number of seconds that have elapsed  *
 *         since the Transport process has initiated the    *
 *         timer.                                                 *
 *        TIMER: Queue variable to delay the Timeout              *
 *         process when it is not being used.                     *
 *        STOP_TIMER: A boolean flag indicating if the            *
 *         Transport process wants the Timeout process      *
 *         turned off.                                            *
 *        TRANS_EVT: Stores the transport event to be             *
 *         delivered in the event of a time out.                  *
 *****************************************************************)
 VAR
    LIMIT, ELAPSED: INTEGER;
    TIMER: QUEUE;
    STOP_TIMER: BOOLEAN;
    TRANS_EVENT: TRANSPORT_COMMANDS;

(***Procedure Entry Start*************************************
 *  PARAMETERS                                                    *
 *     IN                                                         *
 *        MAXTICK: The number of seconds before a time out  *
 *         is delivered.                                          *
 *        T_EVT: The transport event to be delivered if    *
 *         there is a time out.                                   *
 *****************************************************************)
 PROCEDURE ENTRY START (MAX_TICK: INTEGER;
                        T_EVT: TRANSPORT_COMMANDS);
(*Begin entry Start*)
 BEGIN
  (*Reset the clock to 0*)
    ELAPSED := 0;
  (*Remenber the time limit and transport event*)
    TRANS_EVENT := T_EVT;
```

```
                    (*$$$   CLOCK   $$$*)
          (*$$$ Monitor for controling time-outs $$$*)


     LIMIT := MAX_TICK;
   (*Turn the timer on*)
     STOP_TIMER := FALSE;
     CONTINUE (TIMER)
(*End entry Start*)
  END;

 (*************************************************************)
  PROCEDURE ENTRY STOP;
(*Begin entry Stop*)
  BEGIN
   (*Set the STOP_TIMER flag*)
     STOP_TIMER := TRUE
(*End entry Stop*)
  END;

 (***Procedure Entry Tick*****************************************
  *  PARAMETERS                                                  *
  *     OUT                                                      *
  *        TICK_NUMBER: Recieves the current number of ticks     *
  *         since the time-out timer was started.                *
  *        MAX_TICK: Recieves the current time limit for the     *
  *         time-out.                                            *
  *        T_EVT: Recieves the transport event to be sent        *
  *         if the time-out occurs.                              *
  *************************************************************)
  PROCEDURE ENTRY TICK (VAR TICK_NUMBER: INTEGER;
                        VAR MAX_TICK: INTEGER;
                        VAR T_EVT: TRANSPORT_COMMANDS);
(*Begin entry Tick*)
  BEGIN
   (*If [the STOP_TIMER flag is set] then*)
     IF (STOP_TIMER) THEN
      (*Delay the timer*)
        DELAY (TIMER);
   (*Endif*)
   (*Increment the number of ticks since the time-out started*)
     ELAPSED := ELAPSED + 1;
   (*Set the output parameters*)
     TICK_NUMBER := ELAPSED;
     T_EVT := TRANS_EVENT;
     MAX_TICK := LIMIT
(*End entry Tick*)
  END;

  BEGIN
     STOP_TIMER := TRUE
  END;
```

```
                    (*$$$   TIMER   $$$*)
                  (*$$$ Time-out simulator $$$*)


 TYPE TIMEOUT_PROCESS = PROCESS (CLOCK: CLOCK_MONITOR;
                                 TRANSPORT: MAIL_BOX_MONITOR);
(*************************************************************
 *   The Timeout_Process delivers a high priority network    *
 * packet to the Transport layer if it is not turned off     *
 * within a specified time.  The Transport layer, through    *
 * the clock monitor, is able to set both the transport      *
 * control message to be delivered in the packet, and the    *
 * lenght of time the timer will run.                        *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  PROGRAMMER: Ronald C. Albury                             *
 *  DATE WRITTEN: 10/7/82                                    *
 *  Copyright 1982 by Ronald C. Albury                       *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  EXTERNAL                                                 *
 *     TYPE                                                  *
 *        CLOCK_MONITOR: The interface monitor between the   *
 *         Timeout_Process and the Transport_Process.        *
 *        MAIL_BOX_MONITOR: A monitor used for passing       *
 *         network packets between processes.                *
 *        PACKET_TYPE: Record structure of the network       *
 *         packets.                                          *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  INTERNAL                                                 *
 *     VAR                                                   *
 *        TICK_NUMBER: The number the Clock_Monitor has      *
 *         been entered since the time-out has started.      *
 *        MAX_TICK: The number of ticks to wait before       *
 *         sending the time-out packet.                      *
 *        TIME_PKT: The packet used for delivering the       *
 *         time-out to the transport layer.                  *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  PARAMETERS                                               *
 *     CLOCK: The monitor to get the time-out commands from. *
 *     TRANSPORT: The monitor to deliver the time-out        *
 *      packets to.                                          *
 *************************************************************)
 VAR
    TICK_NUMBER, MAX_TICK: INTEGER;
    TIME_PKT: PACKET_TYPE;

(*Begin Timeout_Process*)
 BEGIN
  (*Initialize the Time-out packet*)
    TIME_PKT.PRIORITY := HIGH_PRI;
    TIME_PKT.DIRECTION := INCOMING;
    TIME_PKT.NAME := 'THIS IS A TIME OUT  ';
    TIME_PKT.STATUS := [];
  (*Cycle forever*)
    CYCLE
     (*Go into a wait state for 1 second*)
       WAIT;
```

```
                    (*$$$   TIMER   $$$*)
                (*$$$ Time-out simulator $$$*)


      (*Enter the Clock_Monitor for an update from the*)
      (*Transport layer.*)
        CLOCK.TICK (TICK_NUMBER, MAX_TICK, TIME_PKT.TRANS_CMD);
      (*IF [TIME IS UP EXACTLY] THEN*)
      (*@To avoid synchronization problems, allow Tick_number*)
      (*@to exceed Max_tick*)
        IF (TICK_NUMBER = MAX_TICK) THEN
           BEGIN
         (*Send the time-out packet*)
           TRANSPORT.DEPOSIT (TIME_PKT)
           END
      (*Endif*)
     END (*Cycle*)
(*End Timeout_Process*)
  END;
```

```
                    (*$$$   TRANS   $$$*)
        (*$$$ Process to simulate Transport layer $$$*)


TYPE TRANSPORT_PROCESS = PROCESS (TO_APP: MAIL_BOX_MONITOR;
                                  EVENT: MAIL_BOX_MONITOR;
                                  TO_NET: MAIL_BOX_MONITOR;
                                  TIMER: CLOCK_MONITOR;
                                  THIS_NODE: HOST_ID_TYPE);
(*****************************************************************
 *   The transport layer handles the node's communication       *
 * with the network.  It maps it' hosts requests onto           *
 * network addresses, and manages all connections.  It also     *
 * must assure the delivery of the messages to it's host        *
 * in the order they were sent, despite possible losses in      *
 * the network.                                                 *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  PROGRAMMER: Ronald C. Albury                                *
 *  DATE WRITTEN: 10/7/82                                       *
 *  COPYRIGHT 1982 by Ronald C. Albury                          *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  EXTERNAL                                                    *
 *     TYPE                                                     *
 *        PACKET_TYPE: Record structure of the network          *
 *         packet.                                             *
 *        MAIL_BOX_MONITOR: A monitor used for passing          *
 *         packets between processes.                          *
 *        HOST_ID_TYPE: Enumerations of hosts in network.       *
 *        CLOCK_MONITOR: Communication interface with the       *
 *         Timeout_Process.                                    *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  INTERNAL                                                    *
 *     TYPE                                                     *
 *        TRANS_STATE_TYPE: Enumerations of the states the      *
 *         transport layer can be in.                          *
 *        IPC_TABLE_TYPE: Record structure used for             *
 *         connection management.                              *
 *     VAR                                                      *
 *        PACKET: The network packet this process uses to       *
 *         communicate with.                                   *
 *        STATE: The current state of the transport layer.      *
 *        IPC: Table and buffer used for connection             *
 *         management.                                         *
 *****************************************************************)
TYPE
   TRANS_STATE_TYPE = (NOT_CONNECTED, CONNECTING,
    IN_CONNECTION);
   IPC_TABLE_TYPE = RECORD
                       LOCAL_ADDRS: HOST_ID_TYPE;
                       REMOTE_ADDRS: HOST_ID_TYPE;
                       LOCAL_CONNUM: INTEGER;
                       REMOTE_CONNUM: INTEGER;
                       DATA_SEQ: DATA_WINDOW_TYPE;
                       ACK_SEQ: DATA_WINDOW_TYPE;
                       WAITING_FOR_ACK: BOOLEAN;
                       BUFFER: PACKET_TYPE
```

```
                    (*$$$   TRANS   $$$*)
          (*$$$ Process to simulate Transport layer $$$*)


                      END;
  VAR
     PACKET: PACKET_TYPE;
     STATE: TRANS_STATE_TYPE;
     IPC: IPC_TABLE_TYPE;
     WAITING_FOR_ACK: BOOLEAN;

 (***Internal Procedure Send_Net*****************************)
  PROCEDURE SEND_NET (VAR PACKET: PACKET_TYPE);
(*Begin Send_Net*)
  BEGIN
   (*Set the packet direction, connection numbers,*)
   (*and addresses*)
     PACKET.DIRECTION := OUTGOING;
     PACKET.S_CONNUM := IPC.LOCAL_CONNUM;
     PACKET.D_CONNUM := IPC.REMOTE_CONNUM;
     PACKET.SOURCE := IPC.LOCAL_ADDRS;
     PACKET.DESTINATION := IPC.REMOTE_ADDRS;
     TO_NET.DEPOSIT (PACKET)
(*End internal procedure Send_Net*)
  END;

(*Begin Transport_Process*)
  BEGIN
   (*Initialize the state to NOT_CONNECTED*)
     STATE := NOT_CONNECTED;
   (*Initialize IPC table*)
     IPC.DATA_SEQ := 0;
     IPC.ACK_SEQ := 0;
     IPC.LOCAL_CONNUM := 0;
     IPC.WAITING_FOR_ACK := FALSE;
   (*Cycle forever*)
     CYCLE
      (*Get a packet*)
        EVENT.GET (PACKET);
      (*Process the packet based on current state*)
       CASE STATE OF
        (*When [state = Not_Connected]*)
          NOT_CONNECTED:
           (*If [packet is from application layer] then*)
             IF (PACKET.DIRECTION = OUTGOING) THEN
                CASE PACKET.TRANS_CMD OF
                 (*When [Cmd = Connect]*)
                   CONNECT:
                      BEGIN
                    (*@In an open system, the address of the*)
                    (*@remote process would have to be looked*)
                    (*@up in a directory.  It would consist*)
                    (*@of a node id, and a process id.*)
                    (*Get address of destination host*)
                      IF (PACKET.NAME = DIRECTORY [HOST_S_1])
                       THEN
```

```
                (*$$$   TRANS   $$$*)
(*$$$ Process to simulate Transport layer $$$*)


                    IPC.REMOTE_ADDRS := HOST_S_1
                  ELSE IF (PACKET.NAME = DIRECTORY
                   [HOST_S_2]) THEN
                    IPC.REMOTE_ADDRS := HOST_S_2
                (*If [no record of that host] then*)
                  ELSE
                    BEGIN
                   (*Send an error message to the*)
                   (*application program*)
                    PACKET.DIRECTION := INCOMMING;
                    PACKET.STATUS := PACKET.STATUS
                     + [NO_SUCH_HOST];
                    PACKET.SESSION_CMD := BREAK;
                    PACKET.NAME := 'ERROR MSG NO HOST   ';
                    TO_APP.DEPOSIT (PACKET)
                    END;
                 (*Endif*)
                 (*If [we got the address] then*)
                   IF NOT (NO_SUCH_HOST IN PACKET.STATUS)
                    THEN
                     BEGIN
                    (*Go to Connecting state*)
                     STATE := CONNECTING;
                    (*Set up the IPC table*)
                     IPC.BUFFER := PACKET;
                     IPC.LOCAL_ADDRS := THIS_NODE;
                     IPC.LOCAL_CONNUM :=
                      IPC.LOCAL_CONNUM + 1;
                     IPC.REMOTE_CONNUM := 0;
                    (*Send a connection inquiry to the*)
                    (*destination*)
                     PACKET.TRANS_CMD := INQUIRE;
                     PACKET.NAME := 'TRANS INQUIRE       ';
                     SEND_NET (PACKET);
                    (*Set the time-out timer in case the*)
                    (*inquiry is lost on the net*)
                     TIMER.START (4, T_O_ACCEPT)
                     END
                 (*Endif*)
                   END;
              (*When [Cmd = Disconnect]*)
                DISCONNECT:
                 (*Disregard it*)
                 (*@Should be prevented by session layer*)
                   BEGIN
                   STATE := NOT_CONNECTED
                   END;
              (*Otherwise*)
                ELSE:
                 (*@Should be prevented by session*)
                 (*Resync on a disconnect*)
                   BEGIN
```

```
            (*$$$  TRANS   $$$*)
(*$$$ Process to simulate Transport layer $$$*)


            (*Send an error message to the session*)
            (*and application processes*)
              PACKET.DIRECTION := INCOMMING;
              PACKET.SESSION_CMD := BREAK;
              PACKET.STATUS := PACKET.STATUS
               + [NO_LOCAL_CONNECTION];
              PACKET.NAME := 'DISASTER           ';
              TO_APP.DEPOSIT (PACKET)
              END
        END(*CASE*)
    (*Else from net*)
      ELSE
        CASE PACKET.TRANS_CMD OF
         (*When [Cmd = Inquire]*)
          INQUIRE:
            BEGIN
           (*Go into In_Connection state*)
            STATE := IN_CONNECTION;
           (*Set up the IPC table*)
            IPC.REMOTE_ADDRS := PACKET.SOURCE;
            IPC.LOCAL_ADDRS := THIS_NODE;
            IPC.LOCAL_CONNUM := IPC.LOCAL_CONNUM + 1;
            IPC.REMOTE_CONNUM := PACKET.S_CONNUM;
           (*Pass up piggy-backed messages*)
            PACKET.NAME := 'GOT AN INQUIRE     ';
            TO_APP.DEPOSIT (PACKET);
           (*Send an acceptance to the source of the*)
           (*inquiry*)
            PACKET.TRANS_CMD := ACCEPT;
            PACKET.NAME := 'ACCEPTANCE         ';
            SEND_NET (PACKET)
            END;
         (*When [Cmd = Disconnect]*)
          DISCONNECT:
           (*Disregard it*)
           (*@Should be prevented by session layer*)
            BEGIN
            STATE := NOT_CONNECTED
            END;
         (*When [Cmd = Time_out]*)
          T_O_ACCEPT, T_O_DATA_ACK:
           (*Disregard it*)
           (*@May be caused by possible delays in*)
           (*@receiving the time-outs*)
            BEGIN
            STATE := NOT_CONNECTED
            END;
         (*Otherwise*)
          ELSE:
            BEGIN
           (*Send an error message and a disconnect*)
           (*to the source of the problem*)
```

```
            (*$$$   TRANS   $$$*)
(*$$$ Process to simulate Transport layer $$$*)


            (*@Should be prevented by protocol*)
              PACKET.DIRECTION := OUTGOING;
              PACKET.TRANS_CMD := DISCONNECT;
              PACKET.STATUS := PACKET.STATUS
               + [NO_REMOTE_CONNECTION];
              PACKET.DESTINATION := PACKET.SOURCE;
              PACKET.SOURCE := THIS_NODE;
              PACKET.NAME := 'DISASTER            ';
              TO_NET.DEPOSIT (PACKET)
              END
          END(*CASE*);
    (*Endif*)
 (*When [State = Connecting]*)
   CONNECTING:
    (*If [packet is from the application layer] then*)
      IF (PACKET.DIRECTION = OUTGOING) THEN
       (*@Should be prevented by session*)
       (*Resync on a disconnect*)
         BEGIN
         PACKET.DIRECTION := INCOMMING;
         PACKET.SESSION_CMD := BREAK;
         PACKET.STATUS := PACKET.STATUS
          + [NO_LOCAL_CONNECTION];
         PACKET.NAME := 'DISASTER            ';
         TO_APP.DEPOSIT (PACKET)
         END
    (*Else from net*)
      ELSE
         CASE PACKET.TRANS_CMD OF
          (*When [Cmd = Accept]*)
            ACCEPT:
               BEGIN
             (*If [accept matches our request] then*)
               IF (PACKET.SOURCE = IPC.REMOTE_ADDRS)
                & (PACKET.D_CONNUM = IPC.LOCAL_CONNUM)
                THEN
                  BEGIN
                (*Turn off the time-out*)
                  TIMER.STOP;
                (*Go to In_Connection state*)
                  STATE := IN_CONNECTION;
                (*Complete the IPC table*)
                  IPC.REMOTE_CONNUM := PACKET.S_CONNUM
                  END
             (*Else a bad accept*)
               ELSE
                (*@Should be prevented by session*)
                (*@unless a node crashes*)
                (*Resync on disconnect*)
                  BEGIN
                  PACKET.DIRECTION := OUTGOING;
                  PACKET.SESSION_CMD := BREAK;
```

```
                (*$$$   TRANS   $$$*)
(*$$$ Process to simulate Transport layer $$$*)

                    PACKET.TRANS_CMD := DISCONNECT;
                    PACKET.STATUS := PACKET.STATUS
                     + [NO_REMOTE_CONNECTION];
                    PACKET.S_CONNUM := IPC.LOCAL_CONNUM;
                    PACKET.DESTINATION := PACKET.SOURCE;
                    PACKET.SOURCE := THIS_NODE;
                    PACKET.NAME := 'DISASTER            ';
                    TO_NET.DEPOSIT (PACKET)
                    END
                (*Endif*)
                  END;
               (*When [Cmd = Disconnect]*)
                 DISCONNECT:
                   BEGIN
                  (*@It only needs to be from the right*)
                  (*@address too be taken seriously*)
                  (*If [packet is from right address] then*)
                    IF (PACKET.SOURCE = IPC.REMOTE_ADDRS)
                     THEN
                       BEGIN
                      (*Turn off the time-out*)
                       TIMER.STOP;
                      (*Notify the session and application*)
                      (*layers*)
                       PACKET.NAME := 'RECEIVED DISCONNECT ';
                       PACKET.SESSION_CMD := BREAK;
                       TO_APP.DEPOSIT (PACKET);
                      (*Go to Not_Connected state*)
                       STATE := NOT_CONNECTED
                       END
                  (*Else*)
                    ELSE
                     (*Disregard it*)
                       BEGIN
                       STATE := CONNECTING
                       END
                  (*Endif*)
                    END;
               (*When [Cmd = Time-out Accept]*)
                 T_O_ACCEPT:
                   BEGIN
                  (*Send another inquiry*)
                    PACKET := IPC.BUFFER;
                    PACKET.TRANS_CMD := INQUIRE;
                    PACKET.NAME := 'ANOTHER INQUIRY     ';
                    SEND_NET (PACKET);
                  (*Start the timer again*)
                    TIMER.START (4, T_O_ACCEPT)
                    END;
               (*When [Cmd = Time-out Data Ack]*)
                 T_O_DATA_ACK:
                  (*Disregard it*)
```

```
            (*$$$   TRANS   $$$*)
(*$$$ Process to simulate Transport layer $$$*)


                BEGIN
                STATE := CONNECTING
                END;
            (*Otherwise*)
              ELSE:
               (*Resync on disconnect*)
                BEGIN
                PACKET.DIRECTION := OUTGOING;
                PACKET.TRANS_CMD := DISCONNECT;
                PACKET.SESSION_CMD := BREAK;
                PACKET.STATUS := PACKET.STATUS
                 + [NO_REMOTE_CONNECTION];
                PACKET.S_CONNUM := IPC.LOCAL_CONNUM;
                PACKET.DESTINATION := PACKET.SOURCE;
                PACKET.SOURCE := THIS_NODE;
                PACKET.NAME := 'DISASTER            ';
                TO_NET.DEPOSIT (PACKET)
                END
          END(*CASE*);
     (*Endif*)
 (*When [State = In_Connection]*)
   IN_CONNECTION:
    (*If [packet is from the application layer] then*)
      IF (PACKET.DIRECTION = OUTGOING) THEN
         CASE PACKET.TRANS_CMD OF
          (*When [Cmd = Disconnect]*)
            DISCONNECT:
               BEGIN
             (*Go to Not_Connected state*)
               STATE := NOT_CONNECTED;
             (*Turn off the time-out*)
               TIMER.STOP;
             (*Re-set the IPC table*)
               IPC.DATA_SEQ := 0;
               IPC.ACK_SEQ := 0;
               IPC.WAITING_FOR_ACK := FALSE;
             (*@There is currently nothing in this*)
             (*@protocol to insure the disconnect*)
             (*@command reaches the destination*)
             (*Send the disconnect*)
               PACKET.NAME := 'DISCONNECTING YOU   ';
               SEND_NET (PACKET)
               END;
            (*When [Cmd = Data transfer]*)
              DATA_XFER:
               BEGIN
             (*Set the sequence number of the packet*)
             (*@for end to end protocol*)
               PACKET.DATA_SEQ := IPC.DATA_SEQ;
               IPC.WAITING_FOR_ACK := TRUE;
             (*Send the packet and start a time-out*)
               PACKET.NAME := 'DATA TRANSFER       ';
```

```
            (*$$$   TRANS   $$$*)
(*$$$ Process to simulate Transport layer $$$*)


                IPC.BUFFER := PACKET;
                SEND_NET (PACKET);
                TIMER.START (4, T_O_DATA_ACK)
                END;
            (*Otherwise*)
              ELSE:
               (*Resync on disconnect*)
                BEGIN
                TIMER.STOP;
                PACKET.SESSION_CMD := BREAK;
                PACKET.STATUS := PACKET.STATUS
                 + [CONNECTION_BROKEN];
                PACKET.DIRECTION := INCOMMING;
                PACKET.NAME := 'DISASTER              ';
                TO_APP.DEPOSIT (PACKET);
                PACKET.TRANS_CMD := DISCONNECT;
                SEND_NET (PACKET);
                STATE := NOT_CONNECTED
                END
          END(*CASE*)
      (*Else from net*)
        ELSE
          CASE PACKET.TRANS_CMD OF
           (*When [Cmd = Disconnect]*)
            DISCONNECT:
             (*@It need only come from the right*)
             (*@address*)
               BEGIN
             (*If [packet is from right address] then*)
               IF (PACKET.SOURCE = IPC.REMOTE_ADDRS)
                THEN
                  BEGIN
                (*Turn off the time-out*)
                  TIMER.STOP;
                (*Go to Not_Connected state*)
                  STATE := NOT_CONNECTED;
                (*Re-set the IPC table*)
                  IPC.DATA_SEQ := 0;
                  IPC.ACK_SEQ := 0;
                  IPC.WAITING_FOR_ACK := FALSE;
                (*Pass up piggy-backed messages*)
                  PACKET.NAME := 'WAS DISCONNECTED    ';
                  TO_APP.DEPOSIT (PACKET)
                  END
             (*Else*)
               ELSE
                (*Disregard it*)
                  BEGIN
                  STATE := IN_CONNECTION
                  END
             (*Endif*)
               END;
```

```
            (*$$$   TRANS   $$$*)
(*$$$ Process to simulate Transport layer $$$*)


          (*When [Cmd = Inquire]*)
            INQUIRE:
             (*@This protocol can currently handle*)
             (*@only one connection at a time*)
               BEGIN
             (*If [not re-transmission from peer]*)
               (then*)
               IF (PACKET.S_CONNUM <> IPC.REMOTE_CONNUM)
                 OR (PACKET.SOURCE <> IPC.REMOTE_ADDRS)
                 THEN
                  BEGIN
                 (*Disconnect them*)
                   PACKET.DIRECTION := OUTGOING;
                   PACKET.TRANS_CMD := DISCONNECT;
                   PACKET.DESTINATION := PACKET.SOURCE;
                   PACKET.SOURCE := THIS_NODE;
                   PACKET.NAME := 'CAN NOT TALK TO YOU ';
                   PACKET.STATUS := PACKET.STATUS
                    + [BUSY];
                   TO_NET.DEPOSIT (PACKET)
                   END
             (*Else*)
               ELSE
                  BEGIN
                (*@Assumes the last thing sent*)
                (*@was an Accept*)
                  PACKET.TRANS_CMD := ACCEPT;
                (*Re-transmit the last packet sent*)
                  PACKET.NAME := 'ANOTHER ACCEPT      ';
                  SEND_NET (PACKET)
                  END
             (*Endif*)
               END;
          (*When [Cmd = Data_Xfer]*)
            DATA_XFER:
               BEGIN
             (*If [Packet is from partner] then*)
               IF (PACKET.SOURCE = IPC.REMOTE_ADDRS)
                & (PACKET.S_CONNUM = IPC.REMOTE_CONNUM)
                & (PACKET.D_CONNUM = IPC.LOCAL_CONNUM)
                THEN
                  BEGIN
                (*If [Packet has correct sequence]then*)
                  IF (PACKET.DATA_SEQ = IPC.ACK_SEQ) AND
                   (NOT IPC.WAITING_FOR_ACK) THEN
                     BEGIN
                    (*Increment the Ack sequence num*)
                     IPC.ACK_SEQ := (IPC.ACK_SEQ+1)
                      MOD 2;
                    (*Send the packet up*)
                     PACKET.NAME :=
                      'DATA RECEIVED      ';
```

```
            (*$$$   TRANS   $$$*)
(*$$$ Process to simulate Transport layer $$$*)

                    TO_APP.DEPOSIT (PACKET)
                    END;
                (*Endif*)
                  IF (NOT IPC.WAITING_FOR_ACK) OR
                   (PACKET.DATA_SEQ <> IPC.ACK_SEQ) THEN
                    BEGIN
                   (*Send back an acknowlegment*)
                    PACKET.TRANS_CMD := DATA_ACK;
                    PACKET.STATUS := [];
                    PACKET.TEXT :=
                     '                    ';
                    PACKET.NAME :=
                     'DATA ACK            ';
                    PACKET.PRIORITY := HIGH_PRI;
                    PACKET.SECURITY := PUBLIC;
                    SEND_NET (PACKET)
                    END
                (*ENDIF*)
                  END
              (*Else an illegal packet*)
                ELSE
                 (*Wipe out connection that is sending*)
                 (*data illegaly so it won't keep*)
                 (*timing out*)
                   BEGIN
                   PACKET.DIRECTION := OUTGOING;
                   PACKET.TRANS_CMD := DISCONNECT;
                   PACKET.DESTINATION := PACKET.SOURCE;
                   PACKET.SOURCE := THIS_NODE;
                   PACKET.NAME := 'CANT TALK TO YOU    ';
                   TO_NET.DEPOSIT (PACKET)
                   END
              (*Endif*)
                END;
          (*When [Cmd = Data Acknolegment]*)
            DATA_ACK:
              BEGIN
             (*If [packet is from partner] then*)
               IF (PACKET.SOURCE = IPC.REMOTE_ADDRS)
                & (PACKET.S_CONNUM = IPC.REMOTE_CONNUM)
                & (PACKET.D_CONNUM = IPC.LOCAL_CONNUM)
                & (PACKET.DATA_SEQ = IPC.DATA_SEQ) THEN
                 BEGIN
                (*Turn off time-out*)
                 TIMER.STOP;
                (*Increment the IPC data sequence no.*)
                 IPC.DATA_SEQ := (IPC.DATA_SEQ+1)
                  MOD 2;
                 IPC.WAITING_FOR_ACK := FALSE;
                (*Unblock the application process*)
                 PACKET.SESSION_CMD := IMMEDIATE;
                 PACKET.NAME := 'RECEIVED AN ACK     ';
```

```
                    (*$$$   TRANS   $$$*)
          (*$$$ Process to simulate Transport layer $$$*)


                              TO_APP.DEPOSIT (PACKET)
                              END
                         (*Endif*)
                           END;
                      (*When [Cmd = Time out data ack]*)
                        T_O_DATA_ACK:
                           BEGIN
                         (*Retransmit the last packet*)
                           PACKET := IPC.BUFFER;
                          PACKET.NAME := 'DIDNT GET ACK REXMIT';
                           SEND_NET (PACKET);
                         (*Re-start the time-out*)
                           TIMER.START (4, T_O_DATA_ACK)
                           END;
                      (*Otherwise*)
                        ELSE:
                           BEGIN
                         (*DISREGARD IT*)
                           STATE := IN_CONNECTION
                           END
                    END(*CASE*)
               (*Endif*)
             END(*CASE*)
       (*End cycle*)
         END
  (*End Transport Process*)
    END;
```

```
                    (*$$$   BADNODE   $$$*)
  (*$$$ Process to simulate data loss in the network $$$*)


 TYPE BAD_NODE_PROCESS = PROCESS (EVENT: MAIL_BOX_MONITOR;
                                  NEXT_NODE: MAIL_BOX_MONITOR);
(*****************************************************************
 *  BAD_NODE_PROCESS simulates a faulty node in a local          *
 * area network, resulting in network packets being lost.        *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  Programmer: Ronald C. Albury                                 *
 *  Date Written: 10/11/82                                       *
 *  Copyright 1982 by Ronald C. Albury                           *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  EXTERNAL                                                     *
 *     TYPE                                                      *
 *        MAIL_BOX_MONITOR: A monitor used for passing           *
 *         network packets between processes.                    *
 *        PACKET_TYPE: Record structure of the network           *
 *         packet.                                               *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  INTERNAL                                                     *
 *     CONST                                                     *
 *        LOSS_FREQ: The frequency with which this node          *
 *         looses packets.                                       *
 *     VAR                                                       *
 *        PACKET: The network used by this process to            *
 *         communicate                                           *
 *        SKIP: An integer used to determine when a packet       *
 *         should be lost.                                       *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  PARAMETERS                                                   *
 *     EVENT: The monitor used by this process to recieve        *
 *      packets from other nodes.                                *
 *     NEXT_NODE: The monitor used by this process to send       *
 *      packets to other nodes.                                  *
 *****************************************************************)
 CONST
    LOSS_FREQ = 10;
 VAR
    PACKET: PACKET_TYPE;
    SKIP: INTEGER;

(*Begin Bad_Node process*)
 BEGIN
    SKIP := 0;
  (*Cycle forever*)
    CYCLE
     (*Get a packet*)
       EVENT.GET (PACKET);
       SKIP := (SKIP+1) MOD LOSS_FREQ;
     (*If [this one is not lost] then*)
       IF (SKIP <> 0) THEN
          BEGIN
        (*Send it to the next node*)
          NEXT_NODE.DEPOSIT (PACKET)
```

```
                    (*$$$   BADNODE   $$$*)
   (*$$$ Process to simulate data loss in the network $$$*)


           END
   (ELSE BREAKPNT (80)*)
      (*Endif*)
   (*End cycle*)
     END
(*End Bad_Node process*)
  END;
```

```
                    (*$$$   WORKER4   $$$*)
          (*$$$ Net4 Worker application process $$$*)


TYPE WORKER_PROCESS = PROCESS(CONSOLE: RESOURCE_MONITOR;
                              FROM_NET: MAIL_BOX_MONITOR;
                              TO_NET: MAIL_BOX_MONITOR);
(*************************************************************
 *  The WORKER_PROCESS is an application layer process that  *
 *   transfers remote files to the operator console.         *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 * PROGRAMMER:  RON ALBURY                                   *
 * DATE WRITTEN: 6/28/82                                     *
 * COMPUTER: INTERDATA 8/32                                  *
 * Copyright 1982 by Ronald C. Albury                        *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  EXTERNAL                                                 *
 *    CONST                                                  *
 *       ERROR_MSG = Structured constant containing text     *
 *        explainations of possible packet errors.          *
 *     TYPE                                                  *
 *        MESSAGE_IO_CLASS = A class that uses supervisory   *
 *         calls to handle fixed record I/O to specified     *
 *         logical units.                                    *
 *        PACKET_TYPE = Record structure of the network      *
 *         packets.                                          *
 *        MESSAGE_TYPE = Array of characters.                *
 *        ERROR_SVC1_TYPE = Record structure of the status   *
 *         bytes from the supervisory call.                  *
 *        MAIL_BOX_MONITOR = A monitor used for passing      *
 *         packets between processes.                        *
 *        RESOURCE_MONITOR = Allows only one process to      *
 *         access a resource at a time.                      *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  INTERNAL                                                 *
 *     VAR                                                   *
 *        STATUS_INDEX: Used to report packet errors.        *
 *        OP: Used to write lines of the transfered file     *
 *         to the operator.                                  *
 *        PACKET: A network packet this process uses to      *
 *         communicate with the network.                     *
 *        TEXT: Array of characters used to communicate      *
 *         the operator.                                     *
 *        OP_STATUS: Recieves the status bytes from the      *
 *         MESSAGE_IO_CLASS.  Not used here, but necessary   *
 *         for the calls to OP.                              *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  PARAMETERS                                               *
 *     CONSOLE: The RESOURCE_MONITOR used to reserve the     *
 *      console for exclusive I/O.                           *
 *     FROM_NET: The monitor used to recieve packets from    *
 *      the network.                                         *
 *     TO_NET: The monitor used to send packets to the net   *
 *************************************************************)
VAR
   OP: MESSAGE_IO_CLASS;
```

```
                    (*$$$   WORKER4   $$$*)
              (*$$$ Net4 Worker application process $$$*)


      ERROR: ERROR_CLASS;
      OS: NET_IO_CLASS;
      NET_STATUS: PKT_STATUS_TYPE;
      TEXT: MESSAGE_TYPE;
      NAME: MESSAGE_TYPE;
      OP_STATUS: ERROR_SVC1_TYPE;

  (*Begin Worker process*)
    BEGIN
     (*Initialize the interface to the operator*)
       INIT OP;
     (*Initialize network interfaces*)
       INIT ERROR (CONSOLE);
       INIT OS (FROM_NET, TO_NET);
     (*Cycle forever*)
       CYCLE
        (*Read in session request*)
          CONSOLE.REQUEST;
          OP.WRITE (TERMINAL, 'ENTER SERVER HOST   ', OP_STATUS);
          OP.READ (TERMINAL, NAME, OP_STATUS);
          OP.WRITE (TERMINAL, 'ENTER SERVE PASSWORD', OP_STATUS);
          OP.READ (TERMINAL, TEXT, OP_STATUS);
          CONSOLE.RELEASE;
        (**Request a session from the network*)
          OS.MAKE_SESSION (TEXT, NAME, NET_STATUS); (****)
          ERROR.REPORT ('WORKER 10           ', NET_STATUS);
        (*If [we  connect] then*)
          IF (NET_STATUS = []) THEN
             BEGIN
            (*Repeat for all files desired*)
              REPEAT
               (*Read in the file request*)
                 TEXT := 'ENTER FILE ID.    - ';
                 TEXT [18] := FIRST_FILE_ID;
                 TEXT [20] := LAST_FILE_ID;
                 CONSOLE.REQUEST;
                 OP.WRITE (TERMINAL, TEXT, OP_STATUS);
                 OP.READ (TERMINAL, TEXT, OP_STATUS);
                 CONSOLE.RELEASE;
               (*Send the request to the server*)
                 OS.NET_WRITE (TEXT,IMMEDIATE,PUBLIC,NET_STATUS);
                 ERROR.REPORT (' WORKER 20          ',NET_STATUS);
               (**Transfer the file to the console*)
                 CONSOLE.REQUEST;
               (*Repeat until end of file*)
                 REPEAT
                  (*Get a line from the network*)
                    OS.NET_READ (TEXT, NET_STATUS);
                  (*Output it to the console*)
                    OP.WRITE (TERMINAL, TEXT, OP_STATUS);
               (*End repeat*)
                 UNTIL ((TEXT[1] = '/') AND (TEXT[2] = '*'))
```

```
                    (*$$$   WORKER4   $$$*)
            (*$$$ Net4 Worker application process $$$*)


                 OR (SESSION_ENDING IN NET_STATUS);
                CONSOLE.RELEASE;
                ERROR.REPORT ('WORKER 30          ', NET_STATUS);
              (*Determine if more files are desired*)
                CONSOLE.REQUEST;
                OP.WRITE (TERMINAL, 'MORE FILES   Y/N    ',
                 OP_STATUS);
                OP.READ (TERMINAL, TEXT, OP_STATUS);
                CONSOLE.RELEASE
            (*End repeat*)
              UNTIL (TEXT [1] = 'N');
            (*End that session*)
              OS.CLEAR_SESSION (NET_STATUS);
              ERROR.REPORT ('WORKER 40          ', NET_STATUS)
              END
        (*Endif*)
     (*End cycle*)
       END
  (*End Worker process*)
    END;
```

```
                    (*$$$   SERVER4   $$$*)
          (*$$$ Net4 Server application process $$$*)


 TYPE SERVER_PROCESS = PROCESS (CONSOLE: RESOURCE_MONITOR;
                                FROM_NET: MAIL_BOX_MONITOR;
                                TO_NET: MAIL_BOX_MONITOR;
                                FIRST_NODE_FILE: CHAR;
                                LAST_NODE_FILE: CHAR);
(*****************************************************************
 *  The server process is an application layer process that      *
 *   does the disk I/O for a remote worker process.              *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 * PROGRAMMER:  RON ALBURY                                       *
 * DATE WRITTEN: 6/28/82                                         *
 * COMPUTER: INTERDATA 8/32                                      *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  EXTERNAL                                                     *
 *     CONST                                                     *
 *        FILE_LU: An array of logical units that are            *
 *         subscripted with file id's.  Used to look up          *
 *         logical unit of a requested file.                     *
 *     TYPE                                                      *
 *        MESSAGE_IO_CLASS = A class that uses supervisory       *
 *         calls to handle fixed record I/O to specified         *
 *         logical units.                                        *
 *        PACKET_TYPE = Record structure of the network          *
 *         packets.                                              *
 *        MESSAGE_TYPE = Array of characters.                    *
 *        ERROR_SVC1_TYPE = Record structure of the status       *
 *         bytes from the supervisory call.                      *
 *        MAIL_BOX_MONITOR = A monitor used for passing          *
 *         packets between processes.                            *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  INTERNAL                                                     *
 *     VAR                                                       *
 *        DISK: Used to input lines of a disk file.              *
 *        PACKET: A network packet used to communicate with      *
 *         the network.                                          *
 *        TEXT: Array of characters used for the disk I/O.       *
 *        FILE_ID: The id of the file the worker process is      *
 *         requesting.                                           *
 *        VALID_FILE_IDS: A set of the valid id's this           *
 *         process can access.                                   *
 *        INDEX: Used in initializing Valid_File_Id's            *
 *        OP_STATUS: Recieves the status bytes form the          *
 *         MESSAGE_IO_CLASS.                                     *
 *:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::*
 *  PARAMETERS                                                   *
 *     FROM_NET: The monitor used to recieve packets from        *
 *      the network.                                             *
 *     TO_NET: The monitor used to send packets to the net.      *
 *****************************************************************)
 VAR
    DISK: MESSAGE_IO_CLASS;
    OS: NET_IO_CLASS;
```

```
                    (*$$$   SERVER4   $$$*)
          (*$$$ Net4 Server application process $$$*)


     NET_STATUS: PKT_STATUS_TYPE;
     ERROR: ERROR_CLASS;
     TEXT: MESSAGE_TYPE;
     FILE_ID: CHAR;
     VALID_FILE_IDS: SET OF CHAR;
     INDEX: FILE_RANGE;
     OP_STATUS: ERROR_SVC1_TYPE;

(*Begin Server process*)
  BEGIN
   (*Initialize the interface to the disk files*)
     INIT DISK;
     INIT OS (FROM_NET, TO_NET);
     INIT ERROR (CONSOLE);
  (**Build the set of all valid file id's at this node.*)
   (*For (all files at this node) do*)
     FOR INDEX := FIRST_NODE_FILE TO LAST_NODE_FILE DO (****)
        BEGIN
      (*Remember that it is a valid id*)
        VALID_FILE_IDS := VALID_FILE_IDS + [INDEX]
        END;
   (*Endfor*)
   (*Cycle forever*)
     CYCLE
      (**Put your ears up*)
        OS.NET_LISTEN (NET_STATUS);
        ERROR.REPORT ('SERVER 10          ', NET_STATUS);
      (*Get the request from the net*)
        OS.NET_READ (TEXT, NET_STATUS);
        ERROR.REPORT ('SERVER 15          ', NET_STATUS);
        FILE_ID := TEXT [1];
      (*While (we still have a session) do*)
        WHILE NOT(SESSION_ENDING IN NET_STATUS) DO
           BEGIN
         (*If [it is a valid file id] then*)
           IF (FILE_ID IN VALID_FILE_IDS) THEN
            (**Transfer the file*)
              BEGIN
            (*Read in a line from the disk*)
              DISK.READ (FILE_LU [FILE_ID], TEXT, OP_STATUS);
            (*While not [end of file] do*)
              WHILE (OP_STATUS.DI = 0) AND (OP_STATUS.DD = 0) DO
                 BEGIN
                (*Send it out on the network*)
                  OS.NET_WRITE (TEXT, IMMEDIATE, SECRET,
                    NET_STATUS);
                  ERROR.REPORT ('SERVER 20          ',
                    NET_STATUS);
                (*Read in a new line from the disk file*)
                  DISK.READ (FILE_LU [FILE_ID], TEXT, OP_STATUS)
                  END;
            (*Endwhile*)
```

```
                    (*$$$   SERVER4   $$$*)
          (*$$$ Net4 Server application process $$$*)


            (*Rewind the disk file*)
              DISK.REWIND (FILE_LU [FILE_ID], OP_STATUS);
            (*Send an EOF packet out on the network*)
              OS.NET_WRITE ('/*                    ',
               IMMEDIATE, PUBLIC, NET_STATUS);
              ERROR.REPORT ('SERVER 30             ',NET_STATUS);
              END
          (*Else (an invalid file id)*)
            ELSE
             (*Send an error message*)
              BEGIN
              TEXT := '/*  BAD FILE ID -   ';
              TEXT [19] := FILE_ID;
              OS.NET_WRITE (TEXT,IMMEDIATE,PUBLIC,NET_STATUS);
              ERROR.REPORT ('SERVER 40             ',NET_STATUS);
              END;
          (*Endif*)
          (*Get the next request from the net*)
            OS.NET_READ (TEXT, NET_STATUS);
            FILE_ID := TEXT [1];
            ERROR.REPORT ('SERVER 50           ', NET_STATUS)
            END
       (*Endwhile*)
    (*End cycle*)
      END
(*End Server*)
  END;
```

Appendix B

S T E R L I N G ' S

P R O T O C O L S

Introduction

This appendix presents the protocol specifications of the various layers of STERLING, describing them as finite state automata with variables. The behaviors of these automata, interacting with identical machines representing the peer layers, specifies the layers' protocols.

To aid the student with de-bugging modifications to STERLING, packet fields not essential to the automation are included in the specifications. It must be noted, however, that the inclusion of these fields defeats some of the advantages of layering, in regards to the documentation.

Layer: BLACKBOX

Initial State: BLOCKED

Packet Received (from host):

Direction: OUTGOING

Text: <any message>

Packet Delivered (to next node):

Direction: INCOMING

Text: <unchanged>

Resulting State: BLOCKED

Explanation:

The Blackbox receives a packet from the host, changes its direction flag, then sends it to the next node of the network.

Layer: BLACKBOX

Initial State: BLOCKED

Packet Received (from prior node):

Direction: INCOMING

Text: <any message>

Packet Delivered (to host):

Direction: <unchanged>

Text: <unchanged>

Resulting State: BLOCKED

Explanation:

The Blackbox receives a packet from the network and passes it up to its host.

Layer: PRESENTATION

Initial State: BLOCKED

Packet Received (from host):

Direction: OUTGOING

Security: SECRET

Text: <message with host delimiter>

Packet Delivered (to network):

Direction: <unchanged>

Security: <unchanged>

File_Format: CR_DELIM or NL_DELIM (host delimiter)

Text: <encrypted message with host delimiter>

Resulting State: BLOCKED

Explanation:

The Presentation layer receives a packet from the Application layer with a request for encrypted transmission. It encrypts the message, sets the file format field to indicate which record delimiter is used, and sends the packet to the net. The file_format field does not have a valid value until the field is set by the Presentation layer.

Layer: PRESENTATION

Initial State: BLOCKED

Packet Received (from host):

Direction: OUTGOING

Security: PUBLIC

Text: <message with host delimiter>

Packet Delivered (to network):

Direction: <unchanged>

Security: <unchanged>

File_Format: CR_DELIM or NL_DELIM (host delimiter)

Text: <unchanged>

Resulting State: BLOCKED

Explanation:

The Presentation layer receives a transmission packet from the Application layer. It sets the file format field to indicate which record delimiter is used, and sends the packet to the network. The file_format field does not have a valid value until the field is set by the Presentation layer.

Layer: PRESENTATION

Initial State: BLOCKED

Packet Received (from network):

Direction: INCOMING

Security: SECRET

File Format: CR_DELIM or NL_DELIM (source delimiter)

Text: <encrypted message with source delimiter>

Packet Delivered (to host):

Direction: <unchanged>

Security: PUBLIC

File_Format: CR_DELIM or NL_DELIM (host delimimiter)

Text: <message with host delimiter>

Resulting State: BLOCKED

Explanation:

The Presentation layer receives a packet that is labeled secret from the network. It decrypts the message, makes sure the record delimiter is compatible with its host, and sends the message to the Application layer.

Layer: PRESENTATION

Initial State: BLOCKED

Packet Received (from network):

Direction: INCOMING

Security: PUBLIC

File Format: CR_DELIM or NL_DELIM (source delimiter)

Text: <message with source delimiter>

Packet Delivered (to host):

Direction: <unchanged>

Security: <unchanged>

File_Format: CR_DELIM or NL_DELIM (host delimiter)

Text: <message with host delimiter>

Resulting State: BLOCKED

Explanation:

The Presentation layer receives a packet from the network. It makes sure the record delimiter is compatible with its host, and sends the message to the Application layer.

Layer: APPLICATION

Initial State: ACTIVE

Network Call: NET_LISTEN

Packet Delivered (to network):

Direction: OUTGOING

Security: PUBLIC

Priority: HIGH_PRI

Session_Cmd: LISTEN

Text: ' '

Resulting State BLOCKED

Explanation:

The Application layer issues a packet commanding the Session layer to listen for a session request from the network.

- N E T 3 -

Layer: APPLICATION

Initial State: ACTIVE

Network Call: MAKE_SESSION

Packet Delivered (to network):

Direction: OUTGOING

Security: PUBLIC

Priority: HIGH_PRI

Session_Cmd: ESTABLISH

Status: []

Text: <destination password>

Resulting State: BLOCKED

Explanation:

The Application layer issues a packet commanding the Session layer to request a session on the network.

Layer: APPLICATION

Initial State: ACTIVE

Network Call: CLEAR_SESSION

Packet Delivered (to network):

Direction: OUTGOING

Security: PUBLIC

Priority: LOW_PRI

Session_Cmd: BREAK

Status: []

Text: ' '

Resulting State: BLOCKED

Explanation:

The Application layer issues a packet commanding the Session layer to terminate its session.

Layer: APPLICATION

Initial State: ACTIVE

Network Call: NET_READ

Resulting State: BLOCKED

Explanation:

The Application layer is attempting to receive a packet from its session.

Layer: APPLICATION

Initial State: ACTIVE

Network Call: NET_WRITE

Packet Delivered (to network):

Direction: OUTGOING

Security: SECRET or PUBLIC (application program's option)

Priority: MED_PRI

Session_Cmd: IMMEDIATE, CHAIN, END_CHAIN, or ABORT_CHAIN
(application program's option)

Status: []

Text: <message with host delimiter>

Resulting State: BLOCKED

Explanation:

The Application layer is attempting to send a message on the network.

Layer: SESSION

Initial State: NO_SESSION

Packet Received (from host):

Direction: OUTGOING

Security: PUBLIC

File_Format: CR_DELIM or NL_DELIM (host delimiter)

Priority: HIGH_PRI

Session_Cmd: LISTEN

Status: []

Text: ' '

Resulting State: LISTENING

Explanation:

The Session layer receives a packet from the Application layer asking it to listen for a session request. The Session layer goes into a listening state and waits for a request to arrive.

Layer: SESSION

Initial State: NO_SESSION

Packet Received (from host):

Direction: OUTGOING

Security: PUBLIC

File_Format: CR_DELIM or NL_DELIM (host delimiter)

Priority: HIGH_PRI

Session_Cmd: ESTABLISH

Status: []

Text: <destination password>

Packet Delivered (to network):

Direction: <unchanged>

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: REQUEST

Status: <unchanged>

Text: <unchanged>

Resulting State: REQUESTING

Explanation:

The Session layer receives a packet from the Application

layer asking it to establish a session with a remote site. The Session layer goes into the requesting state and sends a request onto the network.

Layer: SESSION

Initial State: REQUESTING

Packet Received (from network):

Direction: INCOMING

Security: PUBLIC

File_Format: CR_DELIM or NL_DELIM (host delimiter)

Priority: HIGH_PRI

Session_Cmd: START

Status: []

Text: <source password>

Packet Delivered (to host):

Direction: <unchanged>

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: <unchanged>

Status: <unchanged>

Text: <unchanged>

Resulting State: IN_SESSION

Explanation:

The Session layer receives a start signal from its peer

session. The Session layer sends this packet to its Application layer, unblocking it, and goes to an in-session state. The file_format and text have these values because the packet was echoed by the source's Session layer.

Layer: SESSION

Initial State: REQUESTING

Packet Received (from network):

Direction: INCOMING

Security: PUBLIC

File_Format: CR_DELIM or NL_DELIM (host delimiter)

Priority: HIGH_PRI

Session_Cmd: BREAK

Status: + [BAD_PASSWORD]

Text: <incorrect password>

Packet Delivered (to host):

Direction: <unchanged>

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: <unchanged>

Status: + [BAD_PASSWORD, SESSION_ENDING]

Text: <incorrect password>

Resulting State: NO_SESSION

Explanation:

The Session layer receives a packet from its peer

rejecting its request for a session. It resumes a no-session state and sends the rejection packet to its Application layer to unblock it. The file_format and text have these values because the packet was echoed by the source's Session layer.

Layer: SESSION

Initial State: LISTENING

Packet Received (from network):

Direction: INCOMING

Security: PUBLIC

File_Format: CR_DELIM or NL_DELIM (source delimiter)

Priority: HIGH_PRI

Session_Cmd: REQUEST

Status: []

Text: <host password>

Packet Delivered (to host):

Direction: <unchanged>

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: START

Status: <unchanged>

Text: <unchanged>

Packet Delivered (to network):

Direction: OUTGOING

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: START

Status: <unchanged>

Text: <unchanged>

Resulting State: IN_SESSION

Explanation:

The Session layer, while waiting for a session request, receives one with a valid password. It sends back a session start packet to its peer session, and a copy of the packet to its Application layer to unblock it. The Session layer is now in-session.

Layer: SESSION

Initial State: LISTENING

Packet Received (from network):

Direction: INCOMING

Security: PUBLIC

File_Format: CR_DELIM or NL_DELIM (source delimiter)

Priority: HIGH_PRI

Session_Cmd: REQUEST

Status: []

Text: <incorrect password>

Packet Delivered (to network):

Direction: OUTGOING

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: BREAK

Status: + [BAD_PASSWORD]

Text: <unchanged>

Resulting State: LISTENING

Explanation:

The Session layer, while waiting for a session request,

receives one with an invalid password. It sends back a rejection packet to the originator of the request and remains in a listening state.

Layer: SESSION

Initial State: IN_SESSION

Packet Received (from host):

Direction: OUTGOING

Security: SECRET or PUBLIC (application program's option)

File_Format: CR_DELIM or NL_DELIM (host delimiter)

Priority: MED_PRI

Session_Cmd: IMMEDIATE, CHAIN, END_CHAIN, or ABORT_CHAIN

Status: []

Text: <any message>

Packet Delivered (to network):

Direction: <unchanged>

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: <unchanged>

Status: <unchanged>

Text: <unchanged>

Packet Delivered (to host):

Direction: INCOMING

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: <unchanged>

Status: <unchanged>

Text: <unchanged>

Resulting State: IN_SESSION

Explanation:

The Session layer receives a data packet from the Application layer. It transparently passes the packet to the network and sends a copy back to the Application layer indicating a sucessful transfer.

Layer: SESSION

Initial State: IN_SESSION

Packet Received (from host):

Direction: OUTGOING

Security: SECRET or PUBLIC (application program's option)

File_Format: CR_DELIM or NL_DELIM (host delimiter)

Priority: LOW_PRI

Session_Cmd: BREAK

Status: []

Text: ' '

Packet Delivered (to network):

Direction: <unchanged>

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: <unchanged>

Status: <unchanged>

Text: <unchanged>

Packet Delivered (to host):

Direction: INCOMING

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: <unchanged>

Status: + [SESSION_ENDING]

Text: <unchanged>

Resulting State: NO_SESSION

Explanation:

The Session layer receives a command from the Application layer to terminate the session. It sends the termination command on the network to its peer session and sends a copy of the packet to the Application layer to indicate a sucessful termination.

Layer: SESSION

Initial State: IN_SESSION

Packet Received (from network):

Direction: INCOMING

Security: PUBLIC

File_Format: CR_DELIM or NL_DELIM (source delimiter)

Priority: LOW_PRI

Session_Cmd: BREAK

Status: []

Text: ' '

Packets Delivered (to host from chain buffer):

Direction: INCOMING

Security: SECRET or PUBLIC (sender's option)

File_Format: CR_DELIM or NL_DELIM (source delimiter)

Priority: MED_PRI

Session_Cmd: CHAIN

Status: []

Text: <any message>

Packet Delivered (to host):

Direction: <unchanged>

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Status: + [SESSION_ENDING]

Text: <unchanged>

Explanation:

The Session layer receives a packet from the network commanding it to terminate the session. It sends all messages it had stored in the chain buffer to the Application layer, then follows them with the termination packet.

Layer: SESSION

Initial State: IN_SESSION

Packet Received (from network):

Direction: INCOMING

Security: PUBLIC

File_Format: CR_DELIM or NL_DELIM (source delimiter)

Priority: HIGH_PRI

Session_Cmd: REQUEST

Status: []

Text: <host password>

Packet Delivered (to network):

Direction: OUTGOING

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: BREAK

Status: + [BUSY]

Text: <unchanged>

Resulting State: IN_SESSION

Explanation:

The Session layer is already involved in a session when

it receives a request for a session from another process. It refuses the request and remains in its original session.

Layer: SESSION

Initial State: IN_SESSION

Packet Received (from network):

Direction: INCOMING

Security: SECRET or PUBLIC (sender's option)

File_Format: CR_DELIM or NL_DELIM (source delimiter)

Priority: MED_PRI

Session_Cmd: IMMEDIATE

Status: []

Text: <any message>

Packet Delivered (to host):

Direction: <unchanged>

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: <unchanged>

Status: <unchanged>

Text: <unchanged>

Resulting State: IN_SESSION

Explanation:

The layer receives a data transfer packet from the

network with an IMMEDIATE command and transparently forwards it to the Application layer.

Layer: SESSION

Initial State: IN_SESSION

Packet Received (from network):

Direction: INCOMING

Security: SECRET or PUBLIC (sender's option)

File_Format: CR_DELIM or NL_DELIM (source delimiter)

Priority: MED_PRI

Session_Cmd: CHAIN

Status: []

Text: <any message>

Resulting State: IN_SESSION

Explanation:

The layer receives a data packet with a command that it be chained, and it quarantines the packet in a buffer.

Layer: SESSION

Initial State: IN_SESSION

Packet Received (from network):

Direction: INCOMING

Security: SECRET or PUBLIC (sender's option)

File_Format: CR_DELIM or NL_DELIM (source delimiter)

Priority: MED_PRI

Session_Cmd: END_CHAIN

Status: []

Text: <any message>

Packets Delivered (to host from chain buffer):

Direction: INCOMING

Security: SECRET or PUBLIC (sender's option)

File_Format: CR_DELIM or NL_DELIM (source delimiter)

Priority: MED_PRI

Session_Cmd: CHAIN

Status: []

Text: <any message>

Packet Delivered (to host):

Direction: <unchanged>

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Status: <unchanged>

Text: <unchanged>

Resulting State: IN_SESSION

Explanation:

The layer receives a data transfer packet with an END_CHAIN command. It sends all messages in the chain buffer to the Application layer and follows them with the new packet.

Layer: SESSION

Initial State: IN_SESSION

Packet Received (from network):

Direction: INCOMING

Security: SECRET or PUBLIC (sender's option)

File_Format: CR_DELIM or NL_DELIM (source delimiter)

Priority: MED_PRI

Session Cmd: ABORT_CHAIN

Status: []

Text: <any message>

Resulting State: IN_SESSION

Explanation:

The layer receives a packet from the network with an ABORT_CHAIN command. It emptys the chain buffer and discards the packet.

Layer: APPLICATION (revised)

Initial State: ACTIVE

Network Call: MAKE_SESSION

Packet Delivered (to network):

Direction: OUTGOING

Security: PUBLIC

Priority: HIGH_PRI

Session_Cmd: ESTABLISH

Name: <destination name>

Status: []

Text: <destination password>

Resulting State: BLOCKED

Explanation:

The Application layer issues a packet commanding the Session layer to request a session on the network. The name of the destination is included to allow the Transport layer to look up the destination address.

Layer: SESSION (revised)

Initial State: NO_SESSION

Packet Received (from host):

Direction: OUTGOING

Security: PUBLIC

File_Format: CR_DELIM or NL_DELIM (host delimiter)

Priority: HIGH_PRI

Session_Cmd: ESTABLISH

Name: <destination name>

Status: []

Text: <destination password>

Packet Delivered (to network):

Direction: <unchanged>

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: REQUEST

Name: <unchanged>

Trans_Cmd: CONNECT

Status: <unchanged>

Text: <unchanged>

Resulting State: REQUESTING

Explanation:

The Session layer receives a packet from the Application layer asking it to establish a session with a remote site. The Session layer goes into the requesting state and commands the Transport layer to make a connection and deliver the request across the network. The trans_cmd field does not have a valid value until it is set by the Session layer.

Layer: SESSION (revised)

Initial State: LISTENING

Packet Received (from network):

Direction: INCOMING

Security: PUBLIC

File_Format: CR_DELIM or NL_DELIM (source delimiter)

Priority: HIGH_PRI

Session_Cmd: REQUEST

Name: 'GOT AN INQUIRE '

Status: []

Text: <host password>

Packet Delivered (to network):

Direction: OUTGOING

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: START

Name: 'SESSION STARTS '

Trans_Cmd: DATA_XFER

Status: <unchanged>

Text: <unchanged>

Resulting State: IN_SESSION

Explanation:

The Session layer, while waiting for a session request, receives one with a valid password. It commands the Transport layer to deliver a session start packet to its peer session. The Application layer will be unblocked by the Transport layer's ACK. The Session layer is now in-session. The trans_cmd field does not have a valid value until it is set by the Session layer.

Layer: SESSION (revised)

Initial State: LISTENING

Packet Received (from network):

Direction: INCOMING

Security: PUBLIC

File_Format: CR_DELIM or NL_DELIM (source delimiter)

Priority: HIGH_PRI

Session_Cmd: REQUEST

Name: 'GOT AN INQUIRE '

Status: []

Text: <incorrect password>

Packet Delivered (to network):

Direction: OUTGOING

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: BREAK

Name: 'BAD PASSWORD '

Trans_Cmd: DISCONNECT

Status: + [BAD_PASSWORD]

Text: <unchanged>

Resulting State: LISTENING

Explanation:

The Session layer, while waiting for a session request, receives one with a invalid password. It commands the Transport layer to deliver a rejection packet to its peer session and remains in a listening state.

Layer: SESSION (revised)

Initial State: IN_SESSION

Packet Received (from host):

Direction: OUTGOING

Security: SECRET or PUBLIC (application program's option)

File_Format: CR_DELIM or NL_DELIM (host delimiter)

Priority: MED_PRI

Session_Cmd: IMMEDIATE, CHAIN, END_CHAIN, or ABORT_CHAIN

Name: 'APPLI CMD WRITE '

Status: []

Text: <any message>

Packet Delivered (to network):

Direction: <unchanged>

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: <unchanged>

Name: <unchanged>

Trans_Cmd: DATA_XFER

Status: <unchanged>

Text: <unchanged>

Resulting State: IN_SESSION

Explanation:

The Session layer receives a data packet from the Application layer. It transparently passes the packet to the Transport layer as a data transfer. The Transport layer's ACK will unblock the Application layer.

Layer: SESSION (revised)

Initial State: IN_SESSION

Packet Received (from host):

Direction: OUTGOING

Security: SECRET or PUBLIC (application program's option)

File_Format: CR_DELIM or NL_DELIM (host delimiter)

Priority: LOW_PRI

Session_Cmd: BREAK

Name: 'APPLI CMD CLEAR SESS'

Status: []

Text: ' '

Packet Delivered (to network):

Direction: <unchanged>

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Name: 'SESSION ENDING '

Session_Cmd: BREAK

Trans_Cmd: DISCONNECT

Status: <unchanged>

Text: <unchanged>

Packet Delivered (to host):

Direction: INCOMING

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Name: 'SESSION ENDING '

Status: + [SESSION_ENDING]

Text: <unchanged>

Resulting State: NO_SESSION

Explanation:

The Session layer receives a command from the Application layer to terminate the session. It sends the termination command on the network to its peer session piggy-backed on a Transport disconnect and sends a copy of the packet to the Application layer to indicate a sucessful termination.

Layer: TRANSPORT

Initial State: NOT_CONNECTED

Packet Received (from host):

Direction: OUTGOING

Security: PUBLIC

File_Format: CR_DELIM or NL_DELIM (host delimiter)

Priority: HIGH_PRI

Session_Cmd: REQUEST

Name: <destination name>

Trans_Cmd: CONNECT

Status: []

Text: <destination password>

Packet Delivered (to network):

Direction: <unchaged>

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: <unchanged>

Name: 'TRANS INQUIRE '

Trans_Cmd: INQUIRE

S_Connum: <local connection number>

D_Connum: 0

Source: <host address>

Destination: <remote address>

Status: <unchanged>

Text: <unchanged>

Resulting State: CONNECTING

Explanation:

The Transport layer receives a command to establish a connection with a remote site. It sets up a connection management data structure and issues the inquiry to the remote site. The destination's connection number is not yet known, so the d_connum field has no meaning.

Layer: TRANSPORT

Initial State: NOT_CONNECTED

Packet Received (from host):

Direction: OUTGOING

Security: PUBLIC

File_Format: CR_DELIM or NL_DELIM (host delimiter)

Priority: HIGH_PRI

Session_Cmd: REQUEST

Name: <illegal name>

Trans_Cmd: CONNECT

Status: []

Text: <destination password>

Packet Delivered (to host):

Direction: INCOMING

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: BREAK

Name: 'ERROR MSG NO HOST '

Status: + [NO_SUCH_HOST]

Text: <unchanged>

Resulting State: NOT_CONNECTED

Explanation:

The Transport layer receives a command to establish a connection with a remote site. It is unable to find an address for the destination, so it sends back an error packet.

Layer: TRANSPORT

Initial State: NOT_CONNECTED

Packet Received (from network):

Direction: INCOMING

Security: PUBLIC

File_Format: CR_DELIM or NL_DELIM (source delimiter)

Priority: HIGH_PRI

Session_Cmd: REQUEST

Name: 'TRANS INQUIRE '

or 'ANOTHER INQUIRY '

Trans_Cmd: INQUIRE

S_Connum: <source connection number>

D_Connum: 0

Source: <remote address>

Destination: <host address>

Status: []

Text: <host password>

Packet Delivered (to network):

Direction: OUTGOING

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: <unchanged>

Name: 'ACCEPTANCE '

Trans_Cmd: ACCEPT

S_Connum: <local connection number>

D_Connum: <remote connection number>

Source: <host address>

Destination: <remote address>

Status: <unchanged>

Text: <unchanged>

Packet Delivered (to host):

Direction: INCOMING

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: <unchanged>

Name: 'GOT AN INQUIRE '

Status: <unchanged>

Text: <unchanged>

Resulting State: IN_CONNECTION

Explanation:

The Transport layer receives a connection inquiry. It agrees to the connection and sends packets to the host and to the source of the inquiry.

Layer: TRANSPORT

Initial State: CONNECTING

Packet Received (from net):

Direction: INCOMING

Security: PUBLIC

File_Format: <host delimiter>

Priority: HIGH_PRI

Session_Cmd: REQUEST

Name: 'ACCEPTANCE '

Trans_Cmd: ACCEPT

S_Connum: <remote connection number>

D_Connum: <host connection number>

Source: <remote address>

Destination: <host address>

Status: []

Text: <source password>

Resulting State: IN_CONNECTION

Explanation:

The Transport layer receives a packet accepting its connection inquiry. It completes the connection management data structure and goes to the in-connection state. The file_format, session_cmd, and text fields have these values

because the packet was echoed by the source's Transport layer.

Layer: TRANSPORT

Initial State: CONNECTING

Packet Received (from network):

Direction: INCOMING

Security: PUBLIC

File_Format: CR_DELIM or NL_DELIM (host delimiter)

Priority: HIGH_PRI

Session_Cmd: REQUEST

Name: 'CAN NOT TALK TO YOU '

Trans_Cmd: DISCONNECT

S_Connum: <remote connection number>

D_Connum: <host connection number>

Source: <remote address>

Destination: <host address>

Status: []

Text: <source password>

Packet Delivered (to host):

Direction: <unchanged>

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: BREAK

Name: 'RECEIVED DISCONNECT '

Status: <unchanged>

Text: <unchanged>

Resulting State: NOT_CONNECTED

Explanation:

The Transport layer attempts to make a connection with a peer layer that is already connected. It passes the rejection packet to the host and resumes a not-connected state. The file_format and text have these values because the packet was echoed by the source's Transport layer.

Layer: TRANSPORT

Initial State: CONNECTING

Packet Received (from time-out):

Direction: INCOMING

Priority: HIGH_PRI

Name: 'THIS IS A TIME OUT '

Trans_Cmd: T_O_ACCEPT

Status: []

Packet Delivered (to net):

Direction: OUTGOING

Security: PUBLIC

File_Format: CR_DELIM or NL_DELIM (host delimiter)

Priority: <unchanged>

Session_Cmd: REQUEST

Name: 'ANOTHER INQUIRY '

Trans_Cmd: INQUIRE

S_Connum: <host connection number>

D_Connum: 0

Source: <host address>

Destination: <remote address>

Status: <unchanged>

Text: <destination password>

Resulting State: CONNECTING

Explanation:

The Transport layer is timed out while waiting for a response from its peer layer, so it sends another connection inquiry.

Layer: TRANSPORT

Initial State: IN_CONNECTION

Packet Received (from host):

Direction: OUTGOING

Security: PUBLIC

File_Format: CR_DELIM or NL_DELIM (host delimiter)

Priority: LOW_PRI

Session_Cmd: BREAK

Name: 'SESSION ENDING '

Trans_Cmd: DISCONNECT

Status: []

Text: '

Packet Delivered (to network):

Direction: <unchanged>

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: <unchanged>

Name: 'DISCONNECTING YOU '

Trans_Cmd: DISCONNECT

S_Connum: <host connection number>

D_Connum: <remote connection number>

Source: <host address>

Destination: <remote address>

Status: <unchanged>

Text: <unchanged>

Resulting State: Not_Connected

Explanation:

The Transport layer receives a disconnect packet from its host and breaks the connection.

Layer: TRANSPORT

Initial State: IN_CONNECTION

Packet Received (from host):

Direction: OUTGOING

Security: SECRET or PUBLIC (application program's option)

File_Format: CR_DELIM or NL_DELIM (host delimiter)

Priority: HIGH_PRI or MED_PRI

Session_Cmd: START, IMMEDIATE, CHAIN, END_CHAIN, or
ABORT_CHAIN

Name: 'APPLI CMD WRITE ' or 'SESSION STARTS '

Trans_Cmd: DATA_XFER

Status: []

Text: <any message>

Packet Delivered (to net):

Direction: <unchanged>

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: <unchanged>

Name: 'DATA TRANSFER '

Trans_Cmd: <unchanged>

S_Connum: <host connection number>

D_Connum: <remote connection number>

Source: <host address>

Destination: <remote address>

Data_Seq: <current sequence number>

Status: <unchanged>

Text: <unchanged>

Resulting State: IN_CONNECTION

Explanation:

The Transport layer receives a data transfer packet from its host and sends it on the network connection.

Layer: TRANSPORT

Initial State: IN_CONNECTION

Packet Received (from network):

Direction: INCOMING

File_Format: CR_DELIM or NL_DELIM (source delimiter)

Priority: LOW_PRI

Session_Cmd: BREAK

Name: 'DISCONNECTING YOU '

Trans_Cmd: DISCONNECT

S_Connum: <remote connection number>

D_Connum: <host connection number>

Source: <remote address>

Destination: <host address>

Status: []

Text: ' '

Packet Delivered (to host):

Direction: <unchanged>

File_Format: <unchanged>

Priority: <unchanged.

Session_Cmd: <unchanged>

Name: 'WAS DISCONNECTED '

Status: <unchanged>

Text: <unchanged>

Resulting State: NOT_CONNECTED

Explanation:

The Transport layer is disconnected by its peer layer. It passes the disconnect packet to the host and goes to a not-connected state.

Layer: TRANSPORT

Initial State: IN_CONNECTION

Packet Received (from network):

Direction: INCOMING

Security: PUBLIC

File_Format: CR_DELIM or NL_DELIM (source delimiter)

Priority: HIGH_PRI

Session_Cmd: REQUEST

Name: 'TRANS INQUIRE ' or 'ANOTHER INQUIRY '

Trans_Cmd: INQUIRE

S_Connum: <incorrect remote connection number>

D_Connum: 0

Source: <incorrect remote address>

Destination: <host address>

Status: []

Text: <host password>

Packet Delivered (to network):

Direction: OUTGOING

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: <unchanged>

Name: 'CAN NOT TALK TO YOU '

Trans_Cmd: DISCONNECT

S_Connum: <unchanged>

D_Connum: <unchanged>

Source: <host address>

Destination: <originating address>

Status: + [BUSY]

Text: <unchanged>

Resulting State: IN_CONNECTION

Explanation:

The Transport layer receives an inquiry while it is already connected to a different process and sends back a busy signal.

Layer: TRANSPORT

Initial State: IN_CONNECTION

Packet Received (from network):

Direction: INCOMING

Security: PUBLIC

File_Format: CR_DELIM or NL_DELIM (source delimiter)

Priority: HIGH_PRI

Session_Cmd: REQUEST

Name: 'ANOTHER INQUIRY '

Trans_Cmd: INQUIRE

S_Connum: <current remote connection number>

D_Connum: 0

Source: <current remote address>

Destination: <host address>

Status: []

Text: <host password>

Packet Delivered (to network):

Direction: OUTGOING

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: <unchanged>

Name: 'ANOTHER ACCEPT '

Trans_Cmd: ACCEPT

S_Connum: <host connection number>

D_Connum: <remote connection number>

Source: <host address>

Destination: <remote address>

Status: <unchanged>

Text: <unchanged>

Resulting State: IN_CONNECTION

Explanation:

The Transport layer's peer process timed out waiting for an accept and issued another inquiry. The Transport layer returns another accept and remains in-connection.

Layer: TRANSPORT

Initial State: IN_CONNECTION (waiting-for-ack)

Packet Received (from network):

Direction: INCOMING

Security: PUBLIC or SECRET (sender's option)

File_Format: CR_DELIM or NL_DELIM (source delimiter)

Priority: HIGH_PRI or MED_PRI

Session_Cmd: START, IMMEDIATE, CHAIN, END_CHAIN, or ABORT_CHAIN

Name: 'DATA TRANSFER ' or 'DIDNT GET ACK REXMIT'

Trans_Cmd: DATA_XFER

S_Connum: <remote connection number>

D_Connum: <host connection number>

Source: <remote address>

Destination: <host address>

Data_Seq: <any>

Status: []

Text: <any message>

Explanation:

The Transport layer is waiting for an acknowlegment of its last data transfer but, instead, receives a data transfer from its peer layer. The Transport layer cannot pass the incoming data to its host, because the Application

layer is blocked waiting for the acknowlegment, so it discards the new packet. NOTE: Waiting for the acknowlegment of a data transmission could be implemented as another state for the Transport layer, but for historical reasons it was implemented with a Boolean variable.

Layer: TRANSPORT

Initial State: IN_CONNECTION (Not waiting-for-ack)

Packet Received (from network):

Direction: INCOMING

Security: PUBLIC or SECRET (sender's option)

File_Format: CR_DELIM or NL_DELIM (source delimiter)

Priority: HIGH_PRI or MED_PRI

Session_Cmd: START, IMMEDIATE, CHAIN, END_CHAIN, or ABORT_CHAIN

Name: 'DATA TRANSFER ' or 'DIDNT GET ACK REXMIT'

Trans_Cmd: DATA_XFER

S_Connum: <remote connection number>

D_Connum: <host connection number>

Source: <remote address>

Destination: <host address>

Data_Seq: <correct>

Status: []

Text: <any message>

Packet Delivered (to host):

Direction: <unchanged>

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: <unchanged>

Name: 'DATA RECEIVED '

Status: <unchanged>

Text: <unchanged>

Packet Delivered (to net):

Direction: OUTGOING

Security: PUBLIC

File_Format: <unchanged>

Priority: HIGH_PRI

Session_Cmd: <unchanged>

Name: 'DATA ACK '

Trans_Cmd: DATA_ACK

S_Connum: <host connection number>

D_Connum: <destination connection number>

Source: <host address>

Destination: <remote address>

Data_Seq: <unchanged>

Status: []

Text: ' '

Resulting State: IN_CONNECTION

Explanation:

The Transport layer receives a data packet from the network, passes the packet to its host, and returns an

acknowlegment.

Layer: TRANSPORT

Initial State: IN_CONNECTION

Packet Received (from network):

Direction: INCOMING

Security: PUBLIC or SECRET (sender's option)

File_Format: CR_DELIM or NL_DELIM (source delimiter)

Priority: HIGH_PRI or MED_PRI

Session_Cmd: START, IMMEDIATE, CHAIN, END_CHAIN, or ABORT_CHAIN

Name: 'DIDNT GET ACK REXMIT'

Trans_Cmd: DATA_XFER

S_Connum: <remote connection number>

D_Connum: <host connection number>

Source: <remote address>

Destination: <host address>

Data_Seq: <incorrect>

Status: []

Text: <any message>

Packet Delivered (to net):

Direction: OUTGOING

Security: PUBLIC

File_Format: <unchanged>

Priority: HIGH_PRI

Session_Cmd: <unchanged>

Name: 'DATA ACK '

Trans_Cmd: DATA_ACK

S_Connum: <host connection number>

D_Connum: <destination connection number>

Source: <host address>

Destination: <remote address>

Data_Seq: <unchanged>

Status: []

Text: ' '

Explanation:

The Transport layer's peer process timed out waiting for an acknowlegment of a data transfer and sent the packet again. The Transport layer had already received the original data packet and had recognized the new packet as a duplicate because of the incorrect sequence number, so it re-transmitted an acknowlegment of the packet.

Layer: TRANSPORT

Initial State: IN_CONNECTION

Packet Received (from network):

Direction: INCOMING

Security: PUBLIC

File_Format: CR_DELIM or NL_DELIM (host delimiter)

Priority: HIGH_PRI

Session_Cmd: START, IMMEDIATE, CHAIN, END_CHAIN, or
ABORT_CHAIN (echo of data-xfer)

Name: 'DATA ACK '

Trans_Cmd: DATA_ACK

S_Connum: <remote connection number>

D_Connum: <host connection number>

Source: <remote address>

Destination: <host address>

Data_Seq: <correct>

Status: []

Text: ' '

Packet Delivered (to host):

Direction: <unchanged>

Security: <unchanged>

File_Format: <unchanged>

Priority: <unchanged>

Session_Cmd: IMMEDIATE

Name: 'RECEIVED AN ACK '

Status: <unchanged>

Text: <unchanged>

Resulting State: IN_CONNECTION

Explanation:

The Transport layer receives an acknowlegment of its last data transfer and passes it to its host to unblock the application layer.

Layer: TRANSPORT

Initial State: IN_CONNECTION

Packet Received (from time-out):

Direction: INCOMING

Priority: HIGH_PRI

Name: 'THIS IS A TIME OUT '

Trans_Cmd: T_O_DATA_ACK

Status: []

Packet Delivered (to net):

Direction: OUTGOING

Security: <repeat of last x-mit>

File_Format: <repeat of last x-mit>

Priority: <repeat of last x-mit>

Session_Cmd: <repeat of last x-mit>

Name: 'DIDNT GET ACK REXMIT'

Trans_Cmd: <repeat of last x-mit>

S_Connum: <host connection number>

D_Connum: <remote connection number>

Source: <host address>

Destination: <remote address>

Data_Seq: <current sequence number>

Status: <repeat of last x-mit>

Text: <repeat of last x-mit>

Resulting State: IN_CONNECTION

Explanation:

The Transport layer times out without receiving an acknowlegment of its last data transfer, so it re-transmits the packet.

STERLING: A PEDAGOGICAL IMPLEMENTATION OF THE ISO MODEL FOR OPEN SYSTEM INTERCONNECTION

by

Ronald Curtis Albury

B.S. Rochester Institute of Technology 1976

AN ABSTRACT OF A MASTER'S REPORT

Submitted in partial fulfillment of the

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MASTER OF SCIENCE

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1983

This report describes the design and implementation of ve programs which demonstrate some of the functions of a mputer network. The programs are patterned on the tarnational Standards Organization's (ISO) model for mputer interconnection and are intended to be used as an d in teaching that model to graduate level students. The ograms are fully documented and designed to be easily derstood and portable between machines. The report scusses the principles the ISO used in deriving its model d how those principles relate to the implementation's sign. The report restricts itself to the upper layers of e ISO model and concludes with the discussion of the ansport layer.