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SYSTEM ANALYSIS
FOR THE
HUNTSVILLE OPERATIONAL SUPPORT CENTER
DISTRIBUTED COMPUTER SYSTEM

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HUNTSVILLE OPERATIONAL SUPPORT CENTER
DISTRIBUTED COMPUTER SYSTEM Annual Report,
May 1982 - Jun. 1983 (Mississippi State
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ANNUAL REPORT
MSU-EIRS-EE-83-6
May 1982 - June 1983

Submitted by:
F. M. Ingels, Principal Investigator

Mississippi State University
Electrical Engineering Department
Mississippi State, MS 39762
(601) 325-3912

Submitted to:
NASA/MSFC, Alabama
Technical Monitor: Frank Emmens, EB 32.
(205) 453-4629

NASA-34906
July, 1983
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FOR THE
HUNTSVILLE OPERATIONAL SUPPORT CENTER
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NAS8-34906

July, 1983
The Huntsville Operations Support Center (HOSC) is a distributed computer system used to provide real time data acquisition, analysis and display during NASA space missions and to perform simulation and study activities during non-mission times. The primary purpose of this research is to provide a HOSC system simulation model that may be used to investigate the effects of various HOSC system configurations. Such a model would be valuable in planning the future growth of HOSC and in ascertaining the effects of data rate variations, update table broadcasting and smart display terminal data requirements on the HOSC HYPER channel network system.

A simulation model was developed and programmed in three languages BASIC, PASCAL, and SLAM. Two of the programs are included in this report, the BASIC and the PASCAL language programs. SLAM is not supported by NASA/MSFC facilities and hence was not included. The statistical comparison of simulations of the same HOSC system configurations are in good agreement and are in agreement with the operational statistics of HOSC that were obtained.

Three variations of the most recent HOSC configuration have been run and some conclusions drawn as to the system performance.
under these variations. Section 3.4 discusses these results and conclusions.
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1.0 INTRODUCTION

1.1 HOSC System Overview

Marshall Space Flight Center (MSFC), Huntsville, Alabama, has implemented the Huntsville Operations Support Center (HOSC) to provide real time data acquisition, analysis, and display during NASA space missions. The HOSC is a distributed computer system composed of a network of large minicomputers and various peripheral equipment. Primarily designed to provide support for the Space Shuttle, Space Telescope, and Space Laboratory missions, the HOSC has the inherent flexibility to be expanded to meet the needs of future missions as well as providing MSFC with a large computer resource that can be used to support several non-mission activities.

The HOSC facility has been structured to include five large minicomputers and various peripheral equipment. The current network computers are each semi-dedicated to specific mission tasks (e.g. Space Shuttle Main Engine Data Analysis) and include three Perkin Elmer 3244 computers, a Perkin Elmer 8/32c computer, two DEC VAX 11/780 computers and a DEC 11/24 computer. An important role of the Perkin Elmer computers is acting as real time data receivers for mission data arriving via satellite and direct ground links from the Kennedy Space Center Firing Room at Cape Canaveral FL. These computers also act as a gateway to the network for the data which is needed by other mission activities supported by the other computers and peripherals. Peripheral equipment in the system includes two twelve channel Genisco Digital Television (D/TV's), strip recorders, and numerous unintelligent data terminals.
Foreseeable future expansion will include at least five more minicomputers, many more D/TV displays (possibly to 50), several more strip recorders, and intelligent data terminals.

The HOSC currently provides support for MSFC non-mission activities such as the Total POCC Preplanning Activity with future expansion providing data management resources for other non-mission activities. These activities might include the DEC IGDS (interactive graphics) and XEROX SIGMA (text processing) operations. All of these activities would be permitted use of the network resources through the Network Systems Corporation HYPER channel broadband local area network.

1.2 Scope of Report

In order to achieve the flexibility and efficiency needed by the HOSC, an analysis of the present system has been performed. This analysis coupled with projected system growth will insure that the HOSC remains a viable computing resource for MSFC. This report contains a summary of the baseline data gathered to begin the analysis of the HOSC computer network, Section 2.0, results of the analysis, Section 3.0, and a literature/bibliography Section 4.0. The report describes in detail some of the network components and also makes first iteration recommendations concerning network operations. This document should not be considered an end item since work still remains to be done in completely characterizing all the subtleties of the HOSC system.
1.3 Conclusion

From the work done thus far in the program, several conclusions and recommendations can be made.

A. Proposed IGDS/SIGMA Interface With HOSC

Network Systems Corporation does not currently produce hardware for the HYPER channel to XEROX processor interface. Consequently, a great amount of effort would be required to interface the SIGMA system directly with the HOSC HYPER channel. A possible solution might be to interface the XEROX SIGMA to the network through a HYPER channel supported processor such as another DEC VAX. Feasibility of the VAX/XEROX interface has not been explored and may also present problems. A definite possibility to solve this problem is to develop a suitable software/hardware approach.

The DEC IGDS system interfaces with the HYPER channel and will present no obvious problems since the PDP-11 processor interface adapters are currently marketed by Network Systems Corporation.

B. CSO/HOSC Link Via HOSC HYPER Channel Adapter 4 For OF Data Exchange

The current plan is to interface CSO with HOSC using a separate trunk of adapter 4. By connecting the two installations with a separate trunk, CSO will be disallowed easy and immediate access to the HOSC resources on the HYPER channel. Because of the HYPER channel adapter design, direct trunk to trunk exchange of data is not possible. For trunk to trunk transfers, data from the initiating trunk must be channeled
through a processor on the common adapter and retransmitted by
the processor over the other trunk.\textsuperscript{2} It however, it is de-
sireable to prevent CSO from easy access to the total HOSC
resources, then the use of separate trunk is a good approach.

C. **Summary of Analysis Activity**

Progress on the analysis of HOSC has so far been steady
but somewhat slow due to the difficulty in obtaining some needed
baseline data. Below is a summary of the documentation ac-
cumulated to conduct the analysis effort.

. Perkin Elmer Corporation

3240 User's Manual 29-685
3240 Memory System Manual 29-688
8/32 User's Manual 29-394
8/32 Memory System Manual 29-428
(These manuals must contain the actual HOSC Computer
internal DMA to I/O setup.)

. Network Systems Corporation

PI40 Peripheral Interface Manual
(Perkin Elmer I/O Bus Interface)

PI10 PI Manual or PI11 PI Manual
(Dependent on configuration of PDP-11 IGDS
system: PI10 for DR11-B general purpose
direct memory access or PI11 for DR70
MASSBUS interface.)

NETEX Software Documentation

. Marshall Space Flight Center

Completed system computer data rate flows.
D. Effects of Data File Dumps

It is desired to make large data file transfers on a periodic basis to refresh the data display terminals database. This type of activity can create a log/jam effect on the most active data sources if the number of data bytes to be transferred are large enough to create waiting times. The basic relationship involves a tradeoff between the amount of storage of data by the data sources, their rate of data accumulation and the time required to transfer the data files.

This problem is discussed in Section 3.3 and 3.4 in detail.
2.0 HOSC SYSTLM DETAILS

The primary purpose of the Huntsville Operation Support Center is providing MSFC engineers with a near real time summary of vital information describing the operational status of certain components of the Space Shuttle during pre-launch and launch activities. This information allows MSFC engineers and contractor personnel to act in a support capacity to mission personnel at Kennedy Space Center (KSC), Cape Canaveral, Florida, and also Johnson Space Center (JSC), Houston, TX. MSFC support is provided by teams responsible for the Space Shuttle Main Engine (SSME), External Tanks (ET), Solid Rocket Boosters (SRB), Main Propulsion System (MPS) and the Range Safety System (RSS). Additional mission support is provided for various mission activities and programs that are the responsibility of MSFC personnel.

During powered flight, the HOSC will receive only data which is in the LPS (Launch Processing System) at KSC. The Shuttle support team will be in the HOSC during this phase of the mission and will be the point of contact with the JSC Mission Evaluation Room (MER) for problem discussion and resolution as required and will be on call during orbital operations. The Space Lab and experiment support team will be located in the HOSC during orbital operations when applicable.

Following completion of the active Shuttle vehicle support activities, data is recalled as required for more detailed analysis, and initial preparation is made to provide support to postflight evaluation.

The HOSC is located in the west end of A-wing, building 4663 on Martin Road, MSFC. Figures 1 and 2 show the functional components of the HOSC system and gives each component a referencing number that will be used in describing the system activities.
Figure 1. Original HOSC HYPER Channel Network Configuration
Figure 2. Proposed HYPER Channel Network Configuration
2.1 **HOSC System Activities**

In addition to the mission activities, the HOSC also provides support to several non-mission activities at MSFC. Details of all the HOSC activities are described below and summarized in Table 1.

2.1.1 **Total POCC Preplanning**

The POCC activity is an ongoing simulation activity for which the HOSC lends computer resources. This activity is in no way keyed to the real time mission activities and must be viewed as a continuous daily activity.

The POCC activity's impact on the HYPER channel network is basically that of continuous data transfers between the MIPS Primary Computer (VAX4, A400 Adapter 2) and the MIPS Backup Computer (VAX1, A400 Adapter 5). During each 24 hour period 150,000 512-byte blocks of data are transferred. Six times each day, an 8344 byte block is transferred (50,000 bytes cumulative). The remaining 100,000 512-byte blocks are transmitted randomly, but on an evenly distributed basis, throughout the day.

2.1.2 **ECIO Data Stream**

The POCC activity generates a continual 51.2 kilobit/second data stream known as the Experimental Computer Input/Output (ECIO) data stream. This data stream is ongoing and concurrent with the POCC activity. Data is transferred from MIPS Backup (VAX1, A400 Adapter 5) to the Spacelab 8/32 (PE 8/32c, A400 Adapter 1).
<table>
<thead>
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<th>TABLE 1. HOSC DATA TRANSFERS</th>
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I. ROUTINE DAILY ACTIVITIES (Launch Independent)

A. **Total POCC Preplanning Activity**
   - Resources involved: MIPS Primary (VAX4, Adapter 2)  
     MIPS Backup (VAX1, Adapter 5)
   - Quantity of data: 150,000 512-byte blocks daily

B. **ECIO Data Stream** (Generated by POCC)
   - Resources involved: MIPS Backup (VAX1, Adapter 5)  
     Spacelab 8/32 (PE 8/32c, Adapter 1)
   - Quantity of data: 51.2 K bits/second concurrent with POCC.

C. **IGDS/SIGMA Activity** (Proposed)
   - Resources Involved: DEC IGDS and XEROX SIGMA and communication with other resources as needed.
   - Quantity of data: TBD

II. LAUNCH DAY ACTIVITIES:

A. **Routine Daily Activities** (See Above)

B. **Main Engine Data**
   - Resources Involved: STS Primary (PE 3244, Adapter 1)  
     MIPS Backup (VAX1, Adapter 5)
   - Quantity of Data: 50 K bit/second stream (T-8 hours to T+12 minutes)

C. **OI Data Stream**
   - Resources Involved: FEB SSME (PE 3244, Adapter 4)  
     CSO Computers (Adapter 4)  
     STS Primary (PE 3244, Adapter 1)  
     MIPS Backup (VAX1, Adapter 5)
   - Quantity of Data: 128 K bit/second (T-9 sec to T+12 minutes)  
     into FEP and then to CSO. 40% will also be transferred to STS and MIPS.
TABLE 1. HOSC DATA TRANSFERS (Continued)

D. Engineering Display Changes

Resources Involved: STS Primary (PE 3244, Adapter 1)  
STS Backup (PE 8/32 Adapter 1)  
Spacelab 8/32 (PE 8/32, Adapter 1)

Quantity of Data: Insignificant
2.1.3 Main Engine Data

Space Shuttle Main Engine data is collected and disseminated at the HOSC during a launch day activity only. Data is funneled through the HYPER channel network to MIPS Backup (VAX1, A400 Adapter 5) via STS Primary (PE 3244, A400 Adapter 1). STS Primary accepts a continual 50 kilobit per second data stream directly from the KSC firing room from 9 seconds before launch to 12 minutes after launch (MECO). Approximately 24 percent of this 50 Kb/s stream (12 Kb/s) is transferred over the network to MIPS Backup.

2.1.4 OI Data Stream

The OI data stream is a 128 kilobit per second data stream arriving at FEP SSME (PE 3244, A400 Adapter 4) on launch day only (t-9 seconds to T+12 minutes). This data will have a much greater future impact on the network than it does currently. The SSME computer acts as a front end processor for accepting this data stream from Goddard Space Flight Center and then writes the received data directly onto a magnetic tape for later transport to CSO. Later in the program this data will be shipped in its entirety over a separate HYPER channel trunk attached to A400 Adapter 4 to CSO. Additionally, about 40 percent of the data stream will be shipped over the HOSC network to supply and supplant the data currently being transferred by the Main Engine Data Activity.

2.1.5 Engineering Display Changes

This activity adds almost insignificantly to the total HYPER channel trunk traffic. The activity involves a transfer from STS Primary to STS Backup and the Spacelab 8/32 (PE3244 to two PE8/32's,
A400 Adapter, 1 only) of the name of each engineering console
display format that is changed during the pre-launch and launch
activities (T-9 seconds to T+12 minutes). This activity will be
ignored in the HOSC system analysis due to its negligible contribution
to total HYPER channel system traffic.

2.1.6 Proposed Activities

The most immediate proposed expansion of the HOSC network would
allow two other non-mission activities access to the resources of
the HOSC network. This activity would specify an additional A400
Adapter to allow resource sharing with the XEROX SIGMA system and
the DEC PDP-11 IDGS system. Direct interface with the A400 is
available for the PDP-11 but not for the XEROX system. A possible
solution to allow the XEROX system access to the network through the
A400 might be to use a compatible computer such as a DEC VAX 11/780
as a front end processor for the XEROX system. This activity is
incompletely specified and will not affect the immediate analysis
of the HOSC system.

2.2 HOSC System Components

The heart of the HOSC system is the Network Systems Corporation
HYPER channel. The HYPER channel is a high speed digital communica-
tions facility that is used for interconnection of computer resources
in a computing installation. The following sections describe the
computer resources of the HOSC and how they are interconnected using
the HYPER channel.
2.2.1 Computer Resources

2.2.1.1 DEC VAX 11/780

The HOSC makes use of Digital Equipment Corporation's VAX 11/780 computer as computational devices. The system currently includes two VAX computers (VAX1 and VAX4) designated as MIPS Primary and MIPS Backup. Future expansion will add two other VAX computers (VAX2 and VAX3) designated as Software Development and Space Telescope.

VAX computers support a 32-bit work architecture that is designed to aid in system throughput. Data transfers are accomplished via a 32-bit high speed data structure. This structure ties together the central processor, main memory, the UNIBUS subsystem, the MASS BUS subsystem and the DR780 high speed direct memory access subsystem. The 32-bit word architecture of the VAX establishes a virtual address space of 4.3 billion bytes of user addressable memory. A conceptual diagram of the VAX 11/780 bus structure is shown in Figures 3 and 4.

The Synchronous Backplane Interface (SBI) is the data path that links the central processor, the memory subsystem and the hardware adapters provided for the UNIBUS and MASSBUS. When interfaced to the SBI, the memory subsystem, the central processor, and the I/O controllers are known as NEXUSs.

All NEXUSs receive every SBI transfer. Logic in each NEXUS determines whether the NEXUS is the designated receiver for this transfer. Data transfers can occur from

CPU to memory subsystem
I/O controller to memory subsystem
CPU to I/O controllers.
Figure 3. Block Diagram of VAX 11/780 Computer
Figure 4. Basic Bus Configuration of VAX 11/780

- CYCLE TIME
  - 800 NANO SEC PER 64 BIT WORD
  - 1400 NANO SEC PER 64 BIT WORD

- MEMORY

- CPU

- SYNCHRONOUS BACKPLANE INTERFACE

- MAX AGGREGATE I/O RATE 13.3 MB/SEC

- MASS BUS ADAPTER
  - 4 MAX

- UNIBUS ADAPTER
  - 1 STD
  - 4 MAX

- DR/780 ADAPTER
  - 1 OPTIONAL

- DR/780 DEVICES

- MASS BUS DEVICES

- UNIBUS DEVICES

- 1.5 MB/S

- 20 MB/S PER HBA (SYS-MAX=56MB/S)

- 6.6 MB/S MAX
The maximum, aggregate data transfer rate on the SBI is 13.3 megabytes per second which can be derived from the following information.

- 200 Nanoseconds/cycle = 5 million cycles/second
- Each cycle can carry an address (memory request) or for byte of data
- Thus, one cycle is used to request eight bytes of data (to be read or written), and two cycles are used to carry data (at four bytes/cycle).
- Five million cycles/second * 4 bytes/cycle = 20 million bytes/second
- 20 * 2/3 (1 of every 3 cycles is an address) = 13.3 million byte/second.4

The memory controller is the NEXUS used to interface the memory subsystem to the SBI. A system may have more than one memory controller as in the case of a two controller interleaved memory configuration.

The UNIBUS (UBUS) is a high speed asynchronous data system that allows communication between peripheral hardware and the VAX 11/780. The VAX 11/780 is capable of supporting 4 UBUS subsystems; one is standard with three more optional. The UBUS is connected to the SBI through a UBUS adapter (UBA) which performs priority arbitration among the devices on the UBUS. The primary functions of the UBA are to provide:
(1) Access to UBUS address space from the SBI
(2) Mapping of UBUS address to SBI addresses for UBUS
direct memory access (DMA) transfers to system memory.
(3) Data transfer paths for UNIBUS device access to random
SBI memory addresses and high speed transfer for devices
that transfer to consecutive increasing address.
(4) UNIBUS interrupt fielding
(5) UNIBUS priority arbitration.

All of these services are completely transparent to UBUS users.

The address mapping function is necessary because the UBUS has
only 18 data lines thus providing an apparent memory addressing
capability of $2^{18}$ or 200 kilobytes. The UBA, however, provides the
capability of mapping the UNIBUS addresses into SBI addresses so
that the full memory of the system can be accessed. (Full system
memory is 16 array boards of 256 kilobytes each for a total of 4
megabytes.)

The UBA accepts either of two forms of input from the UBUS:
hardware generated interrupt or direct memory access transfer. Each
device connected to the UBUS uses one of five priority levels for
requesting bus service. The NonProcessor Request (NPR) is used when
the device requests a direct access transfer to memory or some other
device and does not require processor intervention. A Bus Request
(BR) is used when the device wishes to interrupt the BPU for service.
Such service might be a CPU directed data transfer or the informing
of some error condition that exists at the peripheral. The NPR has
the highest priority with four levels of BR following (BR7-BR4).
Since there are only five priority levels and more than one device may be connected to a specific request level, if more than one device makes the same request, the device that is electrically closest to the UBS receives higher priority.

The Non Processor Request for direct memory access is a very important feature of the UBUS subsystem. These DMA transfers can be divided into two groups: random access of noncontiguous addresses and sequential access of sequentially increasing address. For random access, each UBUS transfer is made through the Direct Data Path (DDP, one per UNIBUS) and is mapped into an SBI transfer. This procedure allows only one word of data to be transferred during a single SBI cycle. For devices capable of requesting sequential access services, use is made of Buffered Data Path (BDP). Each UNIBUS provides 15 such BDPs. The BDP stores the data so that four UBUS transfers are performed for each SBI transfer.

The DDP must be used by devices not transferring to consecutive increasing addresses or by devices that mix read and write functions. The maximum throughput via the DDP is about 425 kilo words per second for write operations and 316 kilo words per second for each read operation. These rates will decrease as other SBI activity increases.4

Maximum published throughput via the BDP is about 695 kilo words per second for both read and write operations but actual expected throughput rates are only 1.5 mega bits per second. This rate will also decrease as other SBI activity increases.5 BDP transfers are
restricted to block transfers where a block is defined as equal to or greater than one byte. All transfers within the block must be to consecutive and increasing addresses and all transfers must be of the same function type (Read or Write).

The MASSBUS subsystem and the DR780 high performance 32-bit parallel interface will not be described in this report since an understanding of their functional characteristics is not needed to determine their relative impacts on the HYPER channel network. The influence of both may be felt indirectly, however, since activity on the MASSBUS or DR780 will translate to SBI activity which will affect DDP and BDP transfer rates as described previously.4

Likewise, the VAX CPU will not be described in detail but several comments may be made about the CPU's effects on throughput. The CPU represents the most intensive traffic load on the memory subsystem and hence on the SBI. Obviously if the processor is engaged in computing, it will request data much more often than it will write data. Fortunately the large memory cache (8 kilo bytes) available to the CPU reduces the SBI traffic load considerably.

In terms of the SBI traffic, impact on the processor's speed, published figures4 indicate that in a system with two memory controllers, the processor will be slowed about four percent per averaged megabyte per second of I/O traffic. The impact of a single memory controller is to slow the processor by a factor varying from two to four. Table 2 summarizes the DEC VAX 11/780 I/O characteristics.
TABLE 2. SUMMARY OF DEC VAX 11/780 DATA I/O CHARACTERISTICS

<table>
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<th>PROCESSOR</th>
<th>: 32 bit words</th>
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<tr>
<td>MAIN MEMORY</td>
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<tr>
<td>Virtual Address Space</td>
<td>4.3 billion bytes</td>
</tr>
<tr>
<td>Cycle Time</td>
<td>800 nanoseconds per 64-bit read</td>
</tr>
<tr>
<td></td>
<td>1400 nanoseconds per 64-bit write</td>
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I/O UNIBUS Adapter

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<th>Maximum UNIBUS I/O Rate</th>
<th>1.5 Mb/sec through buffered data paths.</th>
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<tbody>
<tr>
<td>Buffered Data Path</td>
<td>15 total, 8 byte buffer in each</td>
</tr>
<tr>
<td></td>
<td>695 K words/second for read operations</td>
</tr>
<tr>
<td></td>
<td>695 K words/second for write operations</td>
</tr>
<tr>
<td></td>
<td>Used for fast DMA transfers</td>
</tr>
<tr>
<td>*Direct Data Path</td>
<td>425 K words/second for write operation</td>
</tr>
<tr>
<td></td>
<td>116 K words/second for read operation</td>
</tr>
<tr>
<td></td>
<td>Used for transfers from non-consecutive memory locations.</td>
</tr>
</tbody>
</table>

All data rates subject to degradation as traffic on SBI increases.
(SBI allows communication interfaces between CPU, Memory, UNIBUS and MASSBUS.)

** Maximum aggregate throughputs on UNIBUS is only 1.5 Megabytes/second.**
2.2.1.2 Perkin Elmer 3244

The Perkin Elmer (PE) 3240 series computer is a high throughput machine with a 32 bit architecture. The HOSC currently uses two PE 3244 machines with primary responsibilities as front end processors (FEP) receiving real time data streams from the KSC firing room.

A block diagram of the 3240 model computer is shown in Figure 5. Detailed information regarding the 3244 has not been obtained but a brief description of the 3244 architectures follows.

The 3244 memory subsystem is organized into banks each capable of handling 4 megabytes of addressable memory. Total system memory ranges from 256 kilo bytes in one bank to a full system complement of four 4 megabyte banks for a maximum of 16 megabytes of addressable memory. All memory is connected to a common memory bus which consists of two undirectional, asynchronous, 32 bit busses. One bus is dedicated to memory write functions and the other is dedicated to memory read functions.

Input/Output is accomplished by up to five external communication busses: one multiplexer bus for medium speed devices and up to four high speed Direct Memory Access (DMA) busses. Each DMA bus supports eight high speed bidirectional ports. Each DMA port is controlled by a selector channel that controls and terminates transfers through the CPU. This selector channel is controlled through the multiplexer bus. Once the channel is activated, the processor is released and is free to continue processing. Published I/O transfer rates for the PE 3244 DMA bus indicate that transfer
Figure 5. Block Diagram of PE 3244 Computer
rates of up to 10 megabytes per second burst mode are possible for each DMA bus.\textsuperscript{6} Table 3 summarizes the PE/3244 I/O characteristics.

2.2.1.3 **Perkin Elmer 8/32c**

Detailed information about the 8/32 computer has not been obtained, but conceptually, the 8/32 is a machine similar in architecture to the 3244. A significant difference is that the 8/32 is capable of supporting only one DMA bus. This DMA operates in a burst mode capable of transferring 6 megabytes per second. The 8/32 will allow configuration with a buffered selector channel that accomplish the 6 MB/s rate by transferring the data in 14 half-word blocks.\textsuperscript{7} Table 4 summarizes the estimated PE 8/32c I/O characteristics.

2.2.2 **NSC HYPER channel**

The Network System Corporation HYPER channel (HC) is a broadband local area communication network supporting data transmissions between network users at a rate of 50 megabyte per second. The HYPER channel network (HCN) serves to interface and interconnect various sizes of mainframe computers of differing manufacturers (e.g., UNIVAC, DEC, CRAY, PERKIN ELMER) with other peripherals such as data entry terminal card readers, printers, mass storage devices and other networks. Communication is provided over a passive 75 ohm coaxial cable called a trunk.
<table>
<thead>
<tr>
<th><strong>PROCESSOR</strong></th>
<th>: 32 bit/word</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MAIN MEMORY</strong></td>
<td></td>
</tr>
<tr>
<td>Virtual Address Space:</td>
<td>4 Megabytes</td>
</tr>
<tr>
<td>Basic Memory Access Time:</td>
<td>500 nanoseconds</td>
</tr>
<tr>
<td><strong>DMA BUS DATA TRANSFER RATE</strong>:</td>
<td>10 Megabytes/second-burst mode</td>
</tr>
<tr>
<td>Maximum of 4 DMA busses can be supported.</td>
<td></td>
</tr>
<tr>
<td>TABLE 4. SUMMARY OF PERKIN ELMER 8/32 I/O CHARACTERISTICS</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>PROCESSOR</strong> : 32 bit/word</td>
<td></td>
</tr>
<tr>
<td><strong>DMA BUS DATA TRANSFER RATE</strong>: 6 Megabytes/second by transferring data in 14 half-word blocks. Only one DMA can be supported.</td>
<td></td>
</tr>
</tbody>
</table>
Host computers gain access to the network trunk through hardware interfaces called processor adapters; unintelligent peripherals through device adapters. Network to network connection are accomplished with a link adapter which supports not only communication with standard transmission lines but also with microwave frequency RF links. Each network adapter may be connected to as many as four separate trunks and provides the service of trunk selection, trunk access, establishment of adapter to adapter virtual circuits and also provides user-to-adapter protocols. Network adapters contend for trunk control using a Carrier Sense Multiple Access scheme with prioritized staggered delays.

The heart of the network is the A400 Adapter. The A400 is a microcomputer controlled interface device that allows up to 4 mini-computers of the same or mixed manufacturer types to transmit and receive data over the HYPER channel network. (All four trunk port may be connected to four channels of the same minicomputer.) The A400 provides a buffered interface between the trunk and the adapter. Some of this buffer is used to provide parallel to serial data stream conversion for host to trunk transmissions and serial to parallel conversion for trunk to host transmissions.

Each A400 adapter is composed of

. a 16 bit microprocessor with 4906 words of read only memory.

. a storage section consisting of

1024 8-bit bytes of control memory with odd parity

4096 8-bit bytes of control buffer with odd parity
16 working registers
16 trunk registers
256 extension register
one trunk interface.

The adapter can be expanded to contain

- 4 trunk interfaces
- 8192 8-bit bytes of buffer memory
- 1024 8 bit bytes of code conversion memory.

Additionally, the adapter has a peripheral device interface that provides a standard interface between the internal busses of the minicomputer and the A400. The peripheral interface adapter is separated from, but connected with ribbon cables to, the nucleus adapter which provides the hardware resources such as the microprocessor and memory register. (See Figure 6)

To perform an operation on the network, the minicomputer loads the necessary parameters into the internal registers on the interface and requests the adapter to perform the indicated functions. Whenever an adapter is not performing a function, it scans all attached ports for a request to perform a function. When a function request is detected, the adapter suspends scanning and initiates the execution of the function. The flow diagram of Figure 7 illustrates the handshaking between the A400 and host processor when data transfers are initiated. Notice that the host processor initiates all actions of the adapter. (A compilation of functions that can be accomplished by the A400 is illustrated in Table 5.)
NOTES:

1. The A400 Adapter supports the maximum host processor data transfer rates. Typical Values:
   - 76244 - 10 Megabytes/sec
   - PE 8/32e - 6 Megabytes/sec in Burst Mode
   - DEC BUS - 1.5 Megabytes/sec. Although
     buffered data paths.

2. Microprocessor (logical) interface consists of firmware (ROMS) to direct and
   control device transmissions, trunk selections, trunk transmissions and assembly/disassembly.

3. Trunk side consists of I/O Buffering, serial/parallel conversion, Checksum
   generator and checker, and trunk transceiver.

4. Device Interface Side consists of I/O Extension Registers and the DMA Controller.

Figure 6. NSC HYPERSchannel Adapter block diagram.
Host places 16 bits of data on DATA OUT bus and issues a GO pulse. Host also disables the READY line which stays inactive until function has been executed.

A function from host initiates every adapter operation.

Figure 7. Host to A400 Adapter Data Exchange
<table>
<thead>
<tr>
<th>CODE</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>04</td>
<td>Transmit message</td>
</tr>
<tr>
<td>08</td>
<td>Transmit data</td>
</tr>
<tr>
<td>0C</td>
<td>Transmit last data</td>
</tr>
<tr>
<td>10</td>
<td>Transmit local message</td>
</tr>
<tr>
<td>24</td>
<td>Input message</td>
</tr>
<tr>
<td>28</td>
<td>Input data</td>
</tr>
<tr>
<td>40</td>
<td>Status</td>
</tr>
<tr>
<td>50</td>
<td>Dump extension register</td>
</tr>
<tr>
<td>60</td>
<td>Mark down port 0</td>
</tr>
<tr>
<td>64</td>
<td>Mark down port 1</td>
</tr>
<tr>
<td>68</td>
<td>Mark down port 2</td>
</tr>
<tr>
<td>6C</td>
<td>Mark down port 3</td>
</tr>
<tr>
<td>70</td>
<td>Mark down port 0 and re-route messages</td>
</tr>
<tr>
<td>74</td>
<td>Mark down port 1 and re-route messages</td>
</tr>
<tr>
<td>78</td>
<td>Mark down port 2 and re-route messages</td>
</tr>
<tr>
<td>7C</td>
<td>Mark down port 3 and re-route messages</td>
</tr>
<tr>
<td>AO</td>
<td>Read statistics</td>
</tr>
<tr>
<td>A4</td>
<td>Read and clear statistics</td>
</tr>
<tr>
<td>C0</td>
<td>Set test</td>
</tr>
<tr>
<td>C4</td>
<td>Set address and length</td>
</tr>
<tr>
<td>C8</td>
<td>Write buffer</td>
</tr>
<tr>
<td>CC</td>
<td>Read buffer</td>
</tr>
<tr>
<td>E0</td>
<td>Clear adapter</td>
</tr>
<tr>
<td>E4</td>
<td>End operation</td>
</tr>
<tr>
<td>E6</td>
<td>Clear and wait for message</td>
</tr>
<tr>
<td>E8</td>
<td>Wait for message</td>
</tr>
</tbody>
</table>

TABLE 5. A400 ADAPTER FUNCTION DESCRIPTION
Data can be transferred from host to adapter in two different modes: direct memory access (DMA) and register mode. In the DMA mode, the adapter uses an alternating buffer scheme. The adapter accepts data from the device into buffer memory. When the buffer is half full, trunk transmission of that amount of data is initiated as, the other half of the buffer is being filled. This filling and sending is continued until all data has been transferred. All DMA transfers are through the extension registers and are initiated by the adapter microprocessor and controlled by the adapter hardware.

In the register mode, data movement is also between the device interface and the nucleus adapter but the DMA controls are not used. These data transfers are also through the extension register but initiated and controlled by the microprocessor.

Data transfers from adapter to adapter are accomplished by the trunk interface. The trunk interface consists of a passive coaxial cable that transmits data serially between two adapters. Each trunk can have up to 64 drops depending on the length of the trunk cable and its transmission qualities.

Transmissions on a trunk are initiated and monitored by the trunk driver which is a microcode program stored in the adapter PROMs. The extension register and the trunk registers support the PROM trunk driver. When an adapter is ready to transmit, it must first contend for use of the trunk. The method for contention is called contention allocation. It is so called because the trunk is allocated to an adapter based on the adapter's need to transmit.
The contention process can be summarized as follows. The adapter first just attempts to transmit on the trunk. If the trunk is busy, the transmitter is disabled. When the trunk becomes free, a fixed delay is initiated by the adapter. This prevents the adapter from transmitting until the receiving party of the most recent transmission has had time to receive a response frame. Upon expiration of the fixed delay, another delay called the priority delay is initiated. This delay is different for each adapter and provides a unique time slot for each adapter on the trunk. Another delay, called end delay, is provided following the fixed delay. This delay is provided to insure that all adapters with higher priority have first access to the trunk. Obviously, with this trunk allocation scheme, higher priority adapters can dominate the trunk. To prevent this, each adapter has a flip flop in it that is known as the wait flip flop. This flip flop is set when the adapter transmits and is cleared when an end delay is signalled. This flip flop is intended to provide a more equitable contention environment. Although all adapters are equipped with wait flip flops, they may be disabled to provide assured trunk access.\textsuperscript{9,10}

Figure 8 shows the flow of the wait algorithm.

Upon gaining access to the trunk, either a function message or data can be transmitted in trunk frames. When a frame is transmitted all adapters receive the frame. The adapter compares the received adapter access code which is part of the frame header with its own code which can be set by thumbwheel switches in the adapter. If and only if the codes match can the communication be accepted. (A zero in the receiving adapter code represents a "don't care" condition and
Fixed delay prevents adapter from transmitting until the receiving party of ongoing transmission has sent a trunk response frame.

Priority delay provides unique time slot for each adapter on trunk.

Wait fused to keep higher priority adapters from dominating the trunk may be disabled or enabled.

All other adapters have free access to trunk during this delay.
the receiving adapter will accept any character in that code position.

The receiving adapter responds to the receipt of a trunk transmission with a trunk response frame. This notifies the sending adapter of the status of the received message. Every transmission frame requires the receipt of a response frame or the sending adapter will time out and retry the transmission. This process will be repeated 256 times. If unsuccessful at transmitting the message, the adapter will terminate the operation and record some status bits for the host in the adapter extension registers. 10

2.2.3 Other HOSC Components

In addition to the computer resources are several other devices in the HOSC. Currently these other devices act as peripherals to the processors on the HYPER channel network and consequently do not directly affect traffic on the network. Indirectly, they represent overhead processor activity and thus slow traffic throughput on the processor I/O busses. These devices will include a Gandalf solid state switching matrix that acts to interface the MIPS consoles through VAX4. Also included in the peripherals are various strip recorders and three twelve-channel Genesco digital televisions that interface the engineering consoles through STS Primary (PE 3244), STS Backup (PE 8/32c) and Spacelab 8/32. No further descriptions of these devices are currently available.
3.0 HOSC ANALYSIS RESULTS

The HOSC system analysis initiated with a study of the system components, the computers, the HYPER channel network, the data flow activity of each device and the input-output characteristics of each device. The system operation is statistical in nature and, although a mathematical analysis is possible, it is not feasible to make such an analysis with much fidelity. Rather a simulation model that emulates the HOSC system with good fidelity can be used to achieve information concerning average bus traffic, average waiting time, collision frequency and maximum waiting times. Furthermore, these parameters can be investigated as a function of HOSC system configuration, input-output variations, and data file dump requirements.

The development of a simulation model with good fidelity has been accomplished. The HOSC system has been modeled with three different program simulations and these three algorithms have been compared against each other. The purpose in using three algorithms was to insure validity of the simulation results, a necessity due to the lack of sufficient system statistics to validate a single simulation algorithm. The three algorithms are similar, but have been programmed in BASIC, PASCAL and SLAM.

BASIC is an engineering oriented language not at all unlike FORTRAN. This simulation program is the main program. The program is listed in Appendix I.

Although many simulation runs were made with simple system configurations that allowed the simulation algorithm to be verified, there is no need to present those in this report. The monthly reports
document these earlier runs and the development of the algorithm. Rather it suffices to illustrate the simulation of the HOSC system as it is projected in configuration in Summer 1983.

3.1 **Typical Basic Algorithm Information Printouts**

Figure 9 depicts the HOSC simulation configuration which is documented in this report. This configuration is perhaps more complex than the actual system configuration for the present, but it is the type of configuration that is desired in the near future. Not all devices are transmitters of data in this system configuration. The A400 labeled port 4 only receives data transmitted on the HYPER channel bus. Other devices receive outside data and transmit and received data over the HYPER channel bus. This system configuration was devised at a meeting between this investigator and NASA/MSFC HOSC personnel on March 9, 1983, and is typical of the configurations to be utilized for HOSC applications in the near future.

In order to determine the number of simulation runs necessary to produce representative statistics and to let the system algorithm achieve steady state, as would occur in the actual system, several runs with the same system configuration parameters but with varying numbers of data transfers were made and the statistics compared.

Figures 10 and 11 illustrate the program printout that depicts the system configuration of figure 9. The # of bytes accumulated refers to the number of bytes which a particular device will accumulate refers to the number of bytes which a particular device will accumulate from a source before it transmits that data to the appropriate destination. As may be noted in Figure 10, there is a
<table>
<thead>
<tr>
<th>PORT, DEVICE, SOURCE</th>
<th>AVERAGE ARRIVAL RATE</th>
<th># OF BYTES ACCUMULATED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 1 1</td>
<td>15000</td>
<td>2048</td>
</tr>
<tr>
<td>2 1 1</td>
<td>4000</td>
<td>4000</td>
</tr>
<tr>
<td>2 2 1</td>
<td>6400</td>
<td>6400</td>
</tr>
<tr>
<td>3 1 1</td>
<td>1000</td>
<td>512</td>
</tr>
<tr>
<td>3 2 1</td>
<td>1000</td>
<td>512</td>
</tr>
<tr>
<td>3 3 1</td>
<td>625</td>
<td>625</td>
</tr>
<tr>
<td>4 1 1</td>
<td>0</td>
<td>2000</td>
</tr>
<tr>
<td>4 2 1</td>
<td>0</td>
<td>2000</td>
</tr>
<tr>
<td>4 3 1</td>
<td>0</td>
<td>2000</td>
</tr>
</tbody>
</table>

(U-LM DATA FILE DUMP: BYTES TO BE DUMPED: 64000; TIME BETWEEN DUMPS (IN SECONDS): 12)

Figure 10. System Configuration Parameters for 1333 Data Transfer Simulation.
WAIT TIME OF PORT 1 BEFORE TRANSMISSION REQUEST (IN EVENT OF A COLLISION) .000001
WAIT TIME OF PORT 2 BEFORE TRANSMISSION REQUEST (IN EVENT OF A COLLISION) .000002
WAIT TIME OF PORT 3 BEFORE TRANSMISSION REQUEST (IN EVENT OF A COLLISION) .000003
WAIT TIME OF PORT 4 BEFORE TRANSMISSION REQUEST (IN EVENT OF A COLLISION) .000004

CHANNEL SETUP AND RELEASE TIME = .000025

CHANNEL DATA TRANSFER RATE = 6250000

<table>
<thead>
<tr>
<th>PORT, DEVICE</th>
<th>TRANSFER RATE</th>
<th>LOAD TIMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 1</td>
<td>500000</td>
<td>.000002</td>
</tr>
<tr>
<td>1, 2</td>
<td>500000</td>
<td>.000002</td>
</tr>
<tr>
<td>1, 2</td>
<td>500000</td>
<td>.000002</td>
</tr>
<tr>
<td>1, 2</td>
<td>500000</td>
<td>.000002</td>
</tr>
<tr>
<td>1, 3</td>
<td>3300000</td>
<td>3.0303030303E-7</td>
</tr>
<tr>
<td>1, 3</td>
<td>3300000</td>
<td>3.0303030303E-7</td>
</tr>
<tr>
<td>1, 3</td>
<td>3300000</td>
<td>8.3333333333E-7</td>
</tr>
<tr>
<td>1, 3</td>
<td>3300000</td>
<td>8.3333333333E-7</td>
</tr>
</tbody>
</table>

COMBINATIONS (IJK - LMN) PROBABILITY TIME TO TRANSMIT Q(IJK) BYTES (IJK - LMN)

| 111311 | .7 | .004441 |
| 111321 | .3 | .004441 |
| 211431 | .1 | .008345 |
| 221421 | .1 | .013145 |
| 311321 | .98 | .001369 |
| 311221 | .01 | .001369 |
| 311211 | .01 | .001369 |
| 321311 | .98 | .001369 |
| 321221 | .01 | .001369 |
| 321211 | .01 | .001369 |
| 331421 | .1 | 6.658333333333E-4 |

Figure 11. System Configuration Parameters for 1333 Data Transfers.
data file dump of 64,000 bytes every 12 seconds as would be typical of a data file refresh operation.

The channel setup and release time is a parameter used to allow the HYPER channel to establish a transmission link and then to release the link after data transfer is complete.

As data is transferred across the system, each port vies for the bus in a contention scheme described in Section 2. Occasionally the ports will collide trying to transmit simultaneously. In Figures 12 and 13, a printout record of the result of a collision is illustrated. These printout records allow the operator to ensure the collision algorithm is working properly. As may be noted, 331 and 111 incurred a collision and 111 retransmitted first, since its assigned waiting time is less than 331.

Every time a data transfer occurs between two devices on the same port, the HYPER channel bus is not utilized and thus it is free for other transmissions except to the port involved in an inter-port data transfer. Figure 14 illustrates a printout record of an inter-device data transfer. Figure 14 also illustrates a record of a data file dump.

The statistical printout of a simulation run is illustrated in Figure 15. This run had 1333 data transfers and over three million bytes transferred.

3.2 Results of A Simulation Run

Inspection of Figure 15 will illustrate the information garnered by a simulation run. The items of interest are the bus busy time, collision frequency of each source, the average waiting time, the longest waiting time and the relative activity of each source.
ITERATION NUMBER 306
PROBABILITY 1
RANDOM NUMBER .364597057222
PROBABILITY 1
ESTIMATION 321

<table>
<thead>
<tr>
<th>ORT DEVICE SOURCE</th>
<th>TOTAL TIME GONE BY SINCE LAST TRANSMISSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.135719168770</td>
</tr>
<tr>
<td>2</td>
<td>.438061499984</td>
</tr>
<tr>
<td>2</td>
<td>.668460499377</td>
</tr>
<tr>
<td>3</td>
<td>.301452499979</td>
</tr>
<tr>
<td>3</td>
<td>.301452499979</td>
</tr>
<tr>
<td>4</td>
<td>1.0000001</td>
</tr>
<tr>
<td>4</td>
<td>99999990</td>
</tr>
<tr>
<td>4</td>
<td>99999995</td>
</tr>
<tr>
<td>4</td>
<td>99999995</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ORT DEVICE SOURCE</th>
<th>REMAINING TIME TO TRANSMIT (NORMALIZED FASHION)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.000841666622</td>
</tr>
<tr>
<td>2</td>
<td>.20193850816</td>
</tr>
<tr>
<td>2</td>
<td>.331539500621</td>
</tr>
<tr>
<td>3</td>
<td>.210547508021</td>
</tr>
<tr>
<td>3</td>
<td>.210547508021</td>
</tr>
<tr>
<td>5</td>
<td>1.0000001</td>
</tr>
<tr>
<td>4</td>
<td>99999990</td>
</tr>
<tr>
<td>4</td>
<td>99999995</td>
</tr>
<tr>
<td>4</td>
<td>99999995</td>
</tr>
</tbody>
</table>

COLLISION NUMBER 3
DATA TRANSFER .004441

Figure 12. Typical Printout When Data Transfer Collision Occurs.
ORT, DEVICE, SOURCE    ACCUMULATED WAITING TIMES SINCE THE LAST TRANSMISSION
1  1  1          0
2  1  1          .502502499984
3  1  1          .672901499977
2  3  1          .305893499979
3  2  1          .305893499979
3  3  1          1.004442
4  1  1          999999
4  2  1          999999
4  3  1          999999

DATA TRANSFER COMPLETED: TOTAL TIME GONE BY 28.340377331

ORT, DEVICE, SOURCE    REMAINING TIME TO TRANSMIT (NORMALIZED FASHION)
1  1  1          .136533333333
2  1  1          .197497506616
2  3  1          .327098500023
3  1  1          .206106500021
3  3  1          .206106500021
3  4  1          -.004442
4  1  1          999999
4  2  1          999999
4  3  1          999999
4  4  1          999999

NEXT TRANSMISSION REQUEST BY 331
TOTAL TIME THAT WILL BE GONE BY WHEN 331 STARTS TO TRANSMIT 28.340377331

TERATION NUMBER 387
RUBABILITY 1
RANDOM NUMBER .608213251646
ESTINATION 421

Figure 13. Typical Printout When Data Transfer Collision Occurs (Continued).
Figure 14. Typical Printout for Data File Dump and Inter Source Data Transfers.
<table>
<thead>
<tr>
<th>SOURCE TO DESTINATION</th>
<th># OF TIMES TRANSMITTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>111311</td>
<td>46</td>
</tr>
<tr>
<td>111321</td>
<td>195</td>
</tr>
<tr>
<td>311431</td>
<td>95</td>
</tr>
<tr>
<td>311421</td>
<td>34</td>
</tr>
<tr>
<td>311325</td>
<td>182</td>
</tr>
<tr>
<td>311221</td>
<td>5</td>
</tr>
<tr>
<td>311211</td>
<td>6</td>
</tr>
<tr>
<td>211311</td>
<td>185</td>
</tr>
<tr>
<td>311221</td>
<td>1</td>
</tr>
<tr>
<td>311211</td>
<td>95</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1333</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PORT, DEVICE, SOURCE</th>
<th>LONGEST WAITING TIME</th>
<th>AVG. WAITING TIME</th>
<th>COLLISIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-1.128345</td>
<td>-5.71129979232E-5</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>-1.128345</td>
<td>-6.04111054163</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>-0.45081</td>
<td>-5.57095512472E-5</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>-1.128345</td>
<td>-6.26356917362E-5</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>-1.10163916665</td>
<td>-1.03009355127</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>-1.129714</td>
<td>-6.26356917362E-5</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL TIME GONE BY</td>
<td>36.3994089909</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BUSY TIME</td>
<td>6.1463851664</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Percent Bus Busy Time = 6.34%

Number of Data Transfer Collisions = 6 Collisions

Number of Data File Dumps (11 to 41) = 8 (64,000 Bytes Each)
Bytes Transferred by Data File Dump = 512,000 Bytes

Bytes Transferred Source to Destination = 2,616,399 Bytes
Total Bytes Transferred = 3,128,399 Bytes

Figure 15. Statistical Summary of 1333 Data Transfer Simulation.
For the 1333 data transfer simulation with data file dump of 64,000 bytes every 12 seconds the parameters of interest are depicted in the figure. Everything points to a satisfactory operation at this point with one notable exception, the longest waiting time. This figure is -128.345 milliseconds (the negative sign indicates waiting time) for P.D.S. 111 which has an average time between transmission requests of 136.533 milliseconds (# of bytes accumulated divided by the average arrival rate of the bytes. The data is drawn from Figure 10.)

This waiting time amounts to 94% of the average time between transmission requests for P.D.S. 111 and serves a warning that P.D.S. 111 is on the verge of being overloaded. This may be alleviated by several means—changing the number of bytes to be accumulated before making a transmission request or by changing the data file dump time interval. In Section 3.4, this is discussed more fully.

3.3 Comparison of BASIC, PASCAL and SLAM Programs

Appendix II contains a listing of the PASCAL program and summary sheet for the HOSC simulation. The SLAM program listing is not included since NASA/MSFC does not carry SLAM software support. The three algorithms are compared in a broad sense in Table 6. The three algorithms were run for comparison purposes using 500 data transfers as the benchmark. The total bus time, bus utilization percentage, number of bytes transferred all compare very favorably. The number of collisions incurred vary due to differences in the collision algorithms used in the programs which were programmed by three different programmers as a check on the algorithms. The
<table>
<thead>
<tr>
<th></th>
<th>BASIC</th>
<th>PASCAL</th>
<th>SLAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Transmissions</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Elapsed Time on Bus (Seconds)</td>
<td>36.08</td>
<td>36.44</td>
<td>35.24</td>
</tr>
<tr>
<td>Collisions</td>
<td>8</td>
<td>29</td>
<td>19</td>
</tr>
<tr>
<td>Waits</td>
<td>N.T.</td>
<td>83</td>
<td>36</td>
</tr>
<tr>
<td>Bus Utilization</td>
<td>5.82%</td>
<td>4.69%</td>
<td>6.02%</td>
</tr>
<tr>
<td>Bytes Transferred</td>
<td>979,795</td>
<td>987,360</td>
<td>985,939</td>
</tr>
</tbody>
</table>

N.T. = Not Tabulated

TABLE 6
COMPARISONS OF BASIC PASCAL AND SLAM PROGRAMS
NO DATA FILE DUMPS SIMULATED
The algorithms programmed all have the following features:

1. Allows up to 9 A400 adaptors
2. Allows up to 9 computer devices per A400 adaptor
3. Allows up to 9 data sources per device
4. Allows each device to transfer large block of data on a periodic basis such as for CRT data base refresh
5. Allows assignment of individual waiting times to be assigned to each A400 in event of a collision
6. Allows the shortest assigned waiting time A400 to retry a transmission in the event of a collision
7. If a data transfer occurs between two devices on the same A400 (Inter A400 data transfer) it allows this to occur without tying up the bus
8. Allows for individual source data arrival rates
9. Allows for individual source data buffer sizes (relates to time between transmission requests)
10. Allows for individual device to A400 I/O data rates.

The results indicate no major discrepancies lie in the HOSC system model used for the algorithm development. The BASIC program has been emphasized since it is more transportable than SLAM or PASCAL. However, for a next generation simulation model, PASCAL will be constructed in a user friendly format since it has some features which make it suitable for this type of simulation.

3.4 Conclusions

Results of a fair run simulation using the configuration of Figure 9 has been tabulated in Table 7. The purpose of this comparison was to determine:
### TABLE 7
COMPARISON OF FOUR SIMULATION RUNS
(BASIC PROGRAM)

<table>
<thead>
<tr>
<th>P.D.S.</th>
<th>TTMR (ms)</th>
<th>RUN A</th>
<th>RUN B</th>
<th>RUN C</th>
<th>RUN D</th>
<th>RUN E</th>
<th>AVG WNT (%)</th>
<th>DDS BRT (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 1 1</td>
<td>136</td>
<td>128 (94%)</td>
<td>128 (94%)</td>
<td>256 (188%)</td>
<td>128 (94%)</td>
<td>8 (6%)</td>
<td>29 29 45 29 39</td>
<td></td>
</tr>
<tr>
<td>2 1 1</td>
<td>1000</td>
<td>128 (13%)</td>
<td>128 (13%)</td>
<td>118 (11.8%)</td>
<td>19 (2%)</td>
<td>4 (.4%)</td>
<td>2.8 4.1 4.8 1.7 .22</td>
<td>6.78E 6.34E 6.32E 5.9E</td>
</tr>
<tr>
<td>2 2 1</td>
<td>1000</td>
<td>45 (52%)</td>
<td>45 (52%)</td>
<td>8.4 (.04%)</td>
<td>8 (.8%)</td>
<td>9 (1%)</td>
<td>1.5 1.7 .35 .47 .42</td>
<td></td>
</tr>
<tr>
<td>3 1 1</td>
<td>512</td>
<td>129 (25%)</td>
<td>128 (52%)</td>
<td>256 (50%)</td>
<td>116 (23%)</td>
<td>5 (12%)</td>
<td>1.9 10.9 11.5 1.6 .21</td>
<td></td>
</tr>
<tr>
<td>3 2 1</td>
<td>512</td>
<td>128 (25%)</td>
<td>130 (26%)</td>
<td>256 (50%)</td>
<td>116 (23%)</td>
<td>4 (12%)</td>
<td>3.2 1.2 .85 1.2 .57</td>
<td></td>
</tr>
<tr>
<td>3 3 1</td>
<td>1000</td>
<td>101 (102%)</td>
<td>101 (102%)</td>
<td>202 (20%)</td>
<td>101 (102%)</td>
<td>13 (1.32)</td>
<td>3.0 3.0 2.8 3.2 .01</td>
<td></td>
</tr>
</tbody>
</table>

**P.D.S.** = PORT, DEVICE, SOURCE

Average Waiting Time is expressed as percent of TTMR

TTMR = Time to Next Transmission Request = Time Between Data Transfer Requests

Number of Collisions: RUN A - 10; RUN B - 6; RUN C - 14; RUN D - 3; RUN E - 3

- **RUN A** 1500 data transfers, Data file dump once every 12 seconds, 64,000 Bytes each dump
- **RUN B** 1333 data transfers, Data file dump once every 12 seconds, 64,000 Bytes each dump
- **RUN C** 1000 data transfers, Data file dump once every 12 seconds, 128,000 Bytes each dump
- **RUN D** 500 data transfers, Data file dump once every 12 seconds, 64,000 Bytes each dump
- **RUN E** 500 data transfers, Data file dump once every 120 seconds, 64,000 Bytes each dump

(For a 500 iteration run time of 36 milliseconds no data file dump occurs.)
a) The number of iterations necessary to produce consistent results.

b) Determine the effects of varying the data file dump interval.

Since each simulation run uses random number generators as part of the program, it should not be surprising to see small differences in the output summary statistics. Indeed two runs of the same configuration with the same number of iterations will produce slightly different results. This is completely expected and does not reduce the value of the results at all.

The results tabulated in Table 7 indicate that the system performs as desired with one exception. The data file dump. Every 24 seconds, Run C, creates a waiting time of 256 milliseconds for P.D.S. 111, which is 188% of the time between transmission requests for source P.D.S. 111. The impact of these results from a realization that 100% waiting time for a source would mean that source has been waiting for an opportunity to transmit for such a long time that it now has three transmission requests rather than one. It is obvious from the data in Table 7 that large data file dumps will tend to create a log jam for devices with active external data sources. These external data sources may not be extinguishable; hence, the need to provide sufficient data storage in the device to hold incoming data during a large data file dump is paramount.

An analytical feeling for this problem is easily derived. Any source with a data file dump will experience an external source transmission request whenever the data file dump time exceeds the total time between transmission requests for that source. In the
configuration of Figure 9, we have a data file dump from P.D. 11 to
P.D. 41. The I/O rate for P.D. 11 is 500 K Bytes per second and the
I/O rate for P.D. 41 is 3.30 M Bytes per second. The channel trans-
fer rate is 0.25 M Bytes per second so that data file dump will take
a total time equal to the channel setup release time plus the time to
dump X Bytes at the slowest I/O rate or for our configurations the
data file dump time (DFDT) is

\[
\text{DFDT} = 25 \text{ msec} + X(2 \text{ msec/Byte})
\]

For 64,000 Bytes DFDT = 128 msec and
for 128,000 Bytes DFDT = 256 msec.

In fact whenever the DFDT exceeds the fastest source average time to
transmission request time a problem will definitely arise. For the
example where the number of bytes in a data file dump exceeds

\[
\text{Number of Bytes} = \frac{126,531 - 0.25}{2 \times 10^{-3}} = 68254 \text{ Bytes}
\]

the fastest source will possibly incur two transmission requests.

There are several ways to correct this situation:

a) Increase the buffer size of the source so it can store
more than two full sets of data between transmission
opportunities. This is a viable option since source
P.D.S. 111 is the most active with highest outside data
arrival rate and only 2048 bytes to be accumulated between
transmission requests.
b) Perform data file dumps more often but transfer proportionally less bytes per dump thereby reducing any sources waiting time. This may not be a viable option due to the lack of data file data being ready in a somewhat steady occurrence rate. Also this would require a data file storage medium at the destinations; however, this is usually the case.

c) Break up the data file dump by transmitting it in smaller packets. That is rather than 64,000 bytes in a steady stream for a short time once every 12 seconds, transmit 8,000 bytes, break and release channel to allow another user but request transmission rights immediately and repeat for 8 times. This would transfer the data in almost the same time as sending all 64,000 bytes while allowing the active devices a chance to clear their stored data.

All the above options could be accomplished through software programming of the source device P.D. 11; thus, it is a HOSC system operators choice of which method to utilize.
4.0 LITERATURE SURVEY

4.1 References


4.2 Bibliography

4.2.1 Publications


4.2.2 Reference Manuals (by Manufacturer)


APPENDIX I

BASIC SIMULATION ALGORITHM PROGRAM

A listing of the BASIC simulation algorithm program is presented in this appendix. The program contains plentiful comments and is user oriented, with prompts and options displayed on the interactive screen. The BASIC language is common to many machines; however, the input output commands are usually particular to a single machine, in this case the HP-87 system.
**PROGRAM:** HUSC

**AUTHOR:** DR. FRANK INGELE

**PROGRAMMER:** TERESA BENT

**DATE:** MAY 12, 1965

1. I -- # OF PORTS
2. J -- # OF DEVICES FOR EACH PORT
3. K -- # OF SOURCES FOR EACH DEVICE
4. L -- AVERAGE ARRIVAL RATE OF DATA TO SOURCE
5. M -- # OF BYTES ACCUMULATED BY SOURCE K, DEVICE J, PORT I
6. N -- BEFORE DEVICE J REQUESTS A TRANSMISSION
7. O -- CHANNEL SETUP AND RELEASE TIME
8. P -- CHANNEL DATA TRANSFER RATE
9. Q -- PROBABILITY THAT SOURCE IJK WILL TRANSMIT DATA TO LMN
10. BBT -- BUSY BUSY TIME
11. BEGIN PROGRAM EXECUTION
12. INTEGER I, J, K, L, M, N, O
13. BBT=0, CH1=999999, CH2=999999, CLNS="N", CLNS="N", EGS="N", AF="F"
14. DIM PDS(200), PRO(200), T(200), TIMES(200), DT(200), BYTES(20), TIM(20), I(20)
15. HIT(20)
16. CLEAR & DISP TAB(20);"MENU" & DISP & DISP "1 -- RECALL AN EXISTING DATA FILE"
17. DISP "2 -- EXECUTE PROGRAM WITHOUT THE FILE OPTION"
18. DISP "3 -- CREATE A NEW DATA FILE AND EXECUTE PROGRAM"
19. DISP & DISP "ENTER YOUR SELECTION " & INPUT A1
20. IF A1=1 OR A1=3 THEN 220
21. IF PRINT IS 701
22. DISP "" & DISP "INDICATE THE NUMBER OF PROGRAM ITERATIONS " & INPUT NUMBER
23. ON A1 GOTO 250, 310, 290
24. DISP & DISP "ENTER THE DATA FILE NAME " & INPUT DFNAME
25. IF A1=1 THEN GETDATA=999 & GOTO 1350 ELSE GETDATA=888
26. DATA ENTRY ROUTINE (IF A1=2 OR A1=3)
27. LINES 310-1330
28. CLEAR & DISP "PLEASE ENTER THE FOLLOWING DATA ITEMS:" & DISP
29. DISP "# OF HYPERCHANNEL PORTS " & INPUT HY
30. FOR I=1 TO HY & DISP "# OF DEVICES FOR PORT " & I: & INPUT DV(I) NEXT I
31. CLEAR
32. FOR I=1 TO DV(I)
33. DISP "# OF SOURCES FOR PORT " & I: & INPUT SR(I)
34. NEXT I = I+1 & IF I= HY THEN 340 ELSE I=0
370 I=I+1 CLEAR I FOR J=1 TO D (I) FOR K=1 TO SRC (I, J) CLEAR
380 DISP "FORT", "I: DEVICE", "I: SOURCE": "I: DISP I DISP
390 DISP "AVERAGE ARRIVAL RATE": : INPUT LA(J, K)
400 DISP "# OF BYTES ACCUMULATED BEFORE EACH TRANSMISSION REQUEST IS TO BE MADE BY:
410 DEVICE": : INPUT QS
420 IF QS <> "" THEN QQ(J, I)=500 & DISP " OTHERWISE SECIFIED": : INPUT QS
430 NEXT J & NEXT I & DO I GOSUB 450, 490, 530, 570, 610, 650, 690, 730, 770
440 IF I=H THEN 810 ELSE GOTO 370
450 FOR J=1 TO D (I) & FOR K=1 TO SRC (I, J) & LA (I, J)+LA (I, K)+LA (I, I)+0 & QQ (J, I)+QQ (J, I)+0
460 IF LA (I, J)=0 THEN ATR (I, K)=999999 ELSE ATR (I, K)=Q1 (J, I)/LA (I, K)
470 NEXT I & NEXT J & RETURN
480 LA (I, J)+QQ (J, I)+0 & ATR (I, K)+Q1 (J, I)/LA (I, K) & RETURN
490 FOR J=1 TO D (I) & FOR K=1 TO SRC (I, J) & LA (I, J)+LA (I, K)+LA (I, I)+0 & QQ (J, I)+QQ (J, K)=0
500 IF LA (I, J)=0 THEN ATR (I, J)=999999 ELSE ATR (I, J)=Q3 (J, K)/LA (I, J)
510 NEXT I & NEXT J & RETURN
520 LA (I, J)+QQ (J, K)+0 & ATR (I, J)+Q3 (J, K)/LA (I, J) & RETURN
530 FOR J=1 TO D (I) & FOR K=1 TO SRC (I, J) & LA (J, J)+LA (J, I)+LA (J, I)+0 & QQ (J, K)+QQ (J, K)=0
540 IF LA (J, J)=0 THEN ATR (J, K)=999999 ELSE ATR (J, K)=Q4 (J, K)/LA (J, J)
550 NEXT K & NEXT J & RETURN
560 LA (J, J)+QQ (J, K)+0 & ATR (J, K)+Q4 (J, K)/LA (J, J) & RETURN
570 FOR J=1 TO D (I) & FOR K=1 TO SRC (I, J) & LA (J, J)+LA (J, I)+LA (J, I)+0 & QQ (J, K)+QQ (J, K)=0
580 IF LA (J, J)=0 THEN ATR (J, K)=999999 ELSE ATR (J, K)=Q5 (J, K)/LA (J, J)
590 NEXT K & NEXT J & RETURN
600 LA (J, J)+QQ (J, K)+0 & ATR (J, K)+Q5 (J, K)/LA (J, J) & RETURN
610 FOR J=1 TO D (I) & FOR K=1 TO SRC (I, J) & LA (J, J)+LA (J, I)+LA (J, I)+0 & QQ (J, K)+QQ (J, K)=0
620 IF LA (J, J)=0 THEN ATR (J, K)=999999 ELSE ATR (J, K)=Q6 (J, K)/LA (J, J)
630 NEXT K & NEXT J & RETURN
640 LA (J, J)+QQ (J, K)+0 & ATR (J, K)+Q6 (J, K)/LA (J, J) & RETURN
650 FOR J=1 TO D (I) & FOR K=1 TO SRC (I, J) & LA (J, J)+LA (J, I)+LA (J, I)+0 & QQ (J, K)+QQ (J, K)=0
660 IF LA (J, J)=0 THEN ATR (J, K)=999999 ELSE ATR (J, K)=Q7 (J, K)/LA (J, J)
670 NEXT K & NEXT J & RETURN
680 LA (J, J)+QQ (J, K)+0 & ATR (J, K)+Q7 (J, K)/LA (J, J) & RETURN
690 FOR J=1 TO D (I) & FOR K=1 TO SRC (I, J) & LA (J, J)+LA (J, I)+LA (J, I)+0 & QQ (J, K)+QQ (J, K)=0
700 IF LA (J, J)=0 THEN ATR (J, K)=999999 ELSE ATR (J, K)=Q8 (J, K)/LA (J, J)
710 NEXT K & NEXT J & RETURN
720 LA (J, J)+QQ (J, K)+0 & ATR (J, K)+Q8 (J, K)/LA (J, J) & RETURN
730 FOR J=1 TO D (I) & FOR K=1 TO SRC (I, J) & LA (J, J)+LA (J, I)+LA (J, I)+0 & QQ (J, K)+QQ (J, K)=0
740 IF LA (J, J)=0 THEN ATR (J, K)=999999 ELSE ATR (J, K)=Q9 (J, K)/LA (J, J)
750 NEXT K & NEXT J & RETURN
760 LA (J, J)+QQ (J, K)+0 & ATR (J, K)+Q9 (J, K)/LA (J, J) & RETURN
770 FOR J=1 TO D (I) & FOR K=1 TO SRC (I, J) & LA (J, J)+LA (J, I)+LA (J, I)+0 & QQ (J, K)+QQ (J, K)=0
740 IF LA8(J,K)=0 THEN ATR8(J,K)=99999 ELSE ATR8(J,K)=Q8(J,K)/LA8(J,K)
750 NEXT K & NEXT J & RETURN;
760 LA=LA8(J,K) & QQ=QQ8(J,K) & ATR=ATR8(J,K) & RETURN
70 FOR J=1 TO DVI(I) & FOR K=1 TO SRC(I,J) & LA9(J,K)=LA(J,K) & LA(J,K)=0 & QS(J,K)=QQ(J,K) & QQ(J,K)=0 & NEXT K & NEXT J & RETURN
80 IF LA9(J,K)=0 THEN ATR9(J,K)=99999 ELSE ATR9(J,K)=Q9(J,K)/LA9(J,K)
30 NEXT K & NEXT J & RETURN
00 LA=LA9(J,K) & QQ=Q9(J,K) & ATR=ATR9(J,K) & RETURN
10 CLEAR & FOR I=1 TO HY & FOR J=1 TO DVI(I)
20 DISP "PROPAGATION DISTANCE BETWEEN PORT ");I;" AND DEVICE ");J;" IN MICROSECONDS"
30 INPUT DI(J)
40 NEXT J & NEXT I
50 CLEAR & DISP "CHANNEL SETUP AND RELEASE TIME ASSIGNED THE VALUE 25 MICROSECONDS"
60 QS=".000025" & DISP "" & DISP "PRESS <END LINE> OR ENTER THE PROPER VALUE "
70 INPUT QS IF QS <> "" THEN TSR=VAL (QS) ELSE TSR=.000025
80 DISP "" & DISP "CHANNEL DATA TRANSFER RATE IS 6.25 KBS" & DISP ""
90 QS="6250000" & DISP "PRESS <END LINE> OR ENTER THE PROPER VALUE " & INPUT QS
10 IF QS <> "" THEN CR=VAL (QS) ELSE CR=6250000
00 CLEAR & FOR I=1 TO HY & FOR J=1 TO DVI(I)
10 DISP "RATE AT WHICH DATA IS TRANSFERRED FROM DEVICE ");J;" TO PORT ");I;"
20 INPUT RI(I,J)
30 LL(I,J)=1/R(I,J)
40 NEXT J & NEXT I
50 GOSUB 960 & GOTO 1080
50 FOR I=1 TO HY & FOR J=1 TO DVI(I) & FOR K=1 TO SRC(I,J)
70 ON I GOSUB 990,1000,1010,1026,1030,1046,1050,1060,1070
80 NEXT K & NEXT J & NEXT I & RETURN
30 MNEG1(J,K)=0 & TNG1(J,K)=0 & TN1(J,K)=0 & COL1(J,K)=0 & RETURN
10 MNEG2(J,K)=0 & TNG2(J,K)=0 & TN2(J,K)=0 & COL2(J,K)=0 & RETURN
10 MNEG3(J,K)=0 & TNG3(J,K)=0 & TN3(J,K)=0 & COL3(J,K)=0 & RETURN
10 MNEG4(J,K)=0 & TNG4(J,K)=0 & TN4(J,K)=0 & COL4(J,K)=0 & RETURN
10 MNEG5(J,K)=0 & TNG5(J,K)=0 & TN5(J,K)=0 & COL5(J,K)=0 & RETURN
10 MNEG6(J,K)=0 & TNG6(J,K)=0 & TN6(J,K)=0 & COL6(J,K)=0 & RETURN
10 MNEG7(J,K)=0 & TNG7(J,K)=0 & TN7(J,K)=0 & COL7(J,K)=0 & RETURN
10 MNEG8(J,K)=0 & TNG8(J,K)=0 & TN8(J,K)=0 & COL8(J,K)=0 & RETURN
10 MNEG9(J,K)=0 & TNG9(J,K)=0 & TN9(J,K)=0 & COL9(J,K)=0 & RETURN
1080 NUMPROB=0
1090 PDS(O)=0 & PRO(O)=0 & FOR I=1 TO 200 & CLEAR & DISP "PREVIOUS COMBINATION ":PDS(I-1);" PROBABILITY ":PRO(I-1) & DISP ""
1100 DISP "SELECT <PORT,DEVICE,SOURCE> WHICH TRANSMITS TO <PORT,DEVICE,SOURCE>"
1440 II=II+1
1450 IF GETDATA=999 THEN READ# 1.II : Q0(I,J,X) ELSE PRINT# 1.II : 00
1460 II=II+1
1470 IF GETDATA=999 THEN READ# 1.II : LA(I,J,X) ELSE PRINT# 1.II : LA
1480 NEXT K & NEXT J & IF GETDATA=999 THEN ON 1 GOSUB 456.496.536.576.616.656.696
1500 ,730.770
1510 NEXT I
1520 FOR I=1 TO HY & FOR J=1 TO DV(I) & II=II+1
1530 IF GETDATA=999 THEN READ# 1.II : D(I,J) ELSE PRINT# 1.II : D(I,J)
1540 NEXT J & NEXT I
1550 FOR I=1 TO HY & IF II=II+1 & IF GETDATA=999 THEN READ# 1.II : USR ELSE PRINT# 1.II : USR
1560 II=II+1 & IF GETDATA=999 THEN READ# 1.II : GR ELSE PRINT# 1.II : GR
1570 FOR I=1 TO HY & FOR J=1 TO DV(I) & II=II+1
1580 IF GETDATA=999 THEN READ# 1.II : R(I,J) & LT(I,J)=1/R(I,J) ELSE PRINT# 1.II
1590 R(I,J)
1600 NEXT J & NEXT I
1610 FOR I=II+1 & IF GETDATA=999 THEN READ# 1.II : NUMPROB ELSE PRINT# 1.II : NUMPROB
1620 NEXT I
1630 FOR I=II+1 & IF GETDATA=999 THEN READ# 1.II : PRO(I) ELSE PRINT# 1.II : PRO(I)
1640 NEXT I
1650 FOR I=II+1 & IF GETDATA=999 THEN READ# 1.II : SNUM ELSE PRINT# 1.II : SNUM
1660 FOR I=II+1 & IF GETDATA=999 THEN READ# 1.II : DF(I) ELSE PRINT# 1.II : DF(I)
1670 FOR I=II+1 & IF GETDATA=999 THEN READ# 1.II : BYTES(I) ELSE PRINT# 1.II : BYTES
1680 II=II+1 & IF GETDATA=999 THEN READ# 1.II : TIM(I) ELSE PRINT# 1.II : TIM(I)
1690 NEXT I
1700 ASSIGN #1 TO *
1710 GOSUB 960
1720 CLEAR & DISP TAB (20):"MENU" & DISP "1" & DISP "2" -- PRINT OUT CURRENT DATA & DISP "3" -- CORRECT DATA ERRORS & DISP "3" -- RUN PROGRAM & DISP "4" -- ENTER YOUR SELECTION":@INFU
1730 SELECT
1740 IF SELECT<1 OR SELECT>3 THEN 1720
1750 IF SELECT=3 THEN 1760 ELSE ON SELECT GOTO 3840.4210
1760 SAVEATR=99999 & SAVELYA=0
1770 FOR I=1 TO HY & FOR J=1 TO DV(I) & FOR I=1 TO SR(I,J)
1780 ON I GOSUB 480.520.560.600.640.680.720.760.800
1790 IF LA>SAVELA THEN SAVELA=LA & SAVEijk=I*100+J*10+K.
1800 IF ATR=0 THEN 1820
1810 IF ATR<SAVEATR THEN SAVEATR=ATR & SAVEATRIJK=I*100+J*10+K
1820 IF ATR=999999 THEN TLST=999999 ELSE TLST=0
1830 ON I GO SUB 1850,1860,1870,1880,1890,1900,1910,1920,1930
1840 NEXT K & NEXT J & NEXT I & GOTO 1940
1850 TLST1(J,K)=TLST & RETURN
1860 TLST2(J,K)=TLST & RETURN
1870 TLST3(J,K)=TLST & RETURN
1880 TLST4(J,K)=TLST & RETURN
1890 TLST5(J,K)=TLST & RETURN
1900 TLST6(J,K)=TLST & RETURN
1910 TLST7(J,K)=TLST & RETURN
1920 TLST8(J,K)=TLST & RETURN
1930 TLST9(J,K)=TLST & RETURN
1940 PRINT "" & PRINT "FIRST USER IS ";SAVEijk & ITERNUM=0 & NUMDEST=0
1950 PRINT "" & PRINT "TOTAL TIME GONE BY ";SAVEATR & CN=0 & TTGB=SSAVEATR
1960 CLEAR & DISP "" & PRINT "MENU" & DISP "" & DISP "I" -- NO PRIN
1970 NEXT GIVEN ON EACH CYCLE"
1980 DISP "2 -- PRINTOUT GIVEN ON EACH CYCLE" & DISP "3 -- SPECIFY THE LAST
1990 CYCLES TO BE PRINTED" & DISP ""
2000 INPUT PR; IF PR<1 OR PR>3 THEN CLEAR & GOTO 1960
2010 IF PR=2 THEN PRINTER IS 701 ELSE PRINTER IS 1
2020 IF PR=3 THEN DIS "ENTER THE LAST X CYCLES WHICH ARE TO BE PRINTED ";& INPUT
2030 NUMCYCLES
2040 ! ************************************************************
2050 ! GENERATE A RANDOM NUMBER, THEN USE IT TO SELECT THE DESTINATION DEVICE
2060 ! LINES 2010-2140
2070 ! **************************************************************
2080 ! XXX=RND
2090 IF PR=3 THEN 2030 ELSE 2040
2100 IF ITERNUM>= NUMITER-NUMCYCLES THEN PRINTER IS 701
2110 PRINT "" & PRINT "" & PRINT "ITERATION NUMBER ";ITERNUM+1 & PRINT "" &
2120 FOR I=1 TO NUMPROB
2130 IJK=INT (PDS(I)/1000)
2140 IF IJK=SAVEijk THEN NUMDEST=NUMDEST+1 & SAVEEND=I ELSE 2090
2150 IF NUMDEST=1 THEN START=I & PROB=PRO(I) & PRINT "PROBABILITY ";PROB
2160 NEXT I & PRINT "RANDOM NUMBER ";XXX
2170 IF XXX<PROB THEN SOURCE=START & GOTO 2140
2180 FOR I=START TO SAVEEND
2190 IF XXX< PROB THEN SOURCE=I & GOTO 2140
2200 XXX=PROB+PRO(I+1) & PRINT "PROBABILITY ";PROB & NEXT I
2210 PRINT "" & PRINT "DESTINATION ";PDS(SOURCE)-SAVEijk*1000
2220 PRINT "" & PRINT "PORT,DEVICE,SOURCE TOTAL TIME GONE BY SINCE LAST
2230 TRANSMISSION" & TTGBSLT=SAVEATR
2160 TIMES(T(SOURCE)=TIMES(T(SOURCE))
2170 FOR I=1 TO H & FOR J=1 TO D(V(i)) & FOR K=1 TO S(R(I,J))
'180 TLST=999999 & ON I GOSUB 2210,2220,2230,2240,2250,2260,2270,2280,2290
190 PRINT I$: "":J$: "":K$:TAB(30):TLST
200 NEXT K & NEXT J & NEXT I & GOTO 2300
210 IF TLST1(J,K)=99999 THEN RETURN ELSE TLST1(J,K)=TLST1(J,K)+TTGBSLT & TLST=
_ST1(J,K) @ RETURN
220 IF TLST2(J,K)=99999 THEN RETURN ELSE TLST2(J,K)=TLST2(J,K)+TTGBSLT & TLST=
_ST2(J,K) @ RETURN
230 IF TLST3(J,K)=99999 THEN RETURN ELSE TLST3(J,K)=TLST3(J,K)+TTGBSLT & TLST=
_ST3(J,K) @ RETURN
240 IF TLST4(J,K)=99999 THEN RETURN ELSE TLST4(J,K)=TLST4(J,K)+TTGBSLT & TLST=
_ST4(J,K) @ RETURN
250 IF TLST5(J,K)=99999 THEN RETURN ELSE TLST5(J,K)=TLST5(J,K)+TTGBSLT & TLST=
_ST5(J,K) @ RETURN
260 IF TLST6(J,K)=99999 THEN RETURN ELSE TLST6(J,K)=TLST6(J,K)+TTGBSLT & TLST=
_ST6(J,K) @ RETURN
270 IF TLST7(J,K)=99999 THEN RETURN ELSE TLST7(J,K)=TLST7(J,K)+TTGBSLT & TLST=
_ST7(J,K) @ RETURN
280 IF TLST8(J,K)=99999 THEN RETURN ELSE TLST8(J,K)=TLST8(J,K)+TTGBSLT & TLST=
_ST8(J,K) @ RETURN
290 IF TLST9(J,K)=99999 THEN RETURN ELSE TLST9(J,K)=TLST9(J,K)+TTGBSLT & TLST=
_ST9(J,K) @ RETURN
300 GOSUB 2310 & GOTO 3020
305 ! ************************************************************************************
306 ! FIND SMALL & SMALL2 TO BE USED TO CHECK FOR COLLISIONS AND NRTT
307 ! LINES 2310-2540
308 ! ************************************************************************************
310 PRINT "": PRINT "PORT,DEVICE,SOURCE RE" REMAINING TIME TO TRANSMIT (NO
311 ALIZED FASHION)"
320 SMALL=99998 & SAVESM=99998 & SMALL2=99998 & SAVESM2=99998
330 FOR I=1 TO H & FOR J=1 TO D(V(i)) & FOR K=1 TO S(R(I,J))
340 ON I GOSUB 480,520,560,600,640,680,720,760,800
350 ON I GOSUB 2370,2380,2390,2400,2410,2420,2430,2440,2450
360 GOTO 2460
370 TLST=TLST1(J,K) @ RETURN
380 TLST=TLST2(J,K) @ RETURN
390 TLST=TLST3(J,K) @ RETURN
400 TLST=TLST4(J,K) @ RETURN
410 TLST=TLST5(J,K) @ RETURN
420 TLST=TLST6(J,K) @ RETURN
430 TLST=TLST7(J,K) @ RETURN
440 TLST=TLST8(J,K) @ RETURN
2450 TLST=TLST9(J,K) @ RETURN
2460 IF ATR=999999 THEN NRTT=999999 ELSE NRTT=ATR-TLST
2470 IF CLSN$="Y" THEN SUB=-1 ELSE SUB=1
2480 ON I GOSUB 2550,2600,2650,2700,2750,2800,2850,2900,2950
2490 IF CLSN$="Y" THEN 2510
2500 PRINT I:" ";J;" ";K;TAB(30);NRTT
510 IF NRTT<SMALL THEN CH1=SMALL & SMALL.=NRTT & CH2=SAVEM & SAVEM=I*100+J*10+
& EQS="Y"
520 IF CH1<SMALL2 THEN SMALL2=CH1 & SAVEM2=CH2
530 IF NRTT<SMALL AND NRTT<SMALL2 AND EQS="N" THEN SMALL2=NRTT & SAVEM2=I*100+
*10+K
540 EQS="N" & NEXT K & NEXT J & NEXT I & EQS="N" & RETURN
550 NRTT1(J,K)=NRTT & IF NRTT<0 THEN TNG1(J,K)=TNG1(J,K)+NRTT & TN1(J,K)=TN1(J,
) &SUB
560 IF CLSN$ <> "Y" THEN 2580
570 IF NRTT<0 THEN TNG1(J,K)=TNG1(J,K)-2*NRTT
580 IF NRTT<MNEG1(J,K) THEN MNEG1(J,K)=NRTT
590 RETURN
600 NRTT2(J,K)=NRTT & IF NRTT<0 THEN TNG2(J,K)=TNG2(J,K)+NRTT & TN2(J,K)=TN2(J,
) &SUB
610 IF NRTT<MNEG2(J,K) THEN MNEG2(J,K)=NRTT
620 IF CLSN$ <> "Y" THEN 2640
630 IF NRTT<0 THEN TNG2(J,K)=TNG2(J,K)-2*NRTT
640 RETURN
650 NRTT3(J,K)=NRTT & IF NRTT<0 THEN TNG3(J,K)=TNG3(J,K)+NRTT & TN3(J,K)=TN3(J,
) &SUB
660 IF CLSN$ <> "Y" THEN 2680
670 IF NRTT<0 THEN TNG3(J,K)=TNG3(J,K)-2*NRTT
680 IF NRTT<MNEG3(J,K) THEN MNEG3(J,K)=NRTT
690 RETURN
700 NRTT4(J.K)=NRTT & IF NRTT<0 THEN TNG4(J,K)=TNG4(J,K)+NRTT & TN4(J,K)=TN4(J,
) &SUB
710 IF CLSN$ <> "Y" THEN 2730
720 IF NRTT<0 THEN TNG4(J,K)=TNG4(J,K)-2*NRTT
730 IF NRTT<MNEG4(J.K) THEN MNEG4(J,K)=NRTT
740 RETURN
750 NRTT5(J.K)=NRTT & IF NRTT<0 THEN TNG5(J.K)=TNG5(J,K)+NRTT & TN5(J,K)=TN5(J,
) &SUB
760 IF CLSN$ <> "Y" THEN 2780
770 IF NRTT<0 THEN TNG5(J.K)=TNG5(J,K)-2*NRTT
780 IF NRTT<MNEG5(J.K) THEN MNEG5(J.K)=NRTT
790 RETURN
800 NRTT6(J.K)=NRTT & IF NRTT<0 THEN TNG6(J.K)=TNG6(J,K)+NRTT & TN6(J,K)=TN6(J,
) &SUB
810 IF CLSN$ <> "Y" THEN 2830
2820 IF NRTT<0 THEN TN66(J,K)=TN66(J,K)-2*NRTT
2830 IF NRTT<MNEG6(J,K) THEN MNEG6(J,K)=NRTT
2840 RETURN
2850 NRTT7(J,K)=NRTT & IF NRTT<0 THEN TN67(J,K)=TN67(J,K)+NRTT & TN7(J,K)=TN7(J,K)+NRTT & +SUB
360 IF NRTT<MNEG7(J,K) THEN MNEG7(J,K)=NRTT
370 IF CLNS<>"Y" THEN 2890
380 IF NRTT<0 THEN TN67(J,K)=TN67(J,K)-2*NRTT
390 RETURN
390 NRTT8(J,K)=NRTT & IF NRTT<0 THEN TN68(J,K)=TN68(J,K)+NRTT & TN8(J,K)=TN8(J,K)+NRTT & +SUB
410 IF NRTT<MNEG8(J,K) THEN MNEG8(J,K)=NRTT
420 IF CLNS<>"Y" THEN 2990
430 IF NRTT<0 THEN TN68(J,K)=TN68(J,K)-2*NRTT
440 RETURN
450 NRTT9(J,K)=NRTT & IF NRTT<0 THEN TN69(J,K)=TN69(J,K)+NRTT & TN9(J,K)=TN9(J,K)+NRTT & +SUB
460 IF NRTT<MNEG9(J,K) THEN MNEG9(J,K)=NRTT
470 IF CLNS<>"Y" THEN 2990
480 IF NRTT<0 THEN TN69(J,K)=TN69(J,K)-2*NRTT
490 RETURN
105 !*****************************************************************************************
106 !THE COLLISION ALGORITHM.
107 !LINES 3020 - 3300
108 !*****************************************************************************************
120 AF$="F" & IF INT ((PDS(SOURCE)-SAVESM*1000)/100)-INT (SAVESM/100) THEN AF$="I"
121 IF AF$="I" THEN PRINT "TRANSMISSION ON SAME A400 SOURCE/DEST = ";PDS(SOURCE & & CLNS="N" & GOTO 3260
122 IF CLNS="Y" THEN 3090
125 IF ABS (SMALL-SMALL2)<= .001 THEN PRINTER IS 701 ELSE GOTO 3260
140 PRINT "A COLLISION OCCURRED BETWEEN ";SAVESM," AND ";SAVESM:
150 I=INT (SAVESM/100) & L=INT (SAVESM2/100)
160 IF W(I)<=W(L) THEN 3090
170 SAVEIJK=SAVESM2 & NUMDEST=0 & SAVEATR=W(L) & TTG=TTGB+W(L) & TIMESTT(SOURCE & & TIMESTT(SOURCE)-1 & & CLNS="Y"
180 PROB=0 & CLNS="Y" & GOSUB 2320 & CLNS="N" & GOTO 2010
190 CN=CN+1 & PRINT "COLLISION NUMBER:";CN
200 I=INT (SAVESM/100) & J=INT (SAVESM/10)-I*10 & K=SAVESM-I*100-J*10
210 ON I GOSUB 3150,3160,3170,3180,3190,3200,3210,3220,3230
212 ON I GOSUB 3150,3160,3170,3180,3190,3200,3210,3220,3230
3140 GOTO 3240
3150 COL1(J,K)=COL1(J,K)+1 @ RETURN
3160 COL2(J,K)=COL2(J,K)+1 @ RETURN
3170 COL3(J,K)=COL3(J,K)+1 @ RETURN
3180 COL4(J,K)=COL4(J,K)+1 @ RETURN
3190 COL5(J,K)=COL5(J,K)+1 @ RETURN
3200 COL6(J,K)=COL6(J,K)+1 @ RETURN
3210 COL7(J,K)=COL7(J,K)+1 @ RETURN
3220 COL8(J,K)=COL8(J,K)+1 @ RETURN
3230 COL9(J,K)=COL9(J,K)+1 @ RETURN
3240 IF CLNS$="Y" THEN DT(SOURCE)=T(SOURCE) & CLNS$="N" ELSE DT(SOURCE)=T(SOURCE)+ (I) & CLNS$="N"
3250 GOTO 3300
3260 DT(SOURCE)=T(SOURCE)
3270 PRINT "NO COLLISION OCCURED " & IF PR=1 THEN PRINTER IS 1
3280 IF PR=3 THEN 3290 ELSE 3300
3290 IF ITERNUM> NUMITER- NUMCYCLES THEN 3300 ELSE PRINTER IS 1
3300 PRINT "DATA TRANSFER" ;DT(SOURCE) & IF AF$="T" THEN AF$="F" & GOTO 3320
3310 BBT=BBT+DT(SOURCE)
3320 PRINT " " & PRINT "PORT, DEVICE, SOURCE ACCUMULATED WAITING TIMES SINCE THE LAST TRANSMISSION"
3330 FOR I=1 TO HY & FOR J=1 TO DVW & FOR K=1 TO 3R(I,J)
3340 IF I*100+J*10+K=SAVEIJK THEN TLST=0 ELSE GOTO 3370
3350 ON I GOSUB 1850,1860,1870,1880,1890,1900,1910,1920,1930
3360 GOTO 3390
3370 TTGBSLT=DT(SOURCE) & TLST=999999
3380 ON I GOSUB 2210,2220,2230,2240,2250,2260,2270,2280,2290
3390 PRINT I:" ";J:" ";K:;TAB(30);TLST
3400 NEXT K & NEXT J & NEXT I
3410 TTGB=TTGB+DT(SOURCE)
3420 PRINT "DATA TRANSFER COMPLETED: TOTAL TIME GONE BY ";TTGB
3430 GOSUB 2310
3440 PRINT "NEXT TRANSMISSION REQUEST BY ";SAVESM & SAVEIJK-SAVESM
3450 TTNR=SMALL
3460 IF TTNR<0 THEN 3480
3470 TTGB=TTGB+TTNR
3480 TTGBSLT=TTNR & SAVESM=0 & SMALL=0 & SMALL2=0
3490 ! PRINT OUT CURRENT ENTRY DATA - EITHER FROM FILE OR USER ENTERED
3490 PRINT "TOTAL TIME THAT WILL BE GONE BY WHEN ";SAVESM;" STARTS TO TRANSMIT "
3500 TTGB
3505 NUMDEST=0 & PROB=0 & SAVEATR=TTNR & SAVESM=0
3506 !**********************************************************
3507 !**********************************************************
3508 ! SOURCE DUMP ALGORITHM LINES 3510 - 3590
3509 !**********************************************************
3510 FOR H=1 TO SNUM ; IF TIM(H)< TTGB-WT(H) THEN 3520 ELSE 3590
3520 WT(H)=TTGB & J=INT (DTFL(H)/1000) & K=INT ((DTFL(H)-J*1000)/100) & L=INT ((
3530 TFL(H)-J*1000-K*100)/10) & M=DTFL(H)-J*1000-K*100-L*10
3540 CP1=BYTES(H)=LT(J,K) & CP2=BYTES(H)=LT(L,M)
3550 PRINTER IS 701 & PRINT " " & PRINT "SOURCE ";J;" ;K;
3560 PRINT " TOTAL TIME GONE BY (BEFORE THE DUMP) ";;
3570 IF CP1>CP2 THEN TL=CP1 ELSE TL=CP2
3580 PRINT " TOTAL TIME GONE BY (AFTER THE DUMP) ";;
3590 IF PR=1 THE
3600 IF PR=3 THEN 3557 ELSE 3560
3610 IF ITERNUM>= NUMITER-NUMCYCLES THEN 3560 ELSE PRINTER IS 1
3620 FOR I=1 TO HY ; FOR J=1 TO DV(I) ; FOR K=1 TO 3R(I,J)
3630 ON I GOSUB 2210,2220,2230,2240,2250,2260,2270,2280,2290
3640 NEXT K ; NEXT J ; NEXT I
3650 NEXT H ; TTGBSLT=TNR
3660 IF ITERNUM=NUMITER-1 THEN 3610 ELSE ITERNUM=ITERNUM+1 & GOTO 2010
3670 PRINTER IS 701
3680 ! ****************************
3690 ! THE FINAL PRINTOUT GIVING A SUMMARY OF THE RUN
3700 ! LINES 3620 - 3830
3710 ! ****************************
3720 TOT=0 & PRINT " " & PRINT "SOURCE TO DESTINATION 
3730 TOT=TOTAL+TIME Truyền
3740 FOR I=1 TO NUMPROB & PRINT PDS(I);TAB (30);TIMESTT(I) ; TOT=TOT+TIMESTT(I)
3750 NEXT I
3760 PRINT "TOTAL";TAB (30);TOT
3770 PRINT "PORT,DEVICE,SOURCE LONGEST WAITING TIME AVG WAITING TIME COLLISIONS"
3780 FOR I=1 TO HY ; FOR J=1 TO DV(I) ; FOR K=1 TO 3R(I,J)
3790 ON I GOSUB 3720,3730,3740,3750,3760,3770,3780,3790,3806
3800 IF TN=0 THEN AVG=0 ELSE AVG=AVG-TNEG/TN
3810 PRINT I;" ";J;" ";K;TAB (25);MNEG;TAB (46);AVG;TAB (68);COLL
3820 NEXT K ; NEXT J ; NEXT I ; GOTO 3810
3830 MNEG=MNEG1(J,K) & TNEG=TNEG1(J,K) & TN=TN1(J,K) & COLL=COL1(J,K) & RETURN
3840 MNEG=MNEG2(J,K) & TNEG=TNEG2(J,K) & TN=TN2(J,K) & COLL=COL2(J,K) & RETURN
3850 MNEG=MNEG3(J,K) & TNEG=TNEG3(J,K) & TN=TN3(J,K) & COLL=COL3(J,K) & RETURN
3860 MNEG=MNEG4(J,K) & TNEG=TNEG4(J,K) & TN=TN4(J,K) & COLL=COL4(J,K) & RETURN
3870 MNEG=MNEG5(J,K) & TNEG=TNEG5(J,K) & TN=TN5(J,K) & COLL=COL5(J,K) & RETURN
3880 MNEG=MNEG6(J,K) & TNEG=TNEG6(J,K) & TN=TN6(J,K) & COLL=COL6(J,K) & RETURN
3890 MNEG=MNEG7(J,K) & TNEG=TNEG7(J,K) & TN=TN7(J,K) & COLL=COL7(J,K) & RETURN
3900 MNEG=MNEG8(J,K) & TNEG=TNEG8(J,K) & TN=TN8(J,K) & COLL=COL8(J,K) & RETURN
3910 MNEG=MNEG9(J,K) & TNEG=TNEG9(J,K) & TN=TN9(J,K) & COLL=COL9(J,K) & RETURN
3920 PRINT " TOTAL TIME GONE BY ";TTGB
320 PRINT "BUSY TIME = ": BBT
330 END

340 ! ****************************************************************************************************
345 ! PRINT OUT CURRENT DATA - EITHER FROM FILE OR ENTERED BY USER
346 ! LINES 3850 - 4200
347 ! ****************************************************************************************************
350 PRINTER IS 701
360 PRINT "/ OF HYPERCHANNEL PORTS = ": HY @ PRINT " 
370 FOR I=1 TO HY @ PRINT "/ OF DEVICES FOR PORT ": I;" = ": DV(I) @ NEXT I @ I=1
380 PRINT " 
390 FOR K=1 TO DV(I)
400 PRINT "/ OF SOURCES FOR PORT ": I;" DEVICE ": K;" = ": SR(I,K)
410 NEXT K @ I=1 @ IF I=HY THEN 3880 ELSE I=0 @ PRINT " 
420 PRINT "PORT,DEVICE,SOURCE AVERAGE ARRIVAL RATE # OF BYTES ACCRUED"
430 I=I+1 @ FOR J=1 TO DV(I) @ FOR K=1 TO SR(I,J)
440 ON I GOSUB 480,520,560,600,640,680,720,760,800
450 PRINT I;" ": J;" ": K:TAB (35);LA:TAB (60);QQ
460 NEXT K @ NEXT J
470 IF I=HY THEN 3970 ELSE GOTO 3920
480 PRINT " 
490 PRINT "PROPAGATION DISTANCE BETWEEN PORT ": I;" AND DEVICE ": J;" = ": D(I,J)
500 NEXT J @ NEXT I @ PRINT " 
510 FOR I=1 TO HY
520 PRINT "WAIT TIME OF PORT ": I;" BEFORE TRANSMISSION REQUEST (IN EVENT OF A COLLISION) ": W(I)
530 NEXT I
540 PRINT " 
550 PRINT "CHANNEL SETUP AND RELEASE TIME = ": TSR @ PRINT " 
560 PRINT "CHANNEL DATA TRANSFER RATE = ": CR
570 PRINT " 
580 PRINT "PORT,DEVICE TRANSFER RATE LOAD TIMES"
590 FOR I=1 TO HY @ FOR J=1 TO DV(I)
600 PRINT I;" ": J:TAB (30);R(I,J);TAB (54);LT(I,J)
610 NEXT J @ NEXT I
620 PRINT " 
630 PRINT "COMBINATIONS (IJK - LMN) PROBABILITY TIME TO TRANSMIT (IJK) BYTES (IJK - LMN)"
640 FOR I=1 TO NUMPROB
650 PRINT PDS(I);TAB (30);PRO(I);TAB (40);T(I)
660 NEXT I
670 PRINT " 
680 PRINT "PORT,DEVICE,SOURCE AVERAGE TIME TO NEXT TRANSMISSION REQUEST"
690 FOR I=1 TO HY @ FOR J=1 TO DV(I) @ FOR K=1 TO SR(I,J)
700 ON I GOSUB 480,520,560,600,640,680,720,760,800
4160 PRINT I:"";J."";K:TAB (30);ATR
4170 NEXT K @ NEXT J @ NEXT I
180 PRINT "";PRINT "IJ-LM DATA FILE DUMP     BYTES TO BE DUMPED   TIME BETWEEN
   DUMPS (IN SECONDS)"
190 FOR I=1 TO SNUM @ PRINT DTLFL(I):TAB (30):BYTES(I):TAB (50):TIM(I)
200 NEXT I @ GOTO 1720
210 !******************************************************************************
215 ! THE EDIT ROUTINE - SAVES CORRECTED DATA TO FILE
216 ! LINES 4220 - 4950
217 !******************************************************************************
220 CLEAR & DISP "     EDIT MENU" & DISP ""
230 DISP "1 -- AVERAGE ARRIVAL RATES"
240 DISP "2 -- NUMBER OF BYTES ACCUMULATED"
250 DISP "3 -- PROPAGATION DISTANCES"
260 DISP "4 -- WAIT TIMES"
270 DISP "5 -- CHANNEL SETUP AND RELEASE TIME"
280 DISP "6 -- CHANNEL DATA TRANSFER RATE"
290 DISP "7 -- TRANSFER RATES"
300 DISP "8 -- PROBABILITY DATA"
310 DISP "9 -- SOURCE DATA DUMPS"
320 DISP "10 -- TERMINATE EDIT MODE"
330 DISP "" & DISP "ENTER YOUR SELECTION ";@ INPUT EDT
340 IF EDT<1 OR EDT>10 THEN 4210
350 ON EDT GOTO 4360,4450,4540,4590,4630,4660,4690,4760,4850,4950
360 FOR I=1 TO HY @ CLEAR @ FOR J=1 TO DV(I) & FOR K=1 TO SR(I,J) @ CLEAR
370 ON I GOSUB 480.520,560,600,640,680,720,760,800
380 DISP "PORT ";I;" DEVICE ";J;" SOURCE ";K & DISP & DISP
390 LA(J,K)=LA @ QQ(J,K)=QQ
400 DISP "AVERAGE ARRIVAL RATE = ";LA
410 QQ=$";" DISP ";" DISP ";" DISP "PRESS ENTER TO RETAIN CURRENT DATA OR
420 IF QQ <> "" THEN LA(J,K)=VAL (QQ)
430 NEXT K @ NEXT J @ ON I GOSUB 450,490,530,570,610,650,690,730,770
440 NEXT I @ GOTO 4210
450 FOR I=1 TO HY @ CLEAR @ FOR J=1 TO DV(I) & FOR K=1 TO SR(I,J) @ CLEAR
460 ON I GOSUB 480,520,560,600,640,680,720,760,800
470 DISP "PORT ";I;" DEVICE ";J;" SOURCE ";K & DISP & DISP
480 QQ(J,K)=QQ @ LA(J,K)=LA
490 DISP "NUMBER OF BYTES ACCUMULATED = ";QQ
500 QQ=$";" DISP ";" DISP ";" DISP "PRESS ENTER TO RETAIN CURRENT DATA OR
510 IF QQ <> "" THEN QQ(J,K)=VAL (QQ)
520 NEXT K @ NEXT J @ ON I GOSUB 450,490,530,570,610,650,690,730,770
530 NEXT I @ GOTO 4840
540 CLEAR @ FOR I=1 TO HY @ FOR J=1 TO DV(I) @ CLEAR
550 DISP "PROPAGATION DISTANCE BETWEEN PORT ";I:" AND DEVICE ";J:" IN MICROSEC
560 DS=":D(I,J) @ Q$=""
560 DISP "" @ DISP "PRESS ENTER TO RETAIN CURRENT DATA OR ENTER THE CORRECT VA
570 INPUT Q$ 580 IF Q$ <> "" THEN D(I,J)=VAL (Q$)
590 NEXT J @ NEXT I @ GOTO 4210
590 CLEAR @ FOR I=1 TO HY @ CLEAR @ DISP "WAIT TIME OF PORT ";I:" BEFORE TRANSMA
600 SESSION REQUEST = ";:W(I)
610 Q$="" @ DISP "" @ DISP "PRESS ENTER TO RETAIN CURRENT DATA OR ENTER THE C
620 INPUT Q$ IF Q$ <> "" THEN W(I)=VAL (Q$)
630 NEXT I @ GOTO 4210
640 CLEAR @ DISP "CHANNEL SETUP AND RELEASE TIME = ";:TSR
650 Q$="" @ DISP "" @ DISP "PRESS ENTER TO RETAIN CURRENT DATA OR ENTER THE PRO
660 PER VALUE ";:INPUT Q$ IF Q$ <> "" THEN TSR=VAL (Q$)
670 Q$="" @ DISP "" @ DISP "PRESS ENTER TO RETAIN CURRENT DATA OR ENTER THE PROPER VALUE
680INPUT Q$ IF Q$ <> "" THEN CR=VAL (Q$)
690 GOTO 4840
700 CLEAR @ FOR I=1 TO HY @ FOR J=1 TO DV(I) @ CLEAR
710 DISP "RATE AT WHICH DATA IS TRANSFERRED FROM DEVICE ";J:" TO PORT ";I:" = "":
720 I,J
730 Q$="" @ DISP "" @ DISP "PRESS ENTER TO RETAIN CURRENT DATA OR ENTER THE C
740 RECT VALUE ";:INPUT Q$
750 IF Q$ <> "" THEN R(I,J)=VAL (Q$)
760 LT(I,J)=1/R(I,J)
770 NEXT J @ NEXT I
780 GOTO 4840
790 CLEAR @ FOR I=1 TO NUMPROB
800 CLEAR @ DISP " (PORT,DEVICE,SOURCE) TRANSMITS TO (PORT,DEVICE,SOURCE) CODE
810 PDS(I) @ DISP ""
820 Q$="" @ DISP "PRESS ENTER TO RETAIN CURRENT DATA OR ENTER THE CORRECT VA
830 LINPUT Q$
840 IF Q$ <> "" THEN PDS(I)=VAL (Q$)
850 DISP "" @ DISP "PROBABILITY = ";PRJ(I) @ DISP ""
860 Q$="" @ DISP "PRESS ENTER TO RETAIN CURRENT DATA OR ENTER THE CORRECT VALU
870 INPUT Q$
880 IF Q$ <> "" THEN PRJ(I)=VAL (Q$)
1830 NEXT I
1840 FOR I=1 TO NUMPROB @ GOSUB 1160 @ NEXT I @ GOTO 4210
1850 CLEAR @ FOR I=1 TO SNUM @ CLEAR @ DISP "(IJ - LM) SOURCE DATA FILE DUMPS TO
DESTINATION LM. CODE = ";DTFL(I) @ DISP ""
1860 QS="" @ DISP "PRESS ENTER TO RETAIN CURRENT DATA OR ENTER THE CORRECT VALU
: ";# INPUT QS
1870 IF QS <> "" THEN DTFL(I)=VAL (QS)
1880 DISP " " @ DISP "# OF BYTES TO BE DUMPED ";BYTES(I) @ DISP ""
1890 QS="" @ DISP "PRESS ENTER TO RETAIN CURRENT DATA OR ENTER THE CORRECT VALU
: ";# INPUT QS
1900 IF QS <> "" THEN BYTES(I)=VAL (QS)
1910 DISP " " @ DISP "TIME INTERVAL BETWEEN DUMPS ";TIM(I) @ DISP ""
1920 QS="" @ DISP "PRESS ENTER TO RETAIN CURRENT DATA OR ENTER THE CORRECT VALU
: ";# INPUT QS
1930 IF QS <> "" THEN TIM(I)=VAL (QS)
1940 NEXT I @ GOTO 4210
1950 @GETDATA=808 @ ON AN GOTO 1350,1720,1350
APPENDIX II

PASCAL SIMULATIONS ALGORITHM PROGRAM

A listing of the PASCAL simulation algorithm program is presented in this appendix. The program contains comments, but is not considered to be user oriented at this point. This program is FORTRAN based, but requires software support for PASCAL in the host computer.
```c
003256  -  A  end;  (*  PRINT  NETWORK  STATS  *)
003256  -  A
003260  -  (*)
003260  -  function  TRANSFER_TIME(SENDER,RECEIVER,  
003260  -  DEVICE_RECORD);  real;
003260  -  (*  Calculates  time  required  to  transmit  a  message  *)
003260  -  (*  from  a  sender  to  a  receiver  *)
003260  -  (*  Trunk  overhead  time  includes  the  fixed  delay  for  each  *)
003260  -  (*  adapter  plus  length  of  time  required  by  a  sending  *)
003260  -  (*  device  to  receive  a  response  frame  *)
003260  -  (*
003260  -  *)
003260  -  var
003260  -  SLOWER_RATE:  real;
003260  -  PKCT CT:  integer;
003260  -  begin
003260  -  SLOWER_RATE:  =  SENDER.TFSR_RATE;
003260  -  if  RECEIVER.TFSR_RATE  <  SLOWER_RATE  then
003260  -  SLOWER_RATE:  =  RECEIVER.TFSR_RATE;
003260  -  PKCT CT:  =  round(SENDER.BUFFER_SIZE/2048);
003260  -  case  PKCT CT  of
003260  -  0:  T:=TRUNK_OVERHEAD;
003260  -  1:  T:=2048/TRUNK_RATE+TRUNK_OVERHEAD;
003260  -  otherwise:  T:=2048/SENDER.TFSR_RATE+2048/TRUNK_RATE+
003260  -  ((PKCT CT-2)*2048)/SLOWER_RATE+TRUNK_OVERHEAD
003260  -  end;
003260  -  TRANSFER_TIME:=T;
003260  -  end;
003260  -  (*
003260  -  (*)
003260  -  procedure  UPDATE_CLOCKS(COND,CLOCK_COND);
003260  -  (*  Update  both  the  system  clocks  and  device  *)
003260  -  (*  clocks  whenever  a  system  action  has  *)
003260  -  (*  occurred  *)
003260  -  (*
003260  -  *)
003260  -  var
003260  -  TA,TD,RA,RD;
003260  -  T1  :  integer;
003260  -  DELAY_TIME;
003260  -  TIME,T1  :  real;
003260  -  begin
003260  -  (*  A  is  transmitter  adapter  no.,  D  is  device  no.  *)
003260  -  A
003260  -  (*
003260  -  *)
003260  -  begin
003260  -  (*
003260  -  *)
003260  -  case  COND  of
003260  -  NORMAL:  begin
003260  -  TIME:=TRANSFER_TIME(THITTR,RCVR);
003260  -  BITS_TX:=BITS_TX+THITTR.BUFFER_SIZE;
003260  -  (*  Update  system  clock  *)
003260  -  CURRENT_TIME:=CURRENT_TIME+TIME;
003260  -  (*  update  each  device  clock  *)
```
for j := 1 to NUM_OF_ADAPTERS do
  for i := 1 to 6 do
    with ADAPTER[i] DEVICE[j] do
      if (NOT (OPEN)) and (NOT (TA=1)) and (TD=J) then
      begin
        NEXT_RX <= CURRENT_TIME then
        begin
          DELAY_TIME:=ADAPTER[i].PRIORITY_DELAY + ADAPTER[i].END_DELAY;
          NEXT_RX := CURRENT_TIME + DELAY_TIME;
          WAIT_STATUS:=WAIT_STATUS + 1;
          WAIT_TIME:=WAIT_TIME + DELAY_TIME + DELAY_TIME;
        end;
      if PRINT_ALL then
        OTT: = 10 * ADAPTER[i].DEVICE[j];
      end; (* NEXT_RX <= A *)
    end;
    (* Reset transmitter clock *)
    with ADAPTER[i] DEVICE[j] do
    begin
      NEXT_TX := CURRENT_TIME + TX_INTRVL;
      LAST_TRUNK_TX := CURRENT_TIME;
      TX_TIME := TX TIME + TIME;
      (* with ADAPTER[i] DEVICE[j] *)
    end;
    with ADAPTER[i] DEVICE[j] do
    begin
      RX_TIME := RX_TIME + TIME;
      (* with ADAPTER[i] DEVICE[j] *)
    end;
    TIME_ACTIVE := TIME_ACTIVE + TRANSFER_TIME(TMTR, RCVR);
  end; (* NORMAL case *)
  COLLISION := begin
    with ADAPTER[i] DEVICE[j] do
    begin
      TIM: = (UNIFORM(0.00, 1.00)) * (1.0/COLL_EPS);
      NEXT_TX := NEXT_TX + 1;
      COLL_CT := COLL_CT + 1;
      COLL_TIME := COLL_TIME + 1;
    end;
  end; (* COLLISION case *)
  OTHER := begin
    (* OTHER case *)
  end; (* OTHER case *)
end; (* case *)

(* UPDATE CLOCKS *)

function TX_INTERVAL (DEVICE : DEVICE_RECORD) : real;
(*) Calculates the time interval between transmissions. Based on the amount (*)
(*) of data (rate) received by a device from an off-net sources and the size of the device (*)
(*) buffer.

var
  I : integer;
  AGGREGATE_RATE: real;
  A := 0
begin
  AGGREGATE_RATE := 0.00;
  for I := 1 to DEVICE.NUM_OF_SOURCES do
    for
begin
AGGREGATE_RATE := AGGREGATE_RATE + DEVICE_SOURCE[i].TX_RATE
end;

if AGGREGATE_RATE <> 0.0 then
  TX_INTERVAL := DEVICE.BUFFER_SIZE / AGGREGATE_RATE
else
  TX_INTERVAL := 1E7;
end;

procedure FIND_NEXT(transmitter:TRANSMITTER;device:DEVICE_RECORD);
  (* Determines the next transmitter by examining *)
  (* each device's next time until next transmission *)
  (* Next transmitter is device with shortest time until *)
  (* next transmission. *)
end;

var
  i,j : integer;
begin
AGGREGATE_RATE := AGGREGATE_RATE + DEVICE.SOURCE[i].TX_RATE
end;

for i := 1 to NUM_OF_ADAPTERS do
  for j := 1 to 4 do
    with ADAPTER[i],DEVICE[j] do
      if NOT OPEN then
        if NEXT_TX < TX_INTERVAL then
          TRANSMITTER := ADAPTER[i],DEVICE[j];
end; (* FIND NEXT TRANSMITTER *)

procedure PICK A(var RECEIVER:DEVICE_RECORD;sender:DEVICE_RECORD);
  (* Picks an eligible receiver for the current *)
  (* transmitter based on the normalized transmission *)
  (* probability matrix. *)
begin
  var
    i,j,k,l : integer;
    FOUND : boolean;
    PROB : real;
  begin
    PROB := UNIFORM(zero,one,0);
    i := SENDER.DEV_NUM div 100;
    j := 1;
    while (PR[i,j] < PROB) and (j < D_NUM) do
      j := j+1;
    A := i;
    K := j;
    FOUND := false;
    while (K < NUM_OF_ADAPTERS) and (not FOUND) do
      begin
        while (L <= 4) and (not FOUND) do
          begin
            with ADAPTER[K],DEVICE[L]
          begin
end;
BEGIN  (procedure CHARACTERIZE_NETWORK)

  רגלינ(TERMIDUAL,"Input mode: INTERACTIVE or FILE");

   if (RESP11 = "1") or (RESP21 = "1")

   begin

      INPUT_MODE := INTERACTIVE
   end

   else INPUT_MODE := FILE_INPUT;
   end;

(* Begin description of network by describing adapters *)

CASE INPUT_MODE OF

INTERACTIVE : begin

   writeln("*******************************************************************");

   writeln("DESCRIPTION OF NETWORK");

   writeln(DEVICE BY DEVICE -- ADAPTER BY ADAPTER");
   end;

for J := 1 to NUM_OF_ADAPTERS do

   begin

      with ADAPTER[I,J] do

         begin

            writeln("Adapter ", I:2, ");

            for J := 1 to NUM_OF_ADAPTERS do

               if J = 1 then J := J + 1;

               while J <= MAX_NUM_ADAPTERS do

                  begin

                     writeln(TERMIDUAL, "2: Propagation distance in sec to adapter ", J:2,

                     in ");

                     readin(TERMIDUAL, PROP DIST [I,J]);

                     J := J + 1;

                  end;

                  writeln(TERMIDUAL, "2: Adapter ", J:2,

                  fixed delay in sec is ");

                  readin(TERMIDUAL, PRIORITY DELAY);

                  end;

                  writeln(TERMIDUAL, "2: Adapter ", J:2,

                  fixed delay in sec is ");

                  readin(TERMIDUAL, PRIORITY DELAY);

end;
J:=J+1;  
end; (* while J<=4 *)  
if J=1 then J:=J+1;  
while (J>1) and (J<MAX_NUM_ADAPTERS) do  
begin  
write(AUX_OUT,":=","Priority message polynomial,"j=2,"+");  
write(AUX_OUT,PROP_DISTANCE:no_adapter_;j=2,"+");  
LCT:=LCT+1;  
J:=J+1;  
end; (* while J>1 AND <= MAX_NUM OF ADAPTERS *);  
write(AUX_OUT);  
LCT:=LCT+1;  
write(AUX_OUT,":=","Priority delay:"+");  
write(AUX_OUT,PRIORITY_DELAY:9.7, sec");  
LCT:=LCT+1;  
write(AUX_OUT,":=","End delay:"+");  
write(AUX_OUT,END_DELAY:9.75, sec");  
write(AUX_OUT);  
LCT:=LCT+1;  
(e Begin individual device descriptions *)  
for J:= 1 to 4 do  
begin  
with ADAPTER(J),DEVICE(J) do  
begin  
write(AUX_OUT);  
LCT:=LCT+1;  
write(AUX_OUT,":=","Device number",DEV_NUM:2);  
write(AUX_OUT,":=","Device":,j=2);  
write(AUX_OUT,":=","Status":,j=2);  
if OPEN then begin write(AUX_OUT,":=","OPEN");  
LCT:=LCT+1;  
end  
else write(AUX_OUT,":=","CLOSED");  
if not(OPEN) then  
begin  
write(AUX_OUT,":=","2","Device number":,DEV_NUM:2);  
write(AUX_OUT,":=","Device":,j=2);  
write(AUX_OUT,":=","Status":,j=2);  
LCT:=LCT+1;  
end  
write(AUX_OUT,":=","3","Size":,j=2);  
write(AUX_OUT,":=","Buffer size":,j=2);  
write(AUX_OUT,BUFFER_SIZE DIV 16, Bytes");  
LCT:=LCT+1;  
write(AUX_OUT,":=","3","170 bus transfer rate:");  
write(AUX_OUT,":=","BPS");  
LCT:=LCT+1;  
write(AUX_OUT,":=","3","Load time:");  
write(AUX_OUT,LOAD_TIME:12.7, sec");  
LCT:=LCT+1;  
write(AUX_OUT,":=","3","Number of offset sources:");  
write(AUX_OUT,NO_OFFSET:SOURCES:3);  
LCT:=LCT+1;  
for K:=1 to NUM_OF_SOURCES do  
begin  
write(AUX_OUT,":=","3","Source K":,K=2,"transmission rate:");  
write(AUX_OUT,SOURCE(K),TX_RATE:9.29, BPS");  
LCT:=LCT+1;  
end  
(* for K:=1 to num of sources *)  
write(AUX_OUT,":=","3","Trunk transmission interval:");  
write(AUX_OUT,TRN_INTRVL:7.4, sec");  
LCT:=LCT+1;  
end  
(* if not OPEN *)  
end; (* with ADAPTER(J),DEVICE(J) *)  
end; (* for J=1 TO 4 *)  
end; (* with ADAPTER(*) *)  
NEWPAGE;  
write(AUX_OUT,":=","6","CUMULATIVE PROBABILITY OF TRANSMISSION MATRIX");  
write(AUX_OUT);  
LCT:=LCT+1;  
write(AUX_OUT,":=","5");  
for J:=1 to MAX_NUM_ADAPTERS do  
for J:=1 to 4 do  
with ADAPTER(J),DEVICE(J) do  
if not OPEN then  
write(AUX_OUT,1.6,J=1);
-- write(AUX_OUT); LCT:=LCT+1;

for I := 1 to NUM_OF_ADAPTERS do
  for J := 1 to Z do
    with ADAPTER[I].DEVICE[J] do
      if not OPEN then begin
        write(AUX_OUT,1:I,J); PWS:=PWS+1;
        for K := 1 to B_NUM do
          begin
            write(AUX_OUT,PREF,W); LCT:=LCT+1;
            end;
            (* for K := 1 to B_NUM *)
        write(AUX_OUT); LCT:=LCT+1;
        end; (* not OPEN *)
      end; (* procedure PRINT DESCRIPTION *)

(* procedure CREATE_DESCRIPTOR *)

rewrite(DESCRIPTOR_FILE);

for I := 1 to NUM_OF_ADAPTERS do
  begin
    with ADAPTER[I] do
      begin
        while J < I do begin
          write(DESCRIPTOR_FILE,PREF_DIST_TOE[J]);
          end;
          (* while J < I *)
        if J = I then J := J+1;
        while (J < I) and (J < MAX_NUM_ADAPTERS) do begin
          write(DESCRIPTOR_FILE,PROP_DIST_TOE[J]);
          J := J+1;
          end; (* while J < I AND < MAX_NUM_ADAPTERS *)
        write(DESCRIPTOR_FILE,PRIORITY_DELAY);
        write(DESCRIPTOR_FILE,END_DELAY);
        (* Begin individual device descriptions *)
        for J := 1 to 4 do
          begin
            with ADAPTER[I].DEVICE[J] do
              begin
                write(DESCRIPTOR_FILE,OPEN); begin
                if not(OPEN) then begin
                  write(DESCRIPTOR_FILE,DEV_NUM); begin
                  write(DESCRIPTOR_FILE,BUFFER_SIZE);
                  write(DESCRIPTOR_FILE,TRANSFER_RATE);
                  write(DESCRIPTOR_FILE,NUM_OF_SOURCES);
                  for K := 1 to NUM_OF_SOURCES do begin
                    write(DESCRIPTOR_FILE,SOURCE(K).X); begin
                    end; (* for K := 1 to num of sources *)
                  end; (* if not(OPEN) *)
                end; (* for J := 1 to 4 *)
              end; (* with ADAPTER[I].DEVICE/J do *)
            end; (* for J := 1 to num of adapters *)
          end; (* with ADAPTER[I] do *)
        end; (* rewrite(DESCRIPTOR_FILE) *)
      end; (* with ADAPTER[I] do *)
    end; (* for I := 1 to NUM_OF_ADAPTERS *)
(* write the probability matrix *)
for J := 1 to D_NUM do
  begin
    for J := 1 to D_NUM do
      writer(DESCRIP_FILE, PR[I, J]);
      writer(DESCRIP_FILE);
    end;
end; (* procedure CREATE *)

begin (* main program *)

(* New run initializations *)
for COND1 := NORMAL to OTHER do
  CONDITION[COND1] := COND1;
  PRINT_ALL := true;
  U := 31622 ; (* U is seed for RNG *)
  WAIT_TALL := 0;
  COLLISION_TALL := 0;
  TOTAL_ATTEMPTS := 0;
  LOR := 0;
  TIME_ACTIVE := 0.0;
  BITS_PA := 0;
  writer(TERMINAL, "Maximum run time in secs?");
  read(TERMINAL, MAX_TIME);

  writer(TERMINAL, "Maximum successful transmissions?");
  read(TERMINAL, MAX_TX);

  writer;
  write(TERMINAL, "Seed for random number generator?");
  read(TERMINAL, U); ID := U;
  writer;

  write(TERMINAL, "PRINT_ALL condition on?";
  if (RESP[1] = 'y') then PRINT_ALL := true
  else PRINT_ALL := false;
  writer;

(* Network cold start conditions *)

CHARACTERIZE_NETWORK;

page(OUTPUT);
CREATE_DESCRIP_FILE;

PRINT_NET_DESCRIPTION;
FIND_NEXT(TITTIR);
CURRENT_TIME := TRITIR.NEXT_TX;

(* Network steady state operation *)
repeat (* until time exceeds max time *)
PICK_A(PCVR,MTTR);

(* Calculate a collision probability *)

if not A_COLLISION then
begin
   TX_TALLY := TX_TALLY +1;
   UPDATE_CLOCKS(CONDITION(NORMAL));
end

if PRINT_ALL then
   PRINT_TX_STATS(TMITR,RCVR);

FIND_NEXT(TMITR);

CURRENT_TIME := TMITR.NEXT_TX;

end

else
begin
   COLLISION_TALLY := COLLISION_TALLY +1;
   UPDATE_CLOCKS(CONDITION(COLLISION));
end

if PRINT_ALL then
   PRINT_COLLISION_STATS(TMITR,RCVR);

FIND_NEXT(TMITR);

CURRENT_TIME := TMITR.NEXT_TX;

end; (* if *)

until (CURRENT_TIME >= MAX_TIME) or (TX_TALLY >= MAX_TX);

TOTAL_ATTEMPTS := TX_TALLY + COLLISION_TALLY;

PRINT_NETWORK_STATS;

ACTIVITY_SUMMARY;

writeln(" END OF RUN");

end. (* main program *)

Compilation complete - no errors found.

 Original Page is of Poor Quality
### End of Run Summary

Current Time: 36.6361 secs

<table>
<thead>
<tr>
<th>Successful transmissions</th>
<th>500</th>
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</thead>
<tbody>
<tr>
<td>Collisions</td>
<td>25</td>
</tr>
<tr>
<td>Wait</td>
<td>529</td>
</tr>
<tr>
<td>Total attempts</td>
<td>529</td>
</tr>
<tr>
<td>Total time active</td>
<td>1.7105 secs</td>
</tr>
<tr>
<td>Total active time</td>
<td>6.67%</td>
</tr>
<tr>
<td>Total bytes transmitted</td>
<td>987360</td>
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</table>

Seed for RNG: 312577

END OF RUN
### END OF RUN NETWORK STATISTICS ###

Current time: 35,4361 secs

Successful transmissions: 520
Collisions: 20
Wait: 529
Total attempts: 529

Total time active: 1.212525 secs
% Total time active: 4.698

Total bytes transmitted: 987360
Seed for RNG: 332577

#### DEVICE ACTIVITY SUMMARIES (SECOND)

<table>
<thead>
<tr>
<th>ADP #</th>
<th>DEV #</th>
<th>TIME TRANSMITTING</th>
<th>TIME WAITING</th>
<th>TIME IN COLLISIONS</th>
<th>TIME RECEIVING</th>
<th>TIME ACTIVE</th>
<th>TRANSMISSION COUNT</th>
<th>RECEPTION COUNT</th>
<th>WAIT COUNT</th>
<th>COLLISION COUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0.9192</td>
<td>0.3897</td>
<td>0.0273</td>
<td>0</td>
<td>1.3357</td>
<td>252</td>
<td>0</td>
<td>39</td>
<td>20</td>
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<tr>
<td>2</td>
<td>1</td>
<td>0.2711</td>
<td>0.4398</td>
<td>0.0045</td>
<td>0</td>
<td>0.7155</td>
<td>35</td>
<td>0</td>
<td>37</td>
<td>3</td>
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<tr>
<td>2</td>
<td>2</td>
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<td>0.0012</td>
<td>0.4355</td>
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<td>1</td>
<td>1</td>
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<td>0.7533</td>
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<td>3</td>
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<tr>
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<tr>
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<td>3</td>
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</table>

#### DEVICE ACTIVITY SUMMARIES (PERCENT)

<table>
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<tr>
<th>ADP</th>
<th>DEV</th>
<th>% TIME active</th>
<th>% TIME TRANSMITTING</th>
<th>% TIME RECEIVING</th>
<th>% TIME IN COLLISIONS</th>
<th>% TIME IN DEVICES</th>
<th>% TIME IN COLLISIONS</th>
<th>% TIME IN DEVICES</th>
</tr>
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<td>1</td>
<td>76.15</td>
<td>9.27</td>
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<td>7.15</td>
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<td>1.26</td>
<td>2.21</td>
<td>0.37</td>
<td>0.06</td>
<td>0.11</td>
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<td>3</td>
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<td>2.40</td>
<td>0.11</td>
<td>0.64</td>
<td>0.71</td>
<td>0.25</td>
<td>0.28</td>
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<td>2</td>
<td>20.77</td>
<td>2.40</td>
<td>0.11</td>
<td>0.43</td>
<td>0.71</td>
<td>0</td>
<td>0</td>
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<td>3</td>
<td>8.72</td>
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</table>
### NETWORK DESCRIPTION

**Adapter #2**

<table>
<thead>
<tr>
<th>Propagation distance to adapter 1:</th>
<th>0 sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propagation distance to adapter 2:</td>
<td>0 sec</td>
</tr>
<tr>
<td>Priority delay:</td>
<td>0.000020 sec</td>
</tr>
<tr>
<td>End delay:</td>
<td>0.000020 sec</td>
</tr>
</tbody>
</table>

**Device 1**
- Status: CLOSED
- Device number: 221
- Buffer size: 4000 Bytes
- 1/0 bus transfer rate: 50000.00 Bps
- Load time: 0.000020 sec
- Number of offset sources: 1
- Source #1 transmission rate: 50000.00 Bps
- Trunk transmission interval: 1.0000 sec

**Device 2**
- Status: CLOSED
- Device number: 322
- Buffer size: 6400 Bytes
- 1/0 bus transfer rate: 50000.00 Bps
- Load time: 0.000020 sec
- Number of offset sources: 1
- Source #1 transmission rate: 50000.00 Bps
- Trunk transmission interval: 1.0000 sec

**Device 3**
- Status: OPEN

**Device 4**
- Status: OPEN
## NETWORK DESCRIPTION

### Adapter # 3

<table>
<thead>
<tr>
<th>Propagation distance to adapter 1</th>
<th>0 sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propagation distance to adapter 2</td>
<td>0 sec</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Priority delay</th>
<th>0 sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>End delay</td>
<td>0.00032 sec</td>
</tr>
</tbody>
</table>

### Device 1 status: CLOSED

<table>
<thead>
<tr>
<th>Device number</th>
<th>531</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer size</td>
<td>512 Bytes</td>
</tr>
<tr>
<td>I/O bus transfer rate</td>
<td>500000.00 Bps</td>
</tr>
<tr>
<td>Load time</td>
<td>0.000002 sec</td>
</tr>
<tr>
<td>Number of offset sources</td>
<td>1</td>
</tr>
<tr>
<td>Source # 1 transmission rate</td>
<td>1000.00 Bps</td>
</tr>
<tr>
<td>Trunk transmission interval</td>
<td>0.512 sec</td>
</tr>
</tbody>
</table>

### Device 2 status: CLOSED

<table>
<thead>
<tr>
<th>Device number</th>
<th>532</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer size</td>
<td>512 Bytes</td>
</tr>
<tr>
<td>I/O bus transfer rate</td>
<td>500000.00 Bps</td>
</tr>
<tr>
<td>Load time</td>
<td>0.000002 sec</td>
</tr>
<tr>
<td>Number of offset sources</td>
<td>1</td>
</tr>
<tr>
<td>Source # 1 transmission rate</td>
<td>1000.00 Bps</td>
</tr>
<tr>
<td>Trunk transmission interval</td>
<td>0.512 sec</td>
</tr>
</tbody>
</table>

### Device 3 status: CLOSED

<table>
<thead>
<tr>
<th>Device number</th>
<th>633</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer size</td>
<td>624 Bytes</td>
</tr>
<tr>
<td>I/O bus transfer rate</td>
<td>500000.00 Bps</td>
</tr>
<tr>
<td>Load time</td>
<td>0.050000 sec</td>
</tr>
<tr>
<td>Number of offset sources</td>
<td>1</td>
</tr>
<tr>
<td>Source # 1 transmission rate</td>
<td>625.00 Bps</td>
</tr>
<tr>
<td>Trunk transmission interval</td>
<td>0.9954 sec</td>
</tr>
</tbody>
</table>

### Device 4 status: OPEN