N95- 18186

1994 NASA/ASEE SUMMER FACULTY FELLOWSHIP PROGRAM

111771

JOHN F. KENNEDY SPACE CENTER
UNIVERSITY OF CENTRAL FLORIDA

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p. 23

PERFORMANCE EVALUATION OF THE NASA/KSC CAD/CAE AND OFFICE AUTOMATION LAN's

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DATE:	August 5, 1994
CONTRACT NUMBER:	University of Central Florida NASA-NGT-60002 Supplement: 17

[redacted]

ACKNOWLEDGMENTS

This is to acknowledge the support of Mr. F. Rico-Cusi and Mr. Hank Perkins of DL-DSD-22 and Mr. Shawn Riley and Mr. Mark Sorger of EG&G. They were very helpful in the initial guidance of this research effort and in obtaining the necessary resources. Ms. Joy Maldonado and Mr. Ed Bertot of DL-DSS-22 are also thanked for additional support.

Additionally, I wish to acknowledge the administrative support of Dr. Loren Anderson and Ms. Kari Stiles, University of Central Florida, and Mr. Bill J. Martin, Program Director, NASA/KSC.

ABSTRACT

This studies objective is the performance evaluation of the existing CAD/CAE network at NASA/KSC. This evaluation also includes a similar study of the Office Automation network, since it is being planned to integrate this network into the CAD/CAE network. The Microsoft mail facility which is presently on the CAD/CAE network was monitored to determine its present usage.

This performance evaluation of the various networks will aid the NASA/KSC network managers in planning for the integration of future workload requirements into the CAD/CAE network and determining the effectiveness of the planned FDDI migration.

SUMMARY

The Computer Aided Design/Computer Aided Engineering (CAD/CAE) network at Kennedy Space Center is composed of segmented Local Area Networks (LAN). These segmented LAN's are to be interconnected through an intelligent switch. At present this LAN is a segmented Ethernet network. The design/engineering workstations are various Intergraph and Digital Equipment Corporation products, mainly. The host is a VAX cluster and there are several Intergraph servers, for plotting/printing/disk storage.

In a NASA/KSC report presented in 1988 the Ethernet peak utilization was under 3% and there were only fourteen Intergraph workstations on the Headquarters LAN. At present utilizations of 80% have been observed in short bursts and 10-25% averaged over longer time periods. There are presently 58 workstations on the NASA/KSC HQ LAN. The Microsoft mail facility and the planned integration of the Office Automation network should have minimal impact, since they have average usage of less than 3-4% at the present time.

An intelligent switch is presently being installed for high speed switching. This is used to bridge multiple LAN's, either FDDI, Ethernet, Token Ring or others. The intelligent switch offers many advantages over shared channel LAN's. The advantages include an increase in the bandwidth, latency (propagation delay) reduction, an increase in connectivity, and better traffic management.

This configuration should increase throughput due to the Ethernet LAN segmentation and the installation of FDDI controllers for the VAX cluster, various Intergraph servers, and several VAX workstations which have a high workload. One also has the option to privatize Ethernet workstations, if the load demands. It should also be noted that other developers have reported that until all workstations are upgraded to FDDI a sizable increase in throughput is usually not recognized, this is due not only to the 10 Mb/s output of the Ethernet controller, but applications are not taking advantage of the higher bandwidth available from FDDI.

Performance data is presented for the 1988 and 1994 CAD/CAE Ethernet configurations and the 1994 Office Automation network. The Microsoft mail facility was also monitored to determine it's impact on the CAD/CAE LAN.

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1. INTRODUCTION

The Computer Aided Design/Computer Aided Engineering (CAD/CAE) network at Kennedy Space Center is composed of segmented Local Area Networks (LAN). These segmented LAN's are interconnected through either bridges or routers. At present this LAN is an Ethernet network. The design/engineering workstations are various Intergraph and Digital Equipment Corporation products, mainly. The host is a VAX cluster and there are several Intergraph servers, for plotting/printing/disk storage.

The workstations use the VAX cluster for their work environment. There are various protocols on the LAN, mainly Internet Protocol (IP) and DecNet, with some LAT (a DECnet protocol).

In the sections that follow, the following items will be discussed. A review of the NASA/KSC CAD/CAE network configuration, Ethernet and FDDI principles and nomenclature, intelligent switch concepts and presentation of performance data for of the CAD/CAE and Office Automation networks.

2. NASA/KSC CAD/CAE NETWORK CONFIGURATION

The NASA/KSC CAD/CAE network (1) configuration is composed of a VAXcluster utilizing a Star Coupler tying together a VAX 11/780, VAX 6000-610, and a VAX 6000-510. The VAX 780 and VAX 6510 are to be replaced with an ALPHA 7610 AXP and an ALPHA 4000 AXP, respectively. The VAX cluster is presently interfaced to the workstation environment through an Ethernet LAN, and by Bridges/Routers to workstations that are not situated at the Headquarters building.

The NASA/KSC CAD/CAE LAN presently provides connectivity for the CAD/CAE workstations, which are Intergraph and DEC, and PC's. The network communicates between HQ's, O&C, EDL, CIF, and the Merritt Island Courthouse (MICH) on Broadband Communication Distribution System (BCDS) Channel FM1. There is also a gateway to NSI-DECnet network.

There are several DEC workstations in the Mechanical Engineering area and Boeing has a DEC workstation. These are VAXstation 4060's and 3176's.

The Headquarters CAD/CAE LAN is a segmented Ethernet network and their is presently an FDDI fiber optic ring for the Kennedy Metropolitan Area Network (KMAN). KMAN is to provide connectivity to other sites (in the future) and presently to off-KSC sites.

The rationale for migrating from the present Ethernet configuration to a fiber optic backbone is due to the increase in the number of workstations and the movement of the applications to a windowing environment, extensive document transfers, and compute intensive applications.

In a NASA/KSC report (2) presented in 1988, the Ethernet utilization was 3%, or less, and there were only fourteen Intergraph workstations on the Headquarters LAN. At present utilizations of 80%, or less, have been observed in short bursts and 10-25% averaged over longer time periods. There are presently 58 workstations on the NASA/KSC HQ LAN.

This is then the rationale for obtaining an increase in bandwidth to relieve present congestion and provide the capabilities for future growth. It should be noted that in network communications terminology bandwidth is the amount of data that can be transmitted over a channel in bits/second. This is a different definition than used in electrical engineering terminology.

There are several alternatives for providing greater bandwidth for the CAD/CAE LAN. One is through segmentation, this is a reconfiguration of the LAN network into segments whereby one tries to keep traffic local to the segment and only obtain access to other segments if needed. This results in usage of Bridge/Routers to connect the various segments. Propagation delay will be increased every time a Bridge/Router is introduced into the network. Propagation delay is the amount of time between the time the message is sent from the source to being received by the intended destination. In the LAN being investigated it is presumed that most traffic is between the workstations and the VAXcluster, thereby segmenting would not alleviate the problem to a great degree, since the channel would be utilized between the workstation and the VAXcluster.

Another approach, i.e., as compared to segmentation, is the concept of Intelligent Switching. Intelligent switches are able to accommodate Ethernet and FDDI modes and able to switch, between segmented networks either internally or externally, at a very rapid rate. This not only reduces the propagation delays, but allows one to migrate to FDDI rather than configuring for fiber optics entirely.

They also provide concurrent communications between workgroups and can match different bandwidth LAN's through the switch interface. In general one can achieve a high through-put, low-propagation delay (latency), and transparent communication between end-stations.

In the case of the NASA/CAE LAN this was a reasonable migration for several reasons. One, most of the workstations are not upgradeable to FDDI controllers and the cost would also be prohibitive. Two, the system is not yet saturated but if the workload increases in the future it will be needed. Thirdly, there is a movement to FDDI configurations at NASA/KSC (3).

3. LOCAL AREA NETWORK TECHNOLOGY

Ethernet (IEEE 802.3 Carrier Sense Multiple Access with Collision Detection - CSMA/CD) (4) provides the services of the lower two layers in the International Standards Organization (ISO) Open Systems Interconnection (OSI) model for network protocols.

Ethernet is a carrier sense protocol, i.e., all stations monitor the cable during their transmission, terminating transmission immediately if a collision is detected. When an Ethernet station wishes to transmit a packet a carrier sense is performed forcing the station to defer if any transmission is in progress. If there is no station sensed to be transmitting then the sender can transmit after an appropriate delay. It is possible that two, or more, stations will sense the channel idle at the same time and begin transmitting. This has the possibility of producing a collision. The station will continue monitoring and sense this collision. When a collision is detected the station will stop transmitting and will reschedule a re-transmission at a later time. Re-transmission time is random and is selected using a binary exponential backoff algorithm.

FDDI is a token passing technology that uses a timed token protocol (5). There can be multiple frames on the network which is configured as a logical dual ring, or a dual ring of trees. The media standard is presently optical fiber, although transmission of the packet over copper is also being considered and should be in the standard, in the future. The designation for the later is Copper Distributed Data Interface (CDDI). The bandwidth is 100 Mb/s. Of course the transmission distance for a predetermined db loss is greater with a fiber optic cable, as compared to a copper cable. There is also concern with cross-talk and radiation with the copper media. These concerns are being addressed, mainly through twisted pair and shielding.

There are various configurations for high speed intelligent switches (6). They are used to interconnect multiple LAN's, either FDDI, Ethernet, Token Ring or others. The intelligent switch offers many advantages over shared channel LAN's. The advantages include an increase in the bandwidth, latency (propagation delay) reduction, an increase in connectivity, and better traffic management.

Depending upon the vendor the switch may/may not interconnect various communication standards internally. Some of the configurations are:

- o Ethernet to Ethernet switching
- o FDDI to FDDI switching
- o FDDI to Ethernet to Token Ring switching externally
- o FDDI to Ethernet switching internally

There are switches which allow only Ethernet to Ethernet or Token Ring to be internetworked by bridging.

The FDDI to FDDI switching configuration is basically a FDDI concentrator. One can typically purchase FDDI line cards with two, or more ports. These ports would support SAS or DAS devices, or presumably SAC or DAC concentrators. Through the purchase of appropriate bridges FDDI and Ethernet segments can be interconnected. These switches can set up concurrent connections to obtain an aggregate throughput much higher than a single segment could obtain. These switches achieve low latency by not utilizing the store and forward concept, but to use cut-through forwarding. This technique forwards a packet as soon as the destination address is determined from the header.

Another type of switch can be called the intelligent switch, in that the internal configuration is such that FDDI can be integrated with Ethernet communications. The concept is to have a collapsed FDDI backbone internal to the switch and be able to bridge from external FDDI or Ethernet stations through the FDDI backbone. There is also the possibility of switching at the module level without going through the FDDI backbone for the Ethernet module. The FDDI module must go through the FDDI backbone internal to the switch.

Each Ethernet module contains ports which can have either Ethernet LAN segments connected or a private Ethernet channel, i.e., an end-station. Ethernet segments attached to a unique module are switched by an internal bridging function to the appropriate output port. Ethernet segment connections for ports on separate modules must go through the FDDI internal backbone to arrive at the destination address. The same is true for FDDI SAS/DAS connections.

This allows very sophisticated interconnections between dissimilar LAN segments and also allows gradual migration to FDDI devices as bandwidth needs increase. The communication between Ethernet and FDDI is transparent. Due to the usage of the FDDI internal backbone (backplane) there is a maximum of two low latency "hops" between any two stations.

Normally, a switch will have filtering capability based on; source address, destination address, protocol type, or some combination of these attributes. This can be usually done on a per port basis, or workgroup. Some routing functions can be obtained through this capability.

4. CONFIGURATION FOR MIGRATION TO FDDI

The present Ethernet LAN in the Headquarters building is a single segmented LAN with bridge/router connections to other CAD/CAE LAN's and other parts of the KSC network. To provide capabilities for migration to FDDI when resources permit and loading necessitates, the intelligent switching configuration was proposed (3).

This configuration consists of a building switch and the configuration will allow migration to FDDI when workstations are upgraded to FDDI. It will also allow the Ethernet LAN to be segmented, which should provide greater access for each segment to the VAX cluster. Components of the VAX cluster and the various servers have FDDI controllers available and hence will be integrated into the building switch. The connection to the Metropolitan Area Network will be provided by a Router.

The intelligent switch is from the Synernetics Corporation and has four modules available (7):

- o System Processor Module (SPM)
- o FDDI Enterprise Access Module (FEAM)
- o FDDI Concentrator Module (FCM)
- o Ethernet Switching Module (ESM)

The SPM module is dedicated to the management of the system and it continually monitors the system and is used to configure the system. This module is required.

The FEAM provides A/B ports for connecting the switch to an FDDI backbone.

The FCM is an FDDI concentrator and allows one to connect end stations and other intelligent switches to the FDDI backbone.

The ESM has Ethernet connections which can be switched and a fully translational Ethernet to FDDI bridge which can forward messages to other ESM modules or to FDDI stations via the FDDI collapsed backbone internal to the intelligent switch. Messages can be switched between ports on an ESM without going through the FDDI backbone.

5. EXPERIMENTAL ENVIRONMENT

To enable collection of data concerning the traffic on the NASA/KSC CAD/CAE network a network analyzer was used to characterize the traffic. Network analyzers are useful for monitoring, debugging, managing, and characterizing local area networks. Specifically, the analyzer can examine all frames transmitted/received on the network. The analyzer can compute, display, and store statistics about network activity, such as average and peak traffic rates, frame sizes, protocol distribution, and other items.

The network analyzer used for these tests was a Network General Corporation Sniffer Network Analyzer (8). The monitor provides an exact picture of network activity at a given instance, or the activity can be captured in various historical logs.

The following is a partial list of the monitor's capabilities:

- o 1024 stations can be monitored.
- o Alarms for specific stations, or the entire network, can be generated.
- o Real-time traffic and historical information for individual stations, and/or the entire network can be captured.
- o The statistics gathered can be sorted to suit the user.
- o Management reports can be generated.
- o Will automatically store in a file, selected information, at pre-determined time intervals.

The Ethernet monitor can monitor a network continuously for up to 49 days. This monitor can be utilized on an Ethernet (IEEE 802.3) network.

In the following a compilation of frame traffic, average and peak utilization, frame length, protocol traffic is presented for the NASA/KSC CAD/CAE network for the network configuration of 1988 and 1994 and the Office Automation network and Microsoft mail facility.

It should be noted that the 1988 data was captured by an Excelan LANalyzer EX 5000 Series Network Analyzer.

6. FRAME TRAFFIC

The frame traffic on the Ethernet has been observed to be the following, see Figures 1,2:

1994 Traffic

- o 3,500,000 frames during normal work hours (approximately, 7:30 to 15:30)
- o 3,500,000 frames during evening hours

This is approximately a 300% increase over the 1988 traffic (during the normal work hours) and a 270% increase over the 1988 traffic (during the evening hours).

7. UTILIZATION/%COLLISIONS/STATION%USE/PROTOCOL DISTRIBUTION

The Ethernet utilization (and other information) is presented in Table I for a period of a month. This Table has summarized the % Collisions, % Average Utilization, and the three Stations and Protocols with with the highest usage. The data for 1988 showed an average utilization of less than 1%, and a maximum peak utilization of 3 %, or less. While 1994 traffic peak utilizations are not shown in Table I, Figure 3 shows that 80 % peak utilizations have been encountered for 10 second snapshots and 10-25 % utilizations have been observed over longer time periods, see Figure 4. Figure 4(a), (b) and (c) show average utilizations (snapshots) over 30 minute, 15 minute and 5 minute time intervals, respectively.

The distribution of frame lengths is similar to the 1988 distribution, although a larger percentage of the frames are now in the high end of the frame distribution. This implies that more "useful" data is being sent over the network, as compared to "handshaking/acknowledgments", see Figure 5. The protocol distribution has changed from a preponderance of XNS (Xerox Network Systems) to basically Internet protocol (IP). This is due to the type of protocols being utilized by the stations, shifting to IP over the last several years, see Figure 6.

Collisions/CRC alignments cause very few frames to be lost, this is expected when the average utilization rate is low and due to the carrier sense before transmission of Ethernet (see Figures 1 and 2).

It can be seen from Table I and Figure 4, that the average % collisions and average % utilization is well below the thresholds that are stated in the literature (9). These are given as, 10% and 35%, respectively. The peak network utilization for the NASA/KSC has been observed as high as 80%, where the peak utilization as stated in the literature is given as 55%. The thresholds, stated in Reference (9), are values for which network segmentation (or, obtain more bandwidth) is deemed advisable.

8. MICROSOFT/OFFICE AUTOMATION UTILIZATION

Table II shows the Microsoft mail data similar to Table I for the CAD/CAE network. While the Microsoft mail service is already absorbed in the previous data, see Table I, and is presently a minor portion of the network traffic (less than 1% average utilization). The Headquarters Office Automation (OA) network segment is presently a separate network and is planned to be moved to the CAD/CAE network. Table III reflects the impact that this migration might have on the CAD/CAE network. This migration should have minimal impact due to it's present activity (less thank 3-4% average utilization, and peak rates in 12-15% range).

9. SUMMARY

The measurements reported reflect only the frame traffic on the CAD/CAE and Office Automation networks, not the actual work effort in a design/office project. The workload in a design/office project is composed of tasks other than workstation interaction and the amount of interaction will depend upon the task.

From the test data obtained in this evaluation one can conclude that there is slack in the CAD/CAE network traffic, with regard to average and peak utilizations. It should be able to accommodate the Office Automation traffic monitored and any increase in Microsoft mail activity.

The planned migration to FDDI utilizing a Synernetics switch, will provide a network configuration that will be able to provide average and peak utilizations and % collisions well below published thresholds. The Synernetics switch also has the capability to further segment the Ethernet workstations and add FDDI workstations, as they become available, or if traffic warrants further segmentation.

A follow-up to this study is to evaluate the CAD/CAE network after the planned migration to FDDI has been finalized and the Office Automation network traffic has been transferred to the CAD/CAE network.

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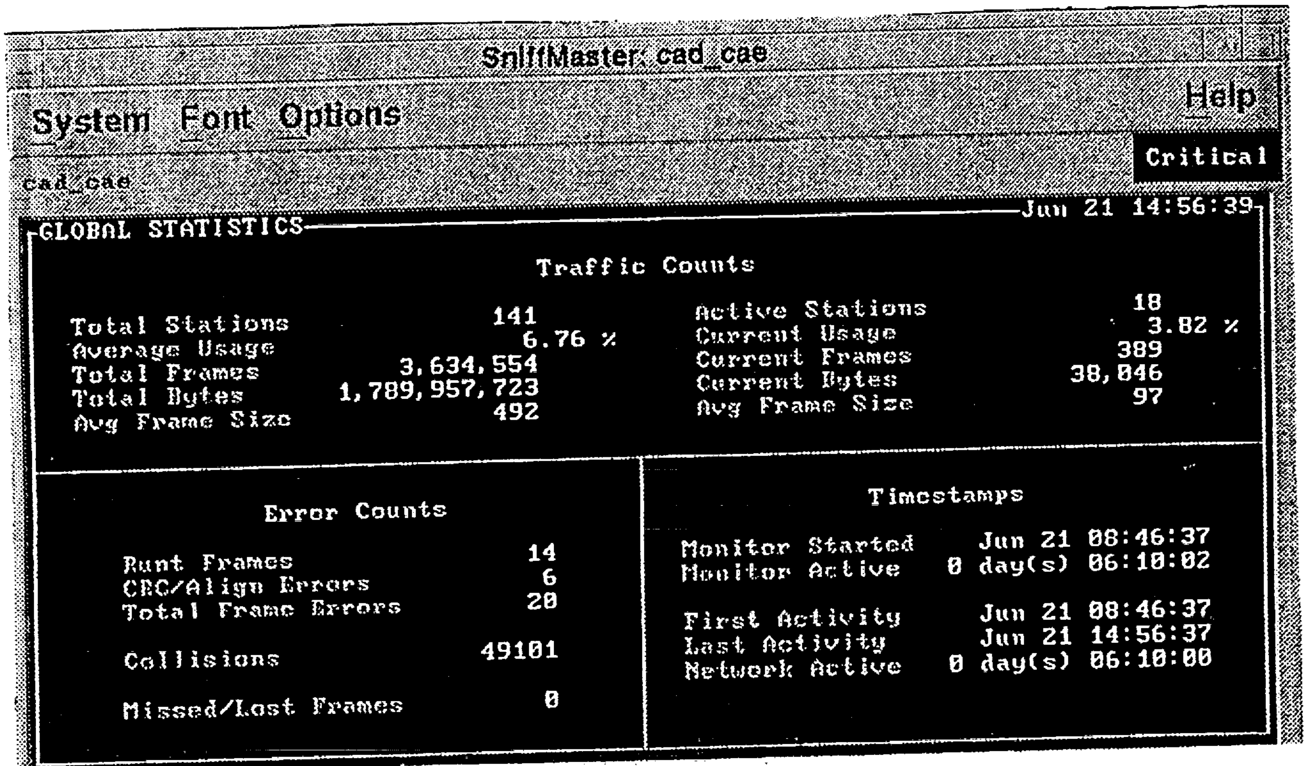

Figure 1. Global Statistics - Normal Hours

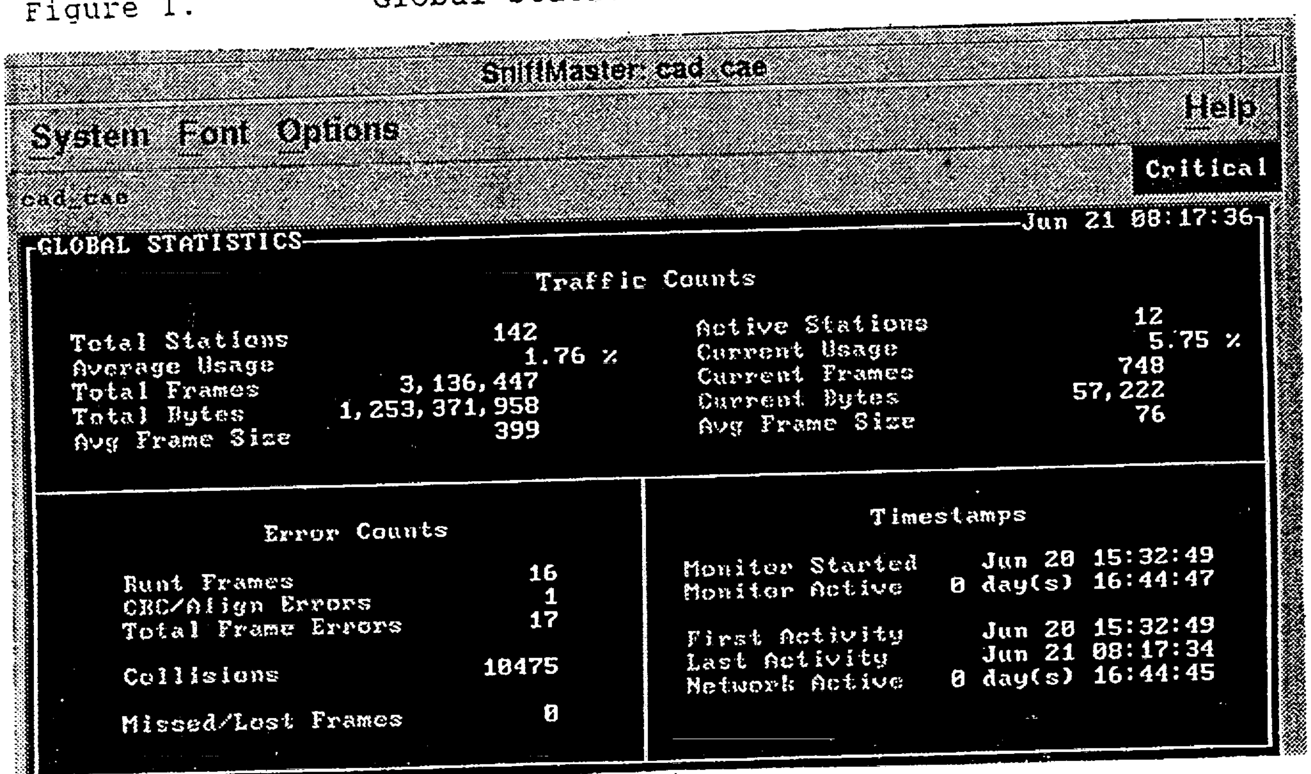

Figure 2. Global Statistics - Evening Hours

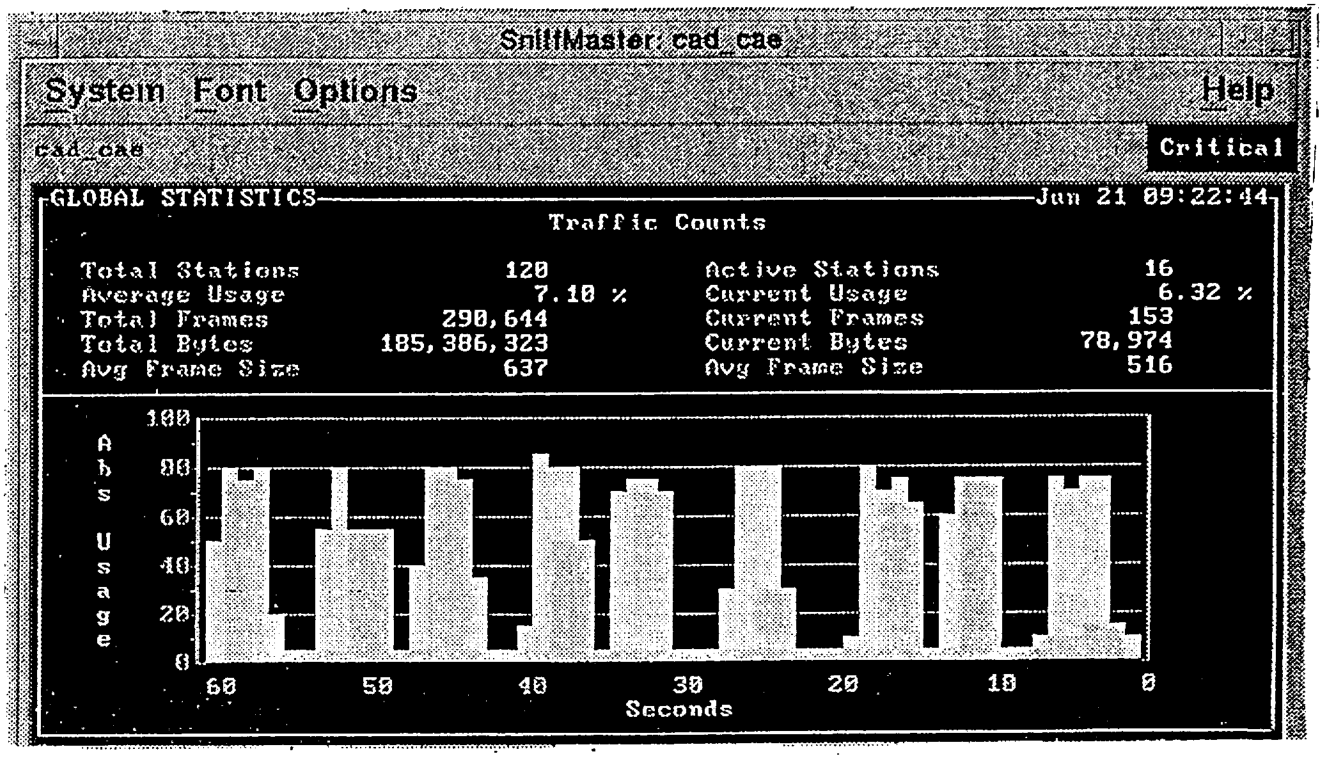

Figure 3. Peak Utilization Snapshot

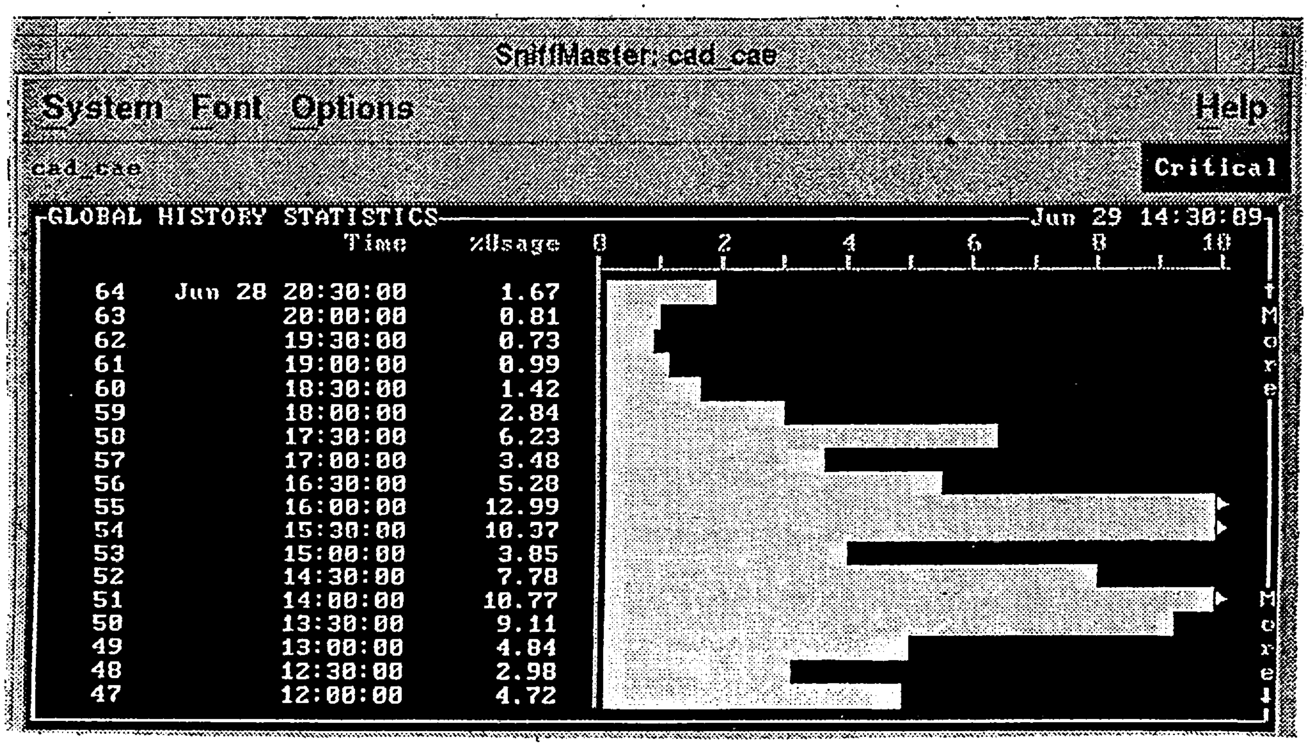

Figure 4(a). Average Utilization - 30 Minute Slot

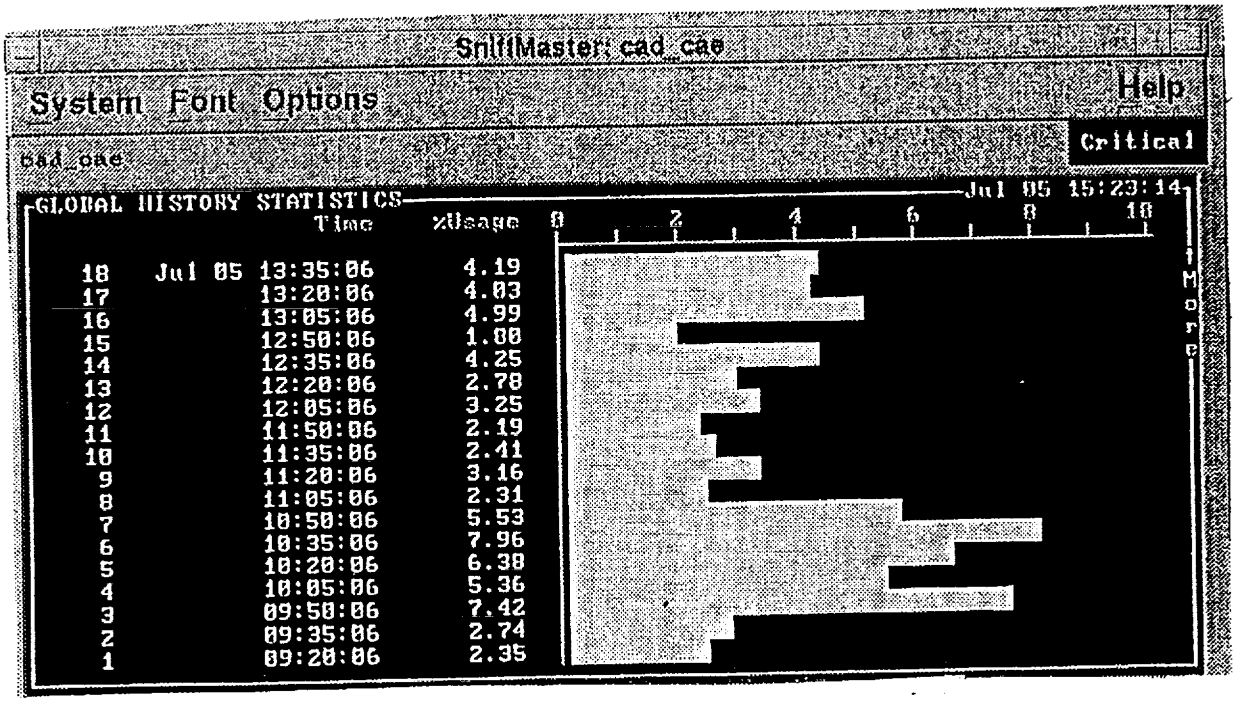

Figure 4(b). Average Utilization - 15 Minute Slot

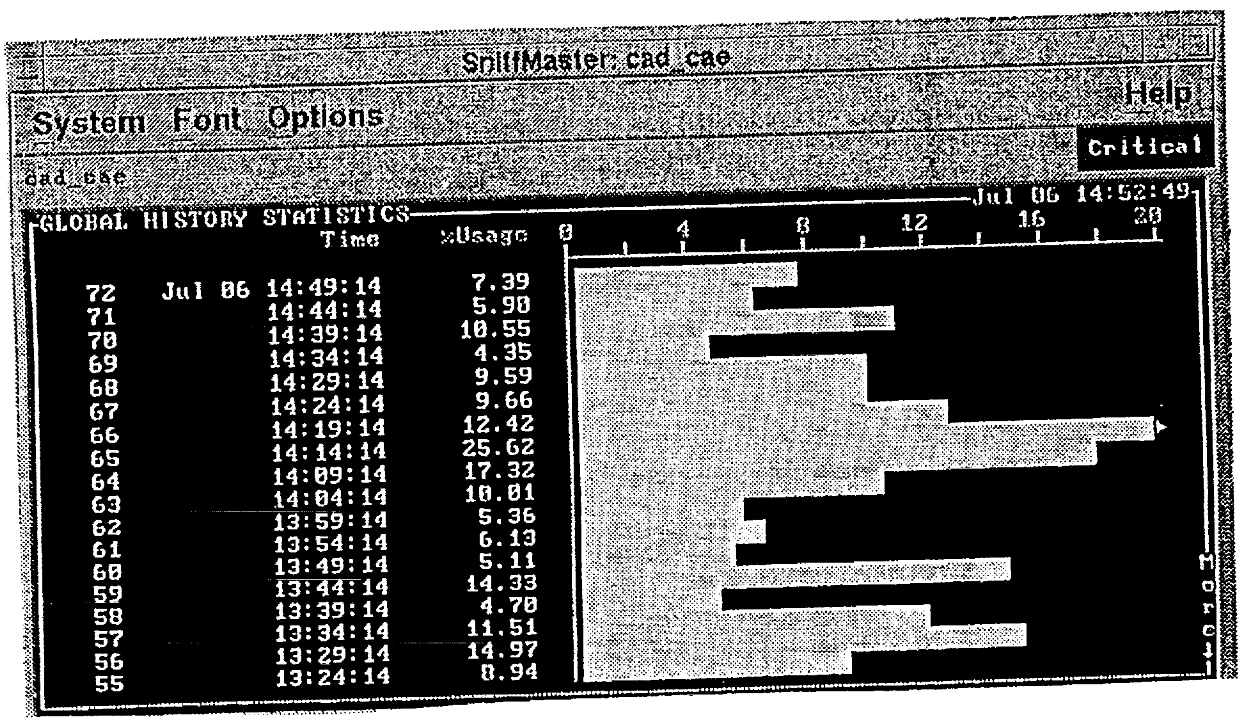

Figure 4(c). Average Utilization - 5 Minute Slot

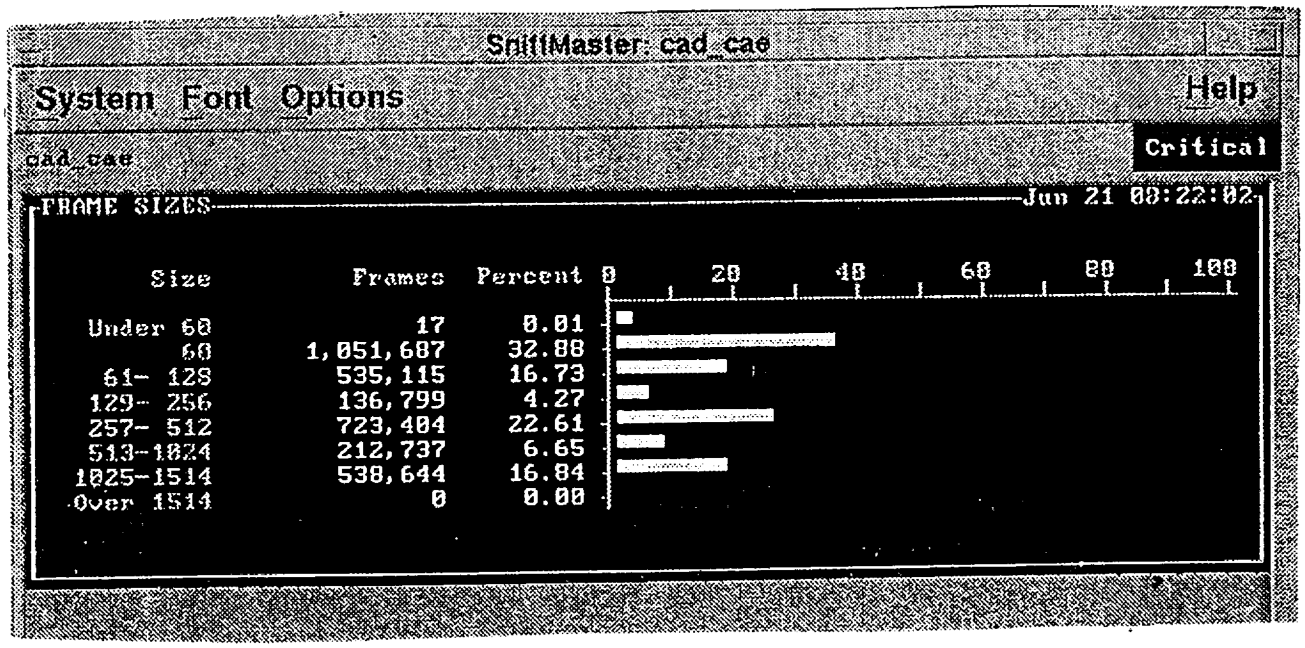

Figure 5. Frame Length Distribution

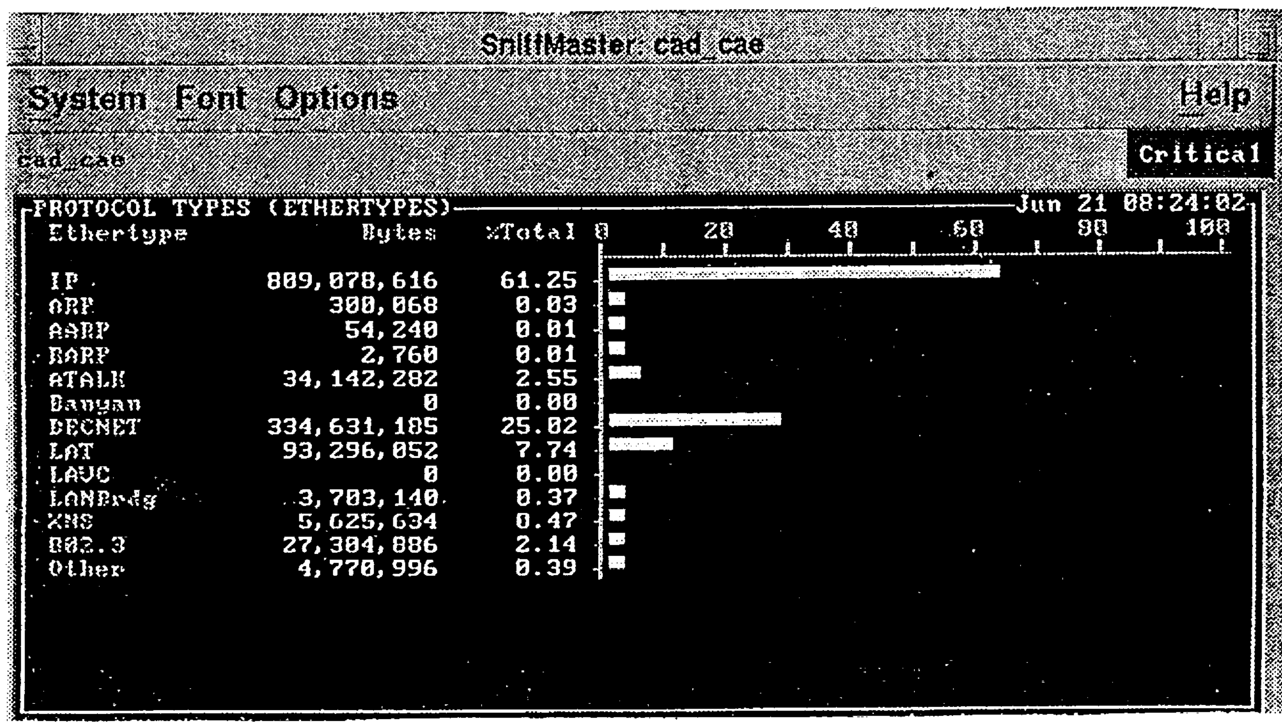

Figure 6. Protocol Distribution

SNIFFER DATA FOR CAD/CAE NETWORK - ETHERNET

COLLECTED BY GEORGE W. ZOBRIST
UNIVERSITY OF MISSOURI-ROLLA

TIME/DATE FROM	TO	%COLLISIONS	%AVE USAGE	STATION %USE	PROTOCOLS
06/03 07:00	06/03 11:00		7.83 %	KSCDL1 4.7% PONRTR 2.3% INTGRn 2.3%	IP 93% DECNET 2% LAT 3%
06/03 15:00	06/06 09:30		0.80 %	BRDCST 0.3% SUN 0.3% PONRTR 0.3%	IP 80% ATLK 6% DECNET 4%
06/03 10:00	06/10 08:00		3.92%	KSCDL1 2.2% PONRTR 0.9% INTGR 0.7%	IP 75% DECNET 16% LAT 5%
06/10 09:00	06/13 13:00		1.50%	KSCDL1 0.5% BRDCST 0.3% PONRTR 0.3%	IP 79% DECNET 10% LAT 4%
06/14 08:30	06/15 08:30	.33%	1.99%	KSCDL1 1.0% PONRTR 0.6% BRDCST 0.3%	IP 58% DECNET 22% LAT 13%
06/15 09:45	06/15 08:30	.33%	3.0%	KSCDL1 2.1% PONRTR 1.7% BRDCST 0.3%	IP 44% DECNET 45% LAT 7%
06/16 09:30	06/17 08:30	ovflw	7.0%	KSCDL1 5.7% PONRTR 1.7% CISCO 0.9%	IP 86% DECNET 8% LAT 3%
06/17 09:15	06/17 15:00	1.0%	6.2%	KSCDL1 3.7% INTGR 1.1% PONRTR 0.9%	IP 66% DECNET 22% LAT 10%
06/17 15:30	06/20 09:00	0.1%	0.7%	BDCST 0.3% SUN 0.3% PONRTR 0.3%	IP 76% DECNET 6% LAT 5%
06/20 09:00	06/20 15:00	0.7%	4.4%	INTGR 1.2% KSCDL1 1.0% INTGR 0.9%	IP 76% LAT 14% DECNET 7%
06/20 15:30	06/21 08:15	0.3%	1.8%	KSCDL1 0.9% PONRTR 0.4% INTGR 0.4%	IP 61% DECNET 25% LAT 8%

Table I. Network Analyzer Data for CAD/CAE Ethernet

SNIFFER DATA FOR CAD/CAE NETWORK - ETHERNET

COLLECTED BY GEORGE W. ZOBRIST
UNIVERSITY OF MISSOURI - ROLLA

TIME/DATE FROM	TO	%COLLISIONS	%AVE USAGE	STATION	%USE	PROTOCOLS	
06/21 08:45	06/21 15:00	1.3%	6.8%	INTGR	4.2%	IP	88%
				INTGR	3.6%	LAT	6%
				PONRTR	1.2%	DECNET	4%
06/21 15:30	06/22 09:30	0.5%	1.9%	KSCDL1	0.8%	IP	65%
				INTGR	0.5%	DECNET	22%
				PONRTR	0.4%	LAT	6%
06/22 10:00	06/29 14:30	OVFLW	3.3%	KSCDL1	1.6%	IP	79%
				INTGR	0.8%	DECNET	13%
				PONRTR	0.8%	LAT	4%
06/29 15:15	06/30 08:00	0.4%	3.2%	KSCDL1	2.2%	IP	38%
				PONRTR	1.7%	DECNET	49%
				INTGR	0.5%	LAT	8%
06/30 14:30	07/01 07:20	OVFLW	9.2%	KSCDL1	7.8%	IP	82%
				INTGR	1.2%	LAT	11%
				CISCO	1.1%	DECNET	4%
07/01 08:00	07/05 09:00	0.2%	1.2%	KSCDL1	0.5%	IP	64%
				PONRTR	0.5%	LAT	18%
				BDCST	0.3%	DECNET	8%
07/05 15:40	07/06 08:20	0.25%	2.0%	KSCDL1	1.2%	IP	51%
				PONRTR	0.4%	DECNET	21%
				KSCDM2	0.4%	LAT	20%
07/06 08:45	07/06 14:30	1.5%	7.4%	INTGR	3.2%	IP	54%
				INTGR	2.4%	DECNET	21%
				KSCDL1	1.7%	LAT	20%

Table I. (cont.) Network Analyzer Data for CAD/CAE Ethernet

CAD/CAE NETWORK TRAFFIC FOR 3COM/MICROSOFT MAIL SYSTEM

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DATE		3COM ACCCE3		3COM AEF52F	
TO	FROM	TOTAL FRAMES/ BYTES	AVE USE%	TOTAL FRAMES/ BYTES	AVE USE%
06/30 14:30	07/01 07:30	23,277/ 2,847,344	.01%	28,299/ 7,355,818	0.01%
07/01 08:00	07/05 09:00	134,533/ 16,465,059	.01%	152,719/ 41,425,007	0.01%
07/05 15:40	07/06 08:20	47,077/ 9,083,530	.01%	77,003/ 22,585,705	0.03%
07/06 08:45	07/06 15:00	20,281/ 3,927,691	.01%	58,635/ 24,108,669	0.09%

Table [illegible]. Network Analyzer Data for Microsoft Mail

SNIFFER DATA FOR OFFICE AUTOMATION - ETHERNET

COLLECTED BY GEORGE W. ZOBRIST
UNIVERSITY OF MISSOURI-ROLLA

TIME/DATE FROM	TO	%COLLISIONS	%AVE USAGE	STATION	%USE	PROTOCOLS	
07/07 14:40	07/11 07:40	1.25%	0.3%	DEC BDCST NOVLL	0.1% 0.1% 0.1%	IP ATLK 802.3	38% 32% 18%
07/11 08:30	07/11 14:45	1.0 %	0.4%	DEC CISCO BDCST	0.2% 0.1% 0.9%	ATLK IP 802.3	47% 34% 11%
07/11 15:20	07/12 08:00	0.2%	0.6%	NOVLL DEC CISCO	0.3% 0.1% 0.1%	IP ATLK 802.3	52% 30% 11%
07/12 08:20	07/12 14:30	0.6%	0.5%	CISCO DEC BDCST	0.3% 0.1% 0.1%	ATLK 802.3 IP	40% 30% 23%
07/12 15:30	07/13 08:15	2.0%	0.7%	NOVLL BDCST DEC	0.4% 0.1% 0.1%	IP ATLK 802.3	60% 22% 11%
07/13 08:45	07/13 14:30	0.7%	0.6%	CISCO DEC ADDR	0.3% 0.1% 0.1%	802.3 ATALK IP	32% 32% 28%
07/13 15:00	07/14 07:45	2.0%	0.7%	NOVLL DEC BDCST	0.4% 0.1% 0.1%	IP ATLK 802.3	57% 26% 11%
07/14 08:10	07/14 14:40	1.6%	0.5%	CISCO DEC BDCST	0.2% 0.1% 0.1%	ATLK IP 802.3	46% 26% 20%
07/14 15:15	07/15 07:30	0.1%	0.5%	NOVLL DEC CISCO	0.2% 0.1% 0.1%	ATLK IP 802.3	41% 40% 12%
07/15 08:00	07/15 14:30	1.0%	0.7%	CISCO DEC BDCST	0.2% 0.2% 0.2%	ATLK IP 802.3	52% 24% 18%

Table III. Network Analyzer Data for Office Automation Network

ATTACHMENT - REPORT DOCUMENTATION PAGE - ITEM #6 (Authors)

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NASA/ASEE Summer Faculty Fellowship Program

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
October 1994

3. REPORT TYPE AND DATES COVERED
Contractor Report - Summer 1994

4. TITLE AND SUBTITLE
1994 Research Reports
NASA/ASEE Summer Faculty Fellowship Program

5. FUNDING NUMBERS
NASA Grant NGT-60002
Supplement: 17

6. AUTHOR(S)
See attached list

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
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8. PERFORMING ORGANIZATION REPORT NUMBER
NASA CR-197448

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Aeronautics and Space Administration
Washington, D.C. 20546

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Unclassified - Unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This document is a collection of technical reports on research conducted by the participants in the 1994 NASA/ASEE Summer Faculty Fellowship Program at Kennedy Space Center (KSC). This was the tenth year that a NASA/ASEE program has been conducted at KSC. The 1994 program was administered by the University of Central Florida in cooperation with KSC. The program was operated under the auspices of the American Society for Engineering Education (ASEE) with sponsorship and funding from the Office of Educational Affairs, NASA Headquarters, Washington, D.C. The KSC Program was one of nine such Aeronautics and Space Research Programs funded by NASA Headquarters in 1994. The NASA/ASEE program is intended to be a two-year program to allow in-depth research by the University faculty member. The editors of this document were responsible for selecting appropriately qualified faculty to address some of the many problems of current interest to NASA/KSC.

14. SUBJECT TERMS
Research and Technology

15. NUMBER OF PAGES
567

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL